THE PACIFIC MARINE ENERGY CENTER'S

NORTH ENERGY TEST SITE

Annual Operations & Monitoring Report 2013

Prepared for the

Adaptive Management Committee

by

NNMREC
Northwest National Marine Renewable Energy Center

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ABBREVIATIONS AND ACRONYMS

ADUH	Autonomous Drifting Underwater Hydrophone
AMC	Adaptive Management Committee
AMF	Adaptive Management Framework
AMP	Adaptive Mitigation Plan
AWAC	Acoustic Wave and Current profiler
BiOp	Biological Opinion
EMF	Electromagnetic field
ESA	Endangered Species Act
FINE	Fishermen Involved in Natural Energy
ITS	Incidental Take Statement
MMPA	Marine Mammal Protection Act
NDBC	National Data Buoy Center
NETS	North Energy Test Site
NMFS	National Marine Fisheries Service
NNMREC	Northwest National Marine Renewable Energy Center
NOAA	National Oceanic and Atmospheric Administration
NOMAD	Navy Oceanographic Meteorological Automatic Device
ODFW	Oregon Department of Fish and Wildlife
OSU	Oregon State University
PMEC	Pacific Marine Energy Center
ROV	Remotely Operated Vehicle
SETS	South Energy Test Site
SPL	Sound Pressure Level
SWH	Significant Wave Height
USFWS	US Fish and Wildlife Service
UW	University of Washington
WEC	Wave Energy Converter

1 BACKGROUND

This Annual Operations and Monitoring Report summarizes the 2013 operational and environmental monitoring activities associated with the Pacific Marine Energy Center's North Energy Test Site, located off the coast of Newport, Oregon.

1.1 WHAT IS THE PACIFIC MARINE ENERGY CENTER?

The Pacific Marine Energy Center (PMEC) is the collective name for a suite of test facilities available to the marine energy industry. These facilities are located in Oregon and Washington.

PMEC includes scaled laboratory testing facilities for wave and tidal energy converters, and intermediate and full-scale open water wave energy converter (WEC) testing facilities:

Oregon State University (OSU) Open Water Testing

The PMEC North Energy Test Site (NETS) can accommodate WECs up to 100kW, and larger devices if no grid emulation or connection is required. Testing utilizes the Ocean Sentinel, an instrumentation buoy that provides an electrical load and performs data acquisition for devices under test.

The PMEC South Energy Test Site (SETS) is a grid-connected site currently under development. SETS will serve as the utility-scale wave energy test facility for the US, and is expected to be available for device testing in the next few years.

OSU Laboratory Testing Facilities

The Wallace Energy Systems and Renewable Facility provides research, testing and consulting services related to machines and drives, power electronics, power systems and renewables. The two wave tanks at the O.H. Hinsdale Wave Research Laboratory - the Large Wave Flume and the directional Tsunami Wave Basin - allow for testing of scaled devices.

University of Washington (UW) Open Water Testing

For intermediate scale tidal energy devices, UW supports open water testing in Puget Sound and in Lake Washington.

UW Laboratory Testing Facilities

The Aeronautical Laboratory maintains a flume suitable for scale testing of tidal turbines. The Harris Hydraulics Laboratory is in the process of upgrading its combined wind/wave channel (available late-2014) suitable for scale testing of wave energy devices and mooring systems.

The Pacific Marine Energy Center is managed and operated by the Northwest National Marine Renewable Energy Center.

1.2 WHAT IS THE NORTHWEST NATIONAL MARINE RENEWABLE ENERGY CENTER?

The Northwest National Marine Renewable Energy Center (NNMREC) is one of three US Department of Energy-funded centers charged with facilitating the development of marine renewable energy technology through research, education, and outreach. Established in 2008, NNMREC is a partnership between OSU and UW. While OSU focuses on wave energy, UW's emphasis is tidal energy. In 2011 NNMREC's research agenda expanded to include offshore wind energy as well.

NNMREC works closely with a variety of stakeholders, including device developers, community members, ocean users, federal and state regulators, and government officials, to conduct research

about marine energy, provide test sites for prototype devices, and assist developers with planning and permitting activities.

NNMREC's objectives are to:

- Develop its facilities to serve as an integrated, standardized test center for US and international developers of wave and tidal energy;
- Evaluate potential environmental, ecosystem, and human dimension impacts, focusing on the compatibility of marine energy technologies in areas with sensitive environments and existing users;
- Facilitate and conduct research to inform adaptive management of marine energy technologies;
- Study and consult on device and array optimization for effective deployment of wave and tidal energy technologies;
- Improve forecasting of the wave energy resource; and
- Increase reliability and survivability of marine energy systems.

NNMREC itself serves as a neutral voice of science and engineering to inform the public and decision-makers about the potential effects and capabilities of wave, tidal, and offshore wind energy technologies.

NNMREC faculty and students come from civil, electrical, mechanical, and chemical engineering; oceanography; marine biology; sociology; and public policy. They investigate technical, environmental, and social dimensions of these ocean energy technologies, and perform research that fills knowledge gaps.

1.3 WHAT IS THE NORTH ENERGY TEST SITE?

The North Energy Test Site (NETS) is PMEC's non-grid connected, open ocean test site located approximately 4.6 km (2.5 nautical miles) off Yaquina Head, north of Newport, Oregon. The site is about 3.4 km^2 (1 square nautical mile) and ranges in depth from 45 - 55 meters. It has a gently sloping soft, sandy bottom. Significant wave heights (SWH) average 1 - 2.5 meters during summer months at 6 - 9 second energy periods. During winter months SWHs increase to an average of 2 - 5 meters at 8 - 12 second energy periods, with maximum significant wave heights of 7 - 14 meters.

NNMREC has characterized the environmental conditions of the site, and has conducted a significant level of environmental monitoring, including baseline and operational monitoring for benthic habitat, marine mammal observations, electromagnetic field studies, and acoustics. The site is fully authorized under all relevant state and federal statutes.

1.4 NETS TESTING CAPABILITIES

NNMREC has developed the Ocean Sentinel instrumentation buoy to provide an electrical load and perform data acquisition for wave energy devices under test at the NETS. Based on the 6-meter Navy Oceanographic Meteorological Automatic Device (NOMAD) design, the Ocean Sentinel buoy is moored approximately 100 meters from the device under test and connected by a power and communication umbilical cable. Power generated by the test device is processed and dissipated in a load bank onboard the Ocean Sentinel. The Ocean Sentinel has an initial average power rating of 100kW. Onboard switchgear and power conversion equipment provides control of the load bank. Data may be transmitted from the device under test to the instrumentation buoy via a fiber optic connection through the umbilical cable. Wave and current data recorded by a measuring instrument nearby can also be transmitted to the buoy via wireless telemetry.

The Ocean Sentinel's data acquisition system records multiple parameters:

- Power measurements, including voltage and current;
- Environmental data, including waves, currents and winds; and
- Mooring force, strain gauges and other signals from instrumentation onboard the WEC device under test.

Data is recorded with redundancy onboard the Ocean Sentinel and can be sent to shore via wireless telemetry to OSU's Hatfield Marine Science Center in Newport. Data may also be accessed remotely. The Ocean Sentinel is designed for testing devices from May through October and is available for environmental testing year round.

1.5 NETS Past Activities

The first wave energy test at the NETS took place in 2012 with the deployment of the WET-NZ WEC and the Ocean Sentinel instrumentation buoy. The WET-NZ and Ocean Sentinel were deployed from late August to early October 2012 and monitoring studies were performed at the test site prior to, during and after the deployment. The 2012 test activities and monitoring are summarized in the 2012 Annual Operations and Monitoring Report (nnmrec.oregonstate.edu/reports).

1.6 NETS Adaptive Management, Review and Reporting

1.6.1 Adaptive Management Framework and Adaptive Mitigation Plans

Operations at the NETS are conducted in accordance with an **Adaptive Management Framework** (AMF). The purpose of the AMF is two-fold:

1. It provides a means for the broader regulatory and stakeholder communities to stay informed of and provide feedback on NNMREC test center monitoring and mitigation.
2. It provides a foundation for the monitoring and adaptive management associated with all activities and tests at the NETS. For each test performed at the NETS, an **Adaptive Mitigation Plan** (AMP) is developed that includes thresholds and mitigation actions for the particular test. Monitoring results are reviewed by NNMREC in real-time, whenever possible, to determine if thresholds have been exceeded. If the results show that thresholds are *not* exceeded then no action is taken. If results show that thresholds are exceeded, NNMREC will consult with National Marine Fisheries Service (NMFS), US Fish and Wildlife Service (USFWS) and the Oregon Department of Fish and Wildlife (ODFW) to develop an appropriate response. Responses may include changes to monitoring methods, project operations and/or mitigation actions, as appropriate.

   Each AMP accounts for the unique attributes of that specific test, such as the characteristics of the technology being tested, the mooring system being used and the duration of testing. In addition, results and analysis of previously completed monitoring studies are used to inform the plans for future tests.

1.6.2 Adaptive Management Committee

A key part of this Framework is the **Adaptive Management Committee** (AMC or Committee). Committee members include representatives from the:

- Northwest National Marine Renewable Energy Center;
- US Army Corps of Engineers;

- National Marine Fisheries Service;
- US Fish and Wildlife Service;
- Oregon Department of Fish and Wildlife;
- Oregon Department of Land Conservation and Development;
- Oregon Department of State Lands;
- Oregon Coastal Management Program;
- Local Tribes;
- Fishermen Involved in Natural Energy;
- Surfrider Foundation; and
- Oregon Shores.

Representatives from other organizations may be asked to join the AMC, as deemed appropriate by NNMREC.

The purpose of the Committee is to review marine resource issues (i.e. benthic habitat, derelict gear, marine mammals, acoustics, and electromagnetic fields) related to wave energy testing activities at the NETS and to make recommendations for changes in monitoring, project operations, and/or adaptive management/mitigation thresholds for the test facility.

Each year, NNMREC prepares an Annual Operations and Monitoring Report (Annual Report), which is provided to the Committee. The Annual Report is a compilation of monitoring results, adaptive management thresholds, and mitigation actions taken during tests conducted at the NETS during that year. The Committee meets on an annual basis to review results and provide guidance on future test center activities. The 2012 Annual Report is available on the NNMREC website at: nnmrec.oregonstate.edu/reports.

2 OPERATIONAL ACTIVITIES IN 2013

In 2013, NNMREC completed its second successful testing season at the NETS. No WEC tests were scheduled for 2013, so NNMREC used the opportunity to deploy the Ocean Sentinel instrumentation buoy in order to gain a better understanding of mooring systems and how to improve them, as well as to continue environmental monitoring at the site.

Experiences gained through successful 2012 operations resulted in the implementation of various modification and changes to the 2013 operations, including:

- New methods for tensioning mooring lines and lifting the Ocean Sentinel bow mooring yoke;
- New methods for recovery of the Ocean Sentinel, including the disconnection of the mooring system;
- Leaving the Ocean Sentinel anchors and anchor buoys at sea for the winter to study maintenance cycle requirements and the effects of long term anchor deployments;
- Deployment of a new Acoustic Wave and Current (AWAC) profiler; and
- Integration of load cells into each of the Ocean Sentinel mooring lines.

Operations for 2013 required the procurement and integration of new equipment, including the AWAC and mooring line load cells. Existing equipment was modified to support the tests, including the Ocean Sentinel data acquisition and control systems.

The experimental mooring testing was conducted from July 29 to October 4, 2013 (Table 1). The Ocean Sentinel was configured in a three-point mooring system with the load cells integrated into each mooring line, where all tension loads were recorded. In addition, a TriAXYS surface wave measurement buoy and the newly acquired seafloor-mounted AWAC profiler both measured wave and ocean current data near the Ocean Sentinel.

Table 1: Operational activities at the NETS in 2013.

Structure / Activity	Installation	Removal
Ocean Sentinel	July 29	October 4
TriAXYS Surface Wave Measurement Buoy	July 29	October 4
Acoustic Wave & Current (AWAC) profiler	August 14	October 3
Site Corner Marker Buoys	July 28 & 29	October 3
Ocean Sentinel Anchors & Marker Floats	July 25, 26 & 27	-
Operations Inspections	September 26 October 10	
Wave Energy Converter	*NONE in 2013*	

Equipment was deployed primarily from the *R/V Pacific Storm*, which is operated by the OSU College of Earth, Ocean, and Atmospheric Sciences' Marine Mammal Institute.

The operations plan for the 2013 testing was straightforward: monitor sea states and collect data. However, during the last few weeks of deployment, the NETS experienced significant sea conditions, including a maximum wave height of almost 12 meters. A notification was received by the Ocean Sentinel monitoring system that the buoy had left its defined operational position boundary. The situation was viewed with the onboard cameras and the Ocean Sentinel's GPS location was tracked. When sea states allowed it, a local fisherman was asked to inspect the site, which appeared to be in order. It was determined that the three, 8,500 lbs anchors had physically moved due to the extreme seas. This movement was in accordance with the mooring system design, which allows for anchor movement during very high sea states, rather than causing the submersion of the Ocean Sentinel. Despite the extreme sea conditions experienced during the 2013 deployment, the mooring system was found to be robust and performed as expected.

Recovery operations proceeded as planned. All equipment was retrieved apart from the Ocean Sentinel anchors and anchor buoys, which will remain deployed over the winter. After recovery operations were completed, the US Coast Guard issued a revised Notice to Mariners providing the locations of the three Ocean Sentinel anchor buoys. This information was also circulated to local fishermen and other stakeholders by the ODFW and OSU's Sea Grant Program.

3 MONITORING AND THRESHOLDS

This section is organized by topic area: Benthic Species and Habitat; Acoustics; Electromagnetic Fields (EMF); Marine Mammals and Entangled/Injured Species; and Derelict Gear. Each topic area has a number of subsections, beginning with a summary of the monitoring methods and results. The second subsection focuses on considerations for future monitoring. The following subsection consists of a comparison of the monitoring results to the thresholds outlined in the 2013 Adaptive Mitigation Plan, as well as recommendations for future Adaptive Mitigation Plans. Similarly, a comparison of monitoring results to the thresholds in the Adaptive Management Framework is provided in the fourth subsection of each topic area, along with recommendations for modifications to adaptive management thresholds and measures. A summary of the 2013 monitoring activities is provided in the Table 2.

In addition to the AMP and AMF, thresholds for effects to adult and juvenile salmonids, adult eulachon and adult and sub-adult green sturgeon were provided in the Incidental Take Statement (ITS) issued by NMFS for the NETS. The ITS was included with the Biological Opinion (BiOp), which concluded that sound pressure (acoustics), EMF and benthic habitat disturbance associated with the project would result in behavioral avoidance of the area (and thus loss of foraging opportunities in the project site) during wave energy tests. As such, a fifth subsection comparing the monitoring results to the ITS thresholds is included in Benthic Habitat (Section 3.1), Acoustics (Section 3.2), EMF (Section 3.3); and Marine Mammals and Entangled or Injured Species (Section 3.4).

3.1 BENTHIC SPECIES AND HABITAT

NOTE: The following section is adapted from the *Benthic Conditions and Organisms at PMEC's North Energy Test Site (NETS): 2013 Activities with Reference to Previous Years* report prepared by Sarah K. Henkel of OSU's Hatfield Marine Science Center (December 27, 2013). The full report is available in Appendix A.

3.1.1 Monitoring Summary

Background

Benthic surveys of sediment and water characteristics, infaunal and epifaunal invertebrates, and groundfishes in sedimentary habitats surrounding the NETS have been conducted since May 2010 to characterize spatial and temporal variability in these habitat and biological components.

The objectives of this monitoring are to: 1) determine if the presence of WECs and/or the Ocean Sentinel, including their anchors and mooring systems, create changes in benthic habitat or the distributions of benthic fishes and invertebrates; and 2) investigate whether bottom-mounted project structures are colonized by marine invertebrates and/or attract fishes.

The deployment at the NETS during the summer of 2013 was focused on the Ocean Sentinel and no WEC testing occurred. The Ocean Sentinel is a modified NOMAD buoy. The US Navy developed the NOMAD buoy in the late 1940s as an offshore autonomous meteorological platform, and the National Data Buoy Center (NDBC) has used NOMAD buoys since 1974 as meteorological and oceanographic data buoys. As there was no WEC deployed this summer and the NOMAD is a standard oceanographic buoy, NNMREC engaged in a slightly reduced set of environmental surveys compared to those that had been conducted in previous years. Pre-deployment sampling was conducted in June 2013 prior to deployment of the Ocean Sentinel, anchors and mooring systems. Surveys were again conducted during active deployment in August 2013 and after removal of the device in October 2013, but with the anchors still in place. The main objective of these measurements was to determine if sediment characteristics and/or fish

assemblages differed during the deployment of the device or after removal, as compared to previous observations.

Table 2: Summary of monitoring activities at the NETS in 2013.

Monitoring	Pre-installation	During Deployment	Post-installation
Sediment Grabs	June 20	August 19	October 24
Beam Trawls	April 25 June 28	August 23	October 30 December 11 [1]
Videography	-	Sepember 13	October 29
CTD Casts	April 25 June 20 & 28	August 19 & 23	October 24 & 30 December 11 [1]
Acoustic Surveys - Drifting Hydrophone	-	September 26	-
Acoustic Surveys - Landers	-	-	2-year deployment pending
Opportunistic Observations [2]	April 25 June 20 & 28 July 25, 26, 27, 28 & 29	August 14, 19 & 23 September 13 & 26 October 3	October 4, 10, 24, 29 & 30 December 11
Dedicated Bird & Marine Mammal Observations [3]	-	-	October 24 & 30

[1] December monitoring is not part of the standard monitoring at the NETS.

[2] Surface observations of marine mammals, sea turtles, seabirds, listed species, and/or derelict gear.

[3] These studies represented opportunities to collaborate with other researchers. They are not part of the standard monitoring at the NETS.

Methods

Water column sampling

At each station-visit vertical water-column profiles of conductivity, temperature, dissolved oxygen, pH, and depth were obtained with a Sea-Bird Electronics unit (CTD cast).

Sediment Grabs

Sediment for grain size analysis was collected from each of the 12 stations (Figure 1) in June, August, and October 2013. Grain sizes of the sediment were analyzed for samples from all visits using a Beckman Coulter Laser Diffraction Particle Size Analyzer (LD-PSA) to determine median grain size and percent silt/clay.

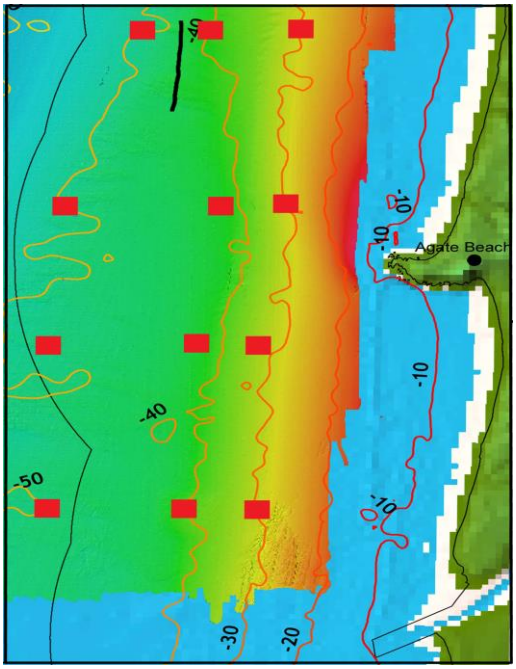

Figure 1: Twelve sampling stations off Newport, Oregon, near the Pacific Marine Energy Center's North Energy Test Site.

Trawling

For collection of epifaunal invertebrates and fishes, a beam trawl was used. The beam trawl is 2 meters wide by 70 centimeters high with a 3-millimeter mesh liner the entire length of the net and a tickler chain. Tows were conducted for 10 minutes, and a constant speed of ~1.5 knots was attempted. A meter wheel on the sled of the trawl provided actual measures of the distance the trawl was on the bottom. For the trawl surveys, nine stations were sampled in April, June, August, October, and December 2013 (December data are not reported here). Upon bringing the collection on board, fish and small epifaunal invertebrates were sorted into major groups and promptly euthanized and frozen. Larger invertebrates such as crabs and sea stars as well as elasmobranchs such as sharks and skates were identified, sexed if appropriate, measured, and released. Upon return to the laboratory, fish were identified to species and counted.

Videography

A video lander was used on September 13, 2013 (during active deployment of the Ocean Sentinel) and on October 29 (after removal of the Ocean Sentinel but, with the anchors still in place). In September, two drops were made at each of the three Ocean Sentinel anchors and two drops were made at each of three sandy reference stations to the north. In October, drops were made at the anchors, the sandy reference stations, and at three reference stations on the very small reef to the south. The lander was dropped off the stern of the *R/V Elakha* and allowed to remain on the bottom for 10 minutes. Upon return to the laboratory, the video was reviewed and all macrofauna were noted.

All monitoring activities and dates are provided in Table 2.

Results

Water Column Sampling

In June 2013 waters were significantly warmer than in June 2011 or 2012, and dissolved oxygen concentrations were higher in June 2013 than in 2010 and 2011. Temperature, salinity, and dissolved

oxygen values for August 2013 (during active deployment) did not differ significantly from values measured in August 2010 - 2012. October temperature and dissolved oxygen levels were similar to 2010 and 2012, with 2011 being warmer with higher oxygen concentrations than other sampled years.

Sediment Characteristics

The median grain size of the sampling stations over the course of the study ranged from 171 µm to 687 µm, with the 30-meter stations having significantly smaller median grain size than the 40- and 50-meter stations ($p < 0.001$). The average grain sizes at all depths were slightly smaller in 2013 than in previous years. However, this was true starting in June (prior to deployment of the Ocean Sentinel) and the differences were not statistically significant. No significant differences in median grain size were detected at the 12 established grab locations across all sampling months from June 2010 through October 2013 ($p = 0.6138$). While no significant differences were found over time, the most seasonal and inter-annual variability in median gran size is observed at the 50-meter stations. A similar pattern was found in the percent silt/clay in the sediment with significant differences among depths ($p = 0.0264$). From June 2010 to August 2013 there were no significant differences over time. However, in October of 2013 an unusually high proportion of silt was present in mid-core of the 50-meter sample off Beverly Beach, resulting in a significant effect of time ($p = 0.0145$). However, this high percentage of silt was not present in the surface layer of that sample. Because this difference was detected deeper than the Ocean Sentinel deployment depth, at a station 2 km north of the Ocean Sentinel location, and only at this station, this is likely not related to the Ocean Sentinel deployment but rather an extreme example of the greater variability historically seen at the 50-meter stations.

Trawling

Fish collections made in spring and summer 2013 were mostly unique from previous years. During our surveys at the test site warm water and high dissolved oxygen levels were present in June 2013, a combination typically not seen in summer in this region. Coast-wide, it was a year of extremely high rockfish recruitment, a phenomenon that was detected even in our sandy benthos trawls. Ten species (including three rockfish species) that had not previously been collected within the study area were collected. Eight of these “new” species were collected in April and/or June before the Ocean Sentinel was deployed. These additional species did not result in significantly higher H’ diversity, as the spring and summer catches were still overwhelmingly dominated by flatfish species, as in years past. Within 2013, June surveys had significantly more species ($S = 14.1$) than April ($S = 10.4$) and August ($S = 9.3$), which were all significantly higher than previous summers. October 2013 assemblages (post Ocean Sentinel retrieval, but with anchors in place) were similar to previous collections.

Cluster and multidimensional scaling analyses indicated that in terms of species composition and number, no significant differences in assemblages could be detected between the pre-deployment summer surveys (June) and the during-deployment summer surveys (August) as samples from these two collections clustered together.

Two notable differences were seen in the trawl-collected invertebrates. Samples contained the mysid species, *Neomysis rayii*, which had not been collected since June of 2010, the last time water temperatures were this warm in June. Samples also contained numerous crab ‘recruits’ (~1 cm carapace width). This recruitment event was also seen statewide, as reported by SCUBA divers and Remotely Operated Vehicle (ROV) surveys conducted by other researchers.

Videography

In the laboratory, each video taken from the lander in September and October 2013 was reviewed and all observed organisms noted. In September, orange sea pens were observed in the sand near the anchors and in the sandy reference locations; no motile invertebrates or fishes were observed. In

October, hermit crabs were observed on both the natural reef and around the Ocean Sentinel anchors. One spotted ratfish and five juvenile rockfish were observed at the natural reef, no fish were observed around the anchors, and two flatfish were observed in the sandy reference locations.

Conclusions

Key findings from the 2013 benthic species and habitat monitoring are:

- Temperature, salinity, and dissolved oxygen values for August 2013 (during active deployment of the Ocean Sentinel) did not differ significantly from values measured in August 2010 - 2012.
- No significant differences in median grain size were detected at the 12 established grab locations across all sampling months from June 2010 through October 2013.
- Sediment conditions at the 12 established sampling stations around the Ocean Sentinel deployment location during operations and after removal of the device did not vary from observations made in the same seasons in previous years. Since no changes to the sediment characteristics were observed, we hypothesize that the device installation, operations, and removal likely also did not affect the infaunal assemblages surrounding the site. Because of an increased shell hash surrounding the anchors observed in the 2012 ROV footage, we made sediment collections near the Ocean Sentinel anchors after removal of the buoy in late fall 2013. These samples have not yet been analyzed, but qualitative differences in sediment (increased shell hash) are seen. These very localized changes to the sediment may have potential effects on infauna, which we will investigate and report on in early 2014.
- Fish collections made in spring and summer 2013 were mostly unique from previous years. In our surveys warm water and high dissolved oxygen levels were present in June 2013, a combination typically not seen in summer in this region. Coast-wide, it was a year of extremely high rockfish recruitment, and we saw new rockfish in our collections. However, these additional species did not result in significantly higher H' diversity, as the spring and summer catches were still overwhelmingly dominated by flatfish species, as in years past. October 2013 assemblages (post Ocean Sentinel recovery, but with anchors in place) were similar to previous collections.
- Despite the increased number of species observed in the spring and summer in the vicinity of the test berth (related to ocean conditions), by October (after removal of the Ocean Sentinel) fish assemblages at the nine sampling stations were not different from those collected at these stations in previous years. Thus, we conclude the device installation, operations, and removal did not affect the fish assemblages in sedimentary habitats surrounding the site.

3.1.2 Considerations for Future Monitoring

As a lack of seasonal variability in sediment characteristics was again observed in 2013, future sampling for this community could be performed less frequently. However, because we did see a large recruitment of polychaete worms in 2012 (which had previously been recorded in 2000 and 2008 by the US Army Corps of Engineers) there apparently are inter-annual differences. Thus, we recommend both infaunal and sediment samplings occur at least in summer each year. If monitoring results or other new information indicate sampling in other seasons is warranted, sediment collections could occur in additional seasons. Sediment-only collection can be executed more quickly and under a wider range of conditions, and processing can be done within a week.

As further discussed in the 2013 Benthic Monitoring Report (Appendix A), NNMREC proposes the following considerations for future monitoring:

- *Because of the qualitative differences observed in the amount of shell hash surrounding the anchors, if effects on the very near-field are of interest, future sediment and infaunal samples should be attempted near deployed anchors (prioritizing safety of the approaching vessel and protection of deployed components).*

- *If/when ROV surveys are conducted for other purposes, NNMREC should use that opportunity to investigate fish attraction effects of different WEC devices and the Ocean Sentinel. If survey time allows, measured transects should be done near the devices to enable quantification of fishes associated with devices.*

3.1.3 Adaptive Mitigation Thresholds: 2013 Test

The 2013 AMP provides that if sediment sampling shows changes in sediment characteristics, or new information indicates a need, then NNMREC will sample infaunal organisms to look for changes in species densities and/or distributions. While no significant differences in median grain size were detected, qualitative differences in sediment (increased shell hash) were observed near the Ocean Sentinel anchors in late fall 2013. Once analysis of these samples is complete, the findings will be utilized to determine if infaunal organismal sampling is needed to evaluate potential changes to species densities and/or distributions. In accordance with the 2013 AMP, if benthic sampling results indicate changes in species densities and/or distributions attributable to the project, NNMREC, in coordination with NMFS and ODFW, will develop a response plan that outlines the appropriate mitigation action(s).

- *NNMREC recommends that adaptive mitigation thresholds and measures for benthic habitat be maintained for future tests, with consideration of potential modifications to monitoring discussed above.*

3.1.4 Adaptive Management Thresholds

The AMF provides that if monitoring shows substantial differences or significant trends in benthic habitat or associated ecological communities between the project-affected sites and reference sites, or at any one site over time, NNMREC will implement one or more actions (as specified in the AMF) to ensure project compliance with Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA) and other relevant federal and state statutes. There were no substantial differences or significant trends in benthic habitat or associated ecological communities between the project-affected sites and reference sites associated with the 2013 test; therefore, no adaptive management measures are being implemented at this time.

- *NNMREC recommends that adaptive management thresholds and measures for benthic habitat be maintained for future tests, with consideration of potential modifications to monitoring (as discussed above).*

3.1.5 Incidental Take Levels

The Biological Opinion (NMFS 2012) concludes that project features creating structure and hard surfaces in the water column and on the bottom from would alter existing benthic habitat. As described in the BiOp, habitat alteration is likely to cause ESA-listed adult and juvenile salmonids, adult eulachon and adult and sub-adult green sturgeon to avoid the area, resulting in the loss of foraging opportunities within the project site. The ITS states that best available indicator for the level of incidental take associated with changes to benthic habitat is changes in substrate grain size and distribution over a substantial portion of the test site. Specifically, NMFS defines the extent of take for benthic habitat modification by the change in substrate type (grain size and distribution) from baseline conditions (188

µm to 462 µm) to another state (e.g. from a fine grained to a coarse sand) over 50% of the test site. If this threshold is exceeded, then ESA Consultation would be reinitiated.

- *Survey data and analysis performed for the 2013 Ocean Sentinel test showed no substantial differences or significant trends in benthic habitat or associated ecological communities between the project-affected sites and reference sites. Changes in substrate type from baseline conditions were well below the 50% threshold.*

3.2 ACOUSTICS

NOTE: The following section is adapted from the *Underwater Acoustic Measurements Near the Ocean Sentinel at PMEC's North Energy Test Site (NETS) Facility* report prepared by Joseph H. Haxel of OSU's Cooperative Institute for Marine Resources Studies (October 26, 2013). The full report is available in Appendix B.

3.2.1 Monitoring Summary

Background

The objective of the 2013 acoustic monitoring was to further characterize acoustic conditions at the NETS and ensure that project devices do not emit acoustic signals above marine mammal harassment thresholds. The acoustic monitoring provides valuable information for comparisons of future WEC tests with ambient noise levels, validates the modified methods and test technology improvements, and establishes the acoustic profile of the Ocean Sentinel.

The initial 2013 monitoring plans aimed to provide information on changes in noise levels associated with Ocean Sentinel operations in a variety of environmental conditions. Specifically, the plans included:

- Implementing a free drifting acoustic recording package capable of collecting quality data and being deployed in a broad range of conditions for a rapid assessment of down range total sound level measurements following device installation.
- Deploying upgraded seafloor mounted hydrophones within the test site to provide continuous fixed range measurements of ambient acoustic levels. If multiple hydrophones were available, they would be deployed in array geometry to allow for localization of discrete signals to determine sound sources. The mounted hydrophones were to be deployed prior to the Ocean Sentinel installation and remain in place through the winter.

The necessary modifications and upgrades to the seafloor mounted instrumentation were delayed due to funding issues and no seafloor mounted acoustic instrumentation was deployed during the Ocean Sentinel testing in 2013. However, NNMREC Principal Investigators recently received funding from the US Department of Energy to move forward with this study.

This project will record underwater ambient noise levels at the NETS before, during, and after the installation and testing operations in May through October of 2014 and 2015.

As part of this study, an array of seafloor mounted hydrophones, recording at 50% duty cycle and a sample rate of 32 kHz with a 13 kHz low frequency cut-off, will be maintained for the duration of the project at the test site. The geometry of the array and precision timing of the hydrophone instrumentation will provide capabilities for localization of noise radiated around the testing area to aid in distinguishing sounds generated by the WEC verses other sources of sound (e.g. mooring hardware). Fixed time series recordings will provide a characterization of the noise generated during the construction and testing operations of the WEC device through a variety of environmental conditions at

fixed distances from the receivers. Changes in ambient noise levels associated with WEC project activities will be evaluated in the context of baseline measurements recorded before and after the device deployments.

Methods

In 2013, passive acoustic recordings were made with a newly developed autonomous drifting underwater hydrophone (ADUH) buoy system near the Ocean Sentinel at the NETS. The deployment of the Ocean Sentinel and associated equipment, in the absence of an operational WEC, provided an opportunity to measure effects on ambient noise levels primarily from sound generated by the motion of mooring hardware (chains, etc.) within the testing site.

Acoustic measurement operations were conducted on site from 12:55 to 13:55 PDT on September 26, 2013. Results reported here represent an acoustic "snapshot" measurement in the vicinity of the Ocean Sentinel limited to the environmental conditions at the time. Environmental conditions experienced during this acoustic recording operation were more energetic than previous recording missions providing a good test of the newly developed acoustic drifter system.

Acoustic measurements were made using the *Gracie Lynn*, Oregon Coast Aquarium's 24 foot fiberglass hulled vessel with the ADUH buoy system deployed and retrieved in a series of two free floating drifts near and down-current of the Ocean Sentinel and marker buoys. The *Gracie Lynn*'s engines and electronics were powered down during the free drifting mode in order to reduce further noise contamination. While the AMF and AMP require acoustic measurements to be taken at 100 meters from the project structure, the environmental conditions at the time meant that this was not possible. Each of two drifts with the acoustic buoy package was started *as near as safely possible* to the Ocean Sentinel, drifting in the dominant current direction northward for 20 minutes and ranging from 138 - 800 meters of the Ocean Sentinel hull. The average drift speed of the ADUH was 0.6 m/s during each drift.

Results

Drift 1 shows a decreasing trend in sound pressure levels with distance from the Ocean Sentinel and the NETS, suggesting ambient levels may be influenced at these ranges by mooring hardware or other site related sound sources. However, a closer look at the spectral levels from Drift 1 shows the majority of the energy decrease occurs in frequencies below f < 500 Hz, not associated with the higher frequency signals attributed to hardware generated noise. Mooring chain noise recorded during both drifts has a distinctive spectral signature with five energy peaks focused at 4.6 - 5.0 kHz, 5.2 - 5.5 kHz, 9.0 - 9.4 kHz, 10.0 - 10.6 kHz, and 12.1 - 13.0 kHz. Time-averaged spectral plots comparing the average energy at each frequency during the drifts show the persistent frequency structure of the observed mooring hardware generated sounds.

Recordings from Drift 2 are contaminated by noise from an approaching vessel (~2 - 3 km range), with spectral levels showing a strong increase in received energy below f < 4 kHz attributed to noise emissions from the approaching ship. SPL_{rms} estimates from Drift 2 are on average ~10 dB higher than the Drift 1 recordings and reveal an increasing trend with distance from the Ocean Sentinel/NETS area suggesting noise generated by nearby vessel traffic is the dominant sound source within the recorded frequency range. Despite the contribution from noise radiated by nearby vessel traffic, SPL_{rms} levels integrated across the 60 Hz - 13 kHz frequency range recorded at a range of distances from the Ocean Sentinel/NETS were below NMFS threshold criteria for marine mammal harassment (120 dB) throughout the recording period.

Summary

Underwater sound pressure levels (SPLs) were recorded around the Ocean Sentinel and NETS facility from a range of distances (138 - 800 meters) using a newly developed free drifting hydrophone buoy system on September 26, 2013. Received energy levels indicate ambient noise levels are strongly influenced by acoustic emissions from nearby vessel traffic in the area. The spectral signature of sounds generated by the motion of mooring hardware (chain noise) associated with the NETS facility was detected and identified as a set of 5 localized spectral peaks (4.6 - 5.0 kHz, 5.2 - 5.5 kHz, 9.0 - 9.4 kHz, 10.0 - 10.6 kHz, and 12.1 – 13.0 kHz) observed at a range of distances. Despite the contribution of these sound sources to ambient levels, SPL_{rms} integrated across the 60 Hz - 13 kHz frequency range remained below NMFS threshold criteria (120 dB) throughout the recording period. Additionally, results show a vast improvement in data quality provided by the new drifting hydrophone approach versus previous tethered recordings.

Reporting

The Adaptive Management Framework specifies that "initial" acoustic monitoring results will be provided to NMFS within seven days of completion of the survey. However, it was felt that "real time" monitoring was less critical in 2013 as no WEC was to be tested and acoustic recordings from the Ocean Sentinel/WET-NZ deployed in 2012 were well below levels known to impact marine mammals and listed species. Therefore, after discussions with NMFS and ODFW, it was agreed that "initial" acoustic test results would be made available to NMFS and ODFW within 14 days of testing, as described in the 2013 Adaptive Mitigation Plan.

The acoustic surveys were conducted on September 26, 2013. Data analysis was initiated but the federal government shutdown (October 1 to 16) meant that NNMREC Principal Investigators could not access the National Oceanic and Atmospheric Administration (NOAA) Laboratory in Newport, OR and so were unable to analyze the acoustic data during that time. NNMREC informed NMFS and ODFW of the potential delay on October 6. Once the shutdown ended, data analysis resumed and the *Underwater Acoustic Measurements near the Ocean Sentinel at PMEC's North Energy Test Site (NETS) Facility* report was provided to both NMFS and ODFW on October 28.

3.2.2 Considerations for Future Monitoring

The newly developed autonomous drifting underwater hydrophone was successfully tested in 2013 and will continue to be used during future testing at the NETS.

Although seafloor mounted hydrophones were not deployed in 2013, funding from the means that an array could be deployed in the near future and be utilized at the NETS during the 2014 and 2015 test periods. The localization capabilities from a seafloor mounted hydrophone array will improve our understanding of soniferous device and mooring components and their contribution to ambient sound levels, as well as provide the capacity to record during varying sea states. In particular, NNMREC proposes the following considerations for future acoustics monitoring:

- *Continue to implement a 2nd generation, free drifting acoustic recording package capable of collecting quality data in a range of environmental conditions to provide for rapid assessment of down range total sound level measurements of both project devices and ambient noise.*
- *Deploy the seafloor-mounted hydrophone landers at the project site prior to, during, and after installation and operation of test devices. This will allow for characterization of the noise field across seasons and when the device is operating in a variety of sea states. It also will capture installation noise.*

3.2.3 Adaptive Mitigation Thresholds: 2013 Test

The 2013 AMP provides that if monitoring indicates that sound pressure levels attributable to the Ocean Sentinel device at a distance of 100 meters are above Level A injury threshold criteria (either continuous or impulse of 180dB RMS for cetaceans and 190dB RMS for pinnipeds) or Level B harassment threshold criteria (120dB RMS continuous and 160dB RMS impulse), NNMREC personnel would develop and implement a response plan that outlines the appropriate mitigation action within 14 days of acquiring monitoring results. Monitoring indicated SPLs below the Adaptive Mitigation Thresholds and, therefore, no mitigating actions were required.

- *Due to safety issues, NNMREC recommends that the adaptive mitigation thresholds and measures for acoustics be modified for future tests to provide for SPL measurements to be taken at a minimum distance of 100 - 150 meters.*

In accordance with the Biological Opinion (NMFS 2012), acoustic data should be provided within 7 days of recordings to limit the potential for take associated with sound. NNMREC recognizes that this provision will remain in place for WEC tests unless: 1) it is possible to document that harm and harassment levels are not exceeded across a broad range of sea states; or 2) NNMREC obtains an Incidental Harassment Authorization or Letter of Authorization for take associated with acoustic outputs from the project.

3.2.4 Adaptive Management Thresholds

The AMF provides that if acoustic monitoring indicates that sound pressure levels attributable to the Ocean Sentinel or a WEC device are above Level A injury threshold criteria (either continuous or impulse of 180dB RMS for cetaceans and 190dB RMS for pinnipeds) or Level B harassment threshold criteria (120dB RMS continuous and 160dB RMS impulse) at a distance of 100 meters, NNMREC would implement one or more of the actions specified in the AMF. Monitoring indicated SPLs below the thresholds provided in the AMF and, therefore, no mitigating actions were required.

- *NNMREC recommends that the adaptive management thresholds and measures for acoustics be modified to allow SPL measurements to be taken at a minimum distance of 100 - 150 meters.*

3.2.5 Incidental Take Levels

As noted in the ITS, the best available indicator for the extent of incidental take associated with sound pressure is the decibel measurements from WEC devices deployed in the test site. NMFS used conservative exposure thresholds of sound pressure levels from impulse sounds that have been shown to cause behavioral disturbance in marine fishes: 183 dB (SEL) re 1 µPa for fishes weighing up to 2 g; 187 dB (SEL) re 1 µPa for fishes weighing over 2 g; and peak sound level of 206 dB (Peak) re 1 µPa.

- *Acoustic monitoring data and analysis performed for the 2013 test show that SPLs did not exceed exposure thresholds provided in the ITS.*

3.3 ELECTROMAGNETIC FIELDS

3.3.1 Monitoring Summary

No WEC tests were planned at the NETS in 2013. The AMC discussed this and approved the suspension of EMF monitoring during 2013.

A 2nd generation EMF monitoring system is currently being tested and optimized for future use in WEC testing.

For more information on the EMF studies conducted at NETS during 2012, please see the 2012 Annual Report available at nnmrec.oregonstate.edu/reports.

3.3.2 Considerations for Future Monitoring

Although no EMF studies were conducted in 2013, NNMREC recommends that the Considerations for Future Monitoring included in the 2012 Annual Report be maintained.

3.3.3 Adaptive Mitigation Thresholds: 2013 Test

As no WEC tests occurred during 2013, the AMC agreed that no EMF monitoring need occur during that year and therefore the thresholds were not evaluated.

3.3.4 Adaptive Management Thresholds

As approved by the AMC, no EMF monitoring was undertaken during 2013 and therefore the thresholds were not evaluated.

3.3.5 Incidental Take Levels

As noted in the ITS, the best available indicator for the extent of incidental take associated with EMF is measurements of EMF more than 500 meters from a WEC device deployed in the test site. The exposure threshold for EMF beyond a 500 meters radius that is attributable to the project components is the level that has been documented to have an adverse impact on marine life.

3.4 Marine Mammals and Entangled or Injured Species

3.4.1 Monitoring Summary

Prior to the 2013 test, NNMREC coordinated with NMFS, USFWS and ODFW to modify the standard form that is used to record and report opportunistic observations of marine species made from the water surface. The updated form is provided in Appendix C. The form was modified in the following ways:

- In addition to marine mammals, sea turtles and derelict gear, 2013 opportunistic observation reporting was expanded to include seabirds and other listed species (not just marine mammals). When possible, reports were to include the full species name, or photographs or video to assist with species identification.
- The observation report form was modified to include the number of individuals observed, their behavior, their proximity to project structures, and local weather conditions when species of interest were observed.

The frequency for opportunistic visual observations of marine mammals and entangled or injured species from the water surface remained the same as in 2012 - they were conducted during **ALL visits** to the NETS. In addition, NNMREC added a provision for a *minimum* frequency of monthly visual observations from the water surface during active deployment.

As part of monitoring and operations, the NETS was visited on 20 separate days between April 25 and December 11, 2013 (Table 3). The Ocean Sentinel was deployed at the NETS between July 29 and October 4. During this active deployment period, the site was visited six times for operational or monitoring purposes. While the Ocean Sentinel was deployed, the average period between visits was 10 days and the maximum was 20 days. Opportunistic observations made during each site visit are summarized in the table below.

No marine mammals, sea turtles or listed species were observed in proximity to or in the NETS during any of the 20 site visits. There were no dead, injured, entangled, or impinged marine mammals or sea turtles observed in the project area before, during or after active deployment. In addition, there were no observations of pinnipeds hauled out on project structures.

Opportunistic observations of seabirds were found to problematic for a number of reasons:

- Birds in the area often flew away when they detected approaching vessels, making observations and identification difficult;
- Bird species identification, especially at distance, requires ornithological skills that most people on board did not have; and
- When on site, NNMREC personnel and crew were focused on their operational or monitoring tasks, limiting the time available to be on the lookout for passing birds.

Table 3: Opportunistic observations made during site visits to the NETS in 2013.

Date	Activity	Deployment Status
April 25	Monitoring	Pre-deployment
June 20	Monitoring	Pre-deployment
June 28	Monitoring	Pre-deployment
July 25	Operations	Pre-deployment
July 26	Operations	Pre-deployment
July 27	Operations	Pre-deployment
July 28	Operations	Pre-deployment
July 29	**Operations**	**Ocean Sentinel Deployed**
August 14	Operations	Active Deployment
August 19	Monitoring	Active Deployment
August 23	Monitoring	Active Deployment
September 13	Monitoring	Active Deployment
September 26	Monitoring & Operations	Active Deployment
October 3	Operations	Active Deployment
October 4	**Operations**	**Ocean Sentinel Retrieved**
October 10	Operations	Post-deployment
October 24	Monitoring	Post-deployment
October 29	Monitoring	Post-deployment
October 30	Monitoring	Post-deployment
December 11	Monitoring	Post-deployment

3.4.2 Considerations for Future Monitoring

Based on the 2013 monitoring, NNMREC suggests that:

- *The current method for opportunistic observations of seabirds is not viable and is unlikely to produce useful scientific data. Having trained ornithologists on board for every site visit would be both unrealistic and cost prohibitive. NNMREC should work with Committee members to*

determine if opportunistic seabird monitoring is warranted and, if so, whether a more practical methodology can be developed.

- *The other opportunistic monitoring implemented for the 2013 testing season appear to be practical.*
- *NNMREC and the Committee should define the spatial extent of opportunistic observations of species of interest.*
- *In 2013, there were no sightings of marine mammals or other species of interest in or around the NETS during site visits, and only two passing seals were observed in 2012. Therefore, NNMREC recommends that opportunistic observation forms only be completed when there are observations to report. In all other instances, NNMREC personnel should simply report, either verbally or via email, that observations were made but no marine mammals or other species of interest were spotted.*

3.4.3 Adaptive Mitigation Thresholds: 2013 Test

The AMP for the 2013 test provides that if marine mammals or sea turtles are observed entangled, injured or impinged at the project structure, NNMREC would immediately follow the Reporting Protocol for Injured or Stranded Marine Mammals (listed in the AMP), give NMFS and ODFW all available information on the incident, and contact NMFS and ODFW as soon as practical within 24 hours to consult with them regarding modifying the project and/or monitoring plans. The AMP also provides that if pinnipeds are identified on one or more of the project structures, NNMREC would implement the NMFS haulout protocols (listed in the AMP) and notify NMFS and ODFW within two weeks of the haul-out incident. No entangled, injured or impinged marine mammals, sea turtles or other species were observed on project structures or within the project site and no pinnipeds were observed on any project structures.

- *NNMREC recommends that the adaptive mitigation thresholds and measures for pinniped haulout and entangled or injured species be maintained for future tests, with consideration of potential monitoring modifications discussed above.*

3.4.4 Adaptive Management Thresholds

The AMF provides that if Annual Reports indicate observations of pinnipeds hauled out on the Ocean Sentinel or other project structures, NNMREC will implement one or more actions (as described in the AMF) to ensure project compliance with the ESA, MMPA and other relevant federal and state statutes. There were no dead, injured, entangled, or impinged marine mammals or sea turtles observed in the project area. In addition, there were no observations of pinnipeds hauled out on the project structures.

- *NNMREC recommends that adaptive management thresholds and measures for pinniped haulout and entangled or injured species be maintained.*

3.4.5 Incidental Take Levels

NMFS has not provided an incidental take exemption for marine mammals because incidental take of marine mammals has not been authorized under section 101(a)(5) of the Marine Mammal Protection Act. Following issuance of such regulations or authorizations, NMFS may amend the ITS for this project to include an incidental take exemption for marine mammals, as appropriate.

3.5 DERELICT GEAR

3.5.1 Monitoring Summary

The frequency for opportunistic visual observations of derelict gear **from the water surface** was the same as the observations of marine mammals and entangled or injured species – i.e. during **ALL visits** to the NETS and at least monthly during active deployment (Table 3).

As no derelict gear was detected within the NETS during the 2012 test season and only the Ocean Sentinel was deployed in 2013, the frequency for **underwater** visual observations was adjusted for this season. Specifically, NNMREC performed underwater visual monitoring in conjunction with the video lander recordings taken as part of benthic monitoring. As described in the 2013 AMP, one video lander survey was conducted during active deployment.

The Ocean Sentinel was deployed at the NETS between July 29 and October 4. During this deployment period, the site was visited six times for operational or monitoring purposes. The average period between visits was 10 days and the maximum was 20 days.

Results of the opportunistic visual observations showed no derelict gear on project structures or within the project site. No fishing or other gear appeared to be entangled in the anchor chains or cables. Further, no derelict gear was observed or detected during the visual analysis conducted as part of the benthic habitat monitoring.

Unlike in 2012, not all the project structures were removed from the NETS at the end of the active deployment period the 2013 - as previously discussed, the three Ocean Sentinel anchors and associated anchor buoys are to remain in the NETS over the winter. This means that these structures will likely be deployed during the northbound Phase B gray whale migration (from April – June 15). Therefore, and as provided for in the AMF, NNMREC will perform visual observations from the water surface at least bi-weekly if project structures remain deployed during this period.

If any derelict gear had been discovered, NNMREC would have applied the procedures described in the 2013 AMP and documented the incident on the standard observations form (see Appendix C).

3.5.2 Considerations for Future Monitoring

NNMREC has and will continue to consult with NMFS and ODFW (through their participation in the Adaptive Management Committee) to ensure the efficacy of the derelict gear monitoring and response methods for the duration of project activities. In addition, NNMREC – through Oregon Sea Grant – has and will continue to participate in Fishermen Involved in Natural Energy (FINE) meetings and engage directly with members of the fishing community.

- *Based on results of and experience gained in 2012 and 2013, NNMREC recommends that derelict gear monitoring methods and frequencies for future WEC tests be specified on a case-by-case basis to account for the particular anchor and mooring system design, as well as the timing and duration of the deployment.*

3.5.3 Adaptive Mitigation Thresholds: 2013 Test

For the 2013 test, NNMREC performed underwater visual monitoring while the Ocean Sentinel was deployed (September 13) and after it had been retrieved (October 29). As noted previously, no derelict gear was detected on project structures or within the project site; as such, none of the adaptive mitigation thresholds were met and no measures were taken.

- *NNMREC recommends that the derelict gear adaptive mitigation thresholds and measures for future tests be specified on a case-by-case basis to account for the particular monitoring methods and frequencies and attributes of each test.*

3.5.4 Adaptive Management Thresholds

No derelict or entangled gear has been detected on project structures or within the project site, so none of the thresholds have been met; as such, no adaptive management measures have been implemented.

- *Based on results of and experienced gained in the 2012 and 2013 Ocean Sentinel deployments, NNMREC proposes to continue to adhere to the modified provisions of the General Procedures for Derelict Gear that were adopted in 2013:*
    - ***Detection**: NNMREC will make visual observations from the water surface during all visits to the project site to identify any derelict gear, and at least monthly during active deployment. In addition, NNMREC will perform underwater visual monitoring of the project anchors and mooring systems at least once every three months during active deployment.*
    - ***Notification**: If derelict gear is detected within the project site, NNMREC will contact NMFS, USFWS and ODFW within 48 hours of detection (unless marine mammals, sea turtles or listed species are observed entangled/injured, in which case the Reporting Protocol for Injured or Stranded Marine Mammals would be followed).*

4 FUTURE TEST PLANS

Currently, test plans for the 2014 season remain unclear. NNMREC continues to seek WEC developers to utilize the NETS during the summer of 2014. A number of companies have expressed an interest in testing innovative mooring technology at NETS and, perhaps, utilizing the Ocean Sentinel as a "surrogate" WEC. However, funding for these potential activities remains unclear and no permits have been applied for.

In the event that no other testing is scheduled in 2014, NNMREC may once again conduct research focused on the Ocean Sentinel.

NNMREC will continue to update the Adaptive Management Committee as plans develop.

5 OVERALL CONCLUSIONS AND RECOMMENDATIONS

Despite the fact that no WEC was tested at the NETS during 2013, NNMREC feels that this was a successful year. The deployment of the Ocean Sentinel allowed for the operational procedures to be further refined, and an additional year of benthic and acoustic data were gathered. No thresholds were triggered and there were no incidences of species or derelict gear entanglement.

5.1 Adaptive Mitigation Thresholds

Monitoring results were reviewed by NNMREC in real-time, whenever possible, to determine if thresholds were being exceeded. The results showed that AMP thresholds were not exceeded, so no mitigation action decisions were required during the 2013 test. NNMREC recommends that the adaptive mitigation thresholds and measures for future tests consider the potential modifications discussed in Section 3 of this report.

5.2 ADAPTIVE MANAGEMENT THRESHOLDS

The thresholds and measures provided in the AMF are designed to consider single- and multi-year data from the test center. NNMREC has just completed its second year of testing at the North Energy Test Site and, as in 2012, none of the adaptive management thresholds were triggered during the 2013 test period; accordingly, no adaptive management measures were implemented. NNMREC proposes to coordinate with the Committee to collectively review and consider any changes to the AMF.

5.3 ANNUAL REPORT AND REVIEW PROCESS

NNMREC proposes that the Committee collectively review and modify the timeframes and components of the Annual Report and Review Process. In particular, NNMREC recommends that Section 2 of the AMF be revised to clarify the components and timing of the annual review process. Critically, NNMREC feels that the initial timeline of deliverables developed for the AMF is proving to be unworkable. Data collection, analysis and reporting, especially for benthic sampling, can be time consuming. In both 2012 and 2013, NNMREC had to request extensions on the deadlines. Post-deployment benthic sampling necessarily happens in late October/early November after removal of the device(s). Thus, it is not feasible to have all collected benthic species identified and enumerated, data analyzed and written up to be included in the Annual Report within a month.

This collective review of the reporting and review process could be performed at the next Annual Meeting (in early 2014); regardless, any modifications to the Annual Report and Review Process should be made prior to the next WEC test.

As the final 2012 Annual Report was not completed until after the Annual Meeting was convened in January 2013, a few recommendations have yet to be discussed with the Committee. A key recommendation from both 2012 and 2013 is that:

- ***NNMREC proposes that the Committee collectively review and modify the timeframes and components of the Annual Report & Review Process.*** *In particular, NNMREC recommends that Section 2 of the Adaptive Management Framework be revised to clarify the components and timing of the annual review process. This collective review should be performed at the next Adaptive Management Committee Annual Meeting (planned for early 2014).*

Annual Report and Committee Review Process

A series of timelines were initially developed to ensure that information from past tests could be used to inform any permitting, adaptive management or other review processes for future year tests. However, the time required to complete all the environmental monitoring, analyze the data and report on findings has meant that extensions have had to be requested in 2012 and 2013. Based on our experiences over the last two seasons of testing, NNMREC feel that the Committee should review these timelines and new, more realistic timelines should be established. The current timelines for reporting and review are:

1. No later than December 1 of each year, the Annual Operations and Monitoring Report will be provided to the Committee for all tests conducted in the previous 12 months. The Annual Report will include a compilation of monitoring conducted (including a summary of the purpose for monitoring, the methods used, and monitoring results) and mitigation actions taken. In addition, plans for future tests will be summarized.

   NOTE: For 2013, this deadline has been extended to December 31, 2013.

2. No later than January 31 of each year, NNMREC will convene and facilitate an annual meeting of the Committee. The Committee will evaluate the information relative to the adaptive management thresholds and mitigation actions discussed in the sections that follow.

   NOTE: For 2013, this deadline has been extended to February 28, 2014.

   The Committee will also evaluate technical issues and data interpretation associated with the monitoring, as appropriate. Such evaluation will include the sufficiency and adequacy of the information provided by the monitoring, consideration of monitoring results, as well as possible adjustments to subsequent monitoring methods and frequencies. Key functions of the Committee are to:

   a) Review the results of studies and monitoring conducted during the previous testing period;
   b) Use study and monitoring results, as well as other sources of relevant information, if applicable, to determine whether a change to project monitoring (e.g. study design, methods, or duration) is warranted or if existing monitoring approaches continue to be appropriate;
   c) Review available information about wave energy devices proposed for testing in the following test season;
   d) Evaluate any changes in plans made by NNMREC in response to the studies and/or monitoring, or upcoming devices; and
   e) In the event effects are identified that require modification to project operations or monitoring, provide NNMREC with recommended measures to avoid, minimize, or mitigate the effects, which may include ceasing testing and/or removal of project structures.

Committee Recommendations

The Annual Report is used by the Committee to inform discussions and make recommendations to NNMREC for the monitoring, operations, and Adaptive Mitigation Plans associated with the NETS. These recommendations are due by February 28.

NOTE: For 2013, this deadline has been extended to March 31, 2014.

Upon conclusion of the Committee's review, NNMREC, in consultation with NMFS, USFWS and ODFW, considers the Committee's recommendations and determines the appropriate approach to the monitoring, operations, and adaptive management/mitigation thresholds to ensure the project's compliance with the Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA) and other relevant federal and state statutes. NNMREC, in consultation with NMFS, USFWS and ODFW, also considers the Committee's recommendations in determining whether any additional mitigation measures are needed. These determinations are incorporated into the next Adaptive Mitigation Plan. These determinations are due by March 31.

NOTE: For 2013, this deadline has been extended to April 30, 2014.

6 APPENDIX A: BENTHIC REPORT

Benthic Conditions and Organisms at PMEC's North Energy Test Site (NETS):

2013 Activities with Reference to Previous Years

A report for the

Northwest National Marine Renewable Energy Center (NNMREC)

Oregon State University

Provided by

Sarah K. Henkel

Hatfield Marine Science Center

Oregon State University

December 27, 2013

BACKGROUND

In summer 2013 the Northwest National Marine Renewable Energy Center (NNMREC) at Oregon State University (OSU) deployed only the wave energy analysis buoy (the Ocean Sentinel, a modified NOMAD buoy) at the North Energy Test site. The US Navy developed the NOMAD buoy in the late 1940s as an offshore autonomous meteorological platform, and the National Data Buoy Center (NDBC) has used NOMAD buoys since 1974 as meteorological and oceanographic data buoys. The NOMAD design also has been adapted for use by Environment Canada, and it was the basis for a boat-shaped buoy developed in Japan (Timpe & Van de Voorde 1995). Because there was no energy-generating WEC deployed this summer and the NOMAD is a standard oceanographic buoy, we engaged in a slightly reduced set of environmental surveys than conducted in previous years. Pre-deployment sampling was conducted in June 2013 prior to deployment of the Ocean Sentinel, anchors and mooring systems. Surveys were again conducted during the active deployment in August 2013 and after removal of the device in October 2013 but with the anchors still in place. The main objective of these measurements was to determine if sediment characteristics and/or fish assemblages differed during the deployment of the device or after removal, as compared to previous observations. This report details observations from 2013 and compares patterns and metrics to 2010 - 2012 findings.

METHODS

Survey types and dates are provided in Table A1.

Table A1: 2013 benthic monitoring surveys.

Monitoring	Pre-deployment	During Deployment	Post-deployment
Sediment Grabs	June 20	August 19	October 24
Beam Trawls	April 25 June 28	August 23	October 30 December 11
Videography	-	September 13	October 29
CTD Casts	April 25 June 20 & 28	August 19 & 23	October 24 & 30 December 11

Water column sampling

At each station-visit vertical water-column profiles of conductivity, temperature, dissolved oxygen, pH, and depth were obtained with a Sea-Bird Electronics unit (CTD cast).

Sediment Grabs

Sediment for grain size analysis was collected from each of the 12 stations in June, August, and October 2013. Grain sizes of the sediment were analyzed for samples from all visits using a Beckman Coulter Laser Diffraction Particle Size Analyzer (LD-PSA) to determine median grain size and percent silt/clay.

Trawling

For collection of epifaunal invertebrates and fishes, a beam trawl was used. The beam trawl is 2 meters (m) wide by 70 centimeters (cm) high with a 3-millimeter (mm) mesh liner the entire length of the net and a tickler chain (Figure A1). Tows were conducted for 10 minutes, and a constant speed of ~1.5 knots

was attempted. A meter wheel on the sled of the trawl provided actual measures of the distance the trawl was on the bottom. For the trawl surveys, nine stations were sampled in April, June, August, October, and December 2013 (December data not reported here). Upon bringing the collection on board, fish and small epifaunal invertebrates were sorted into major groups and promptly euthanized and frozen. Larger invertebrates such as crabs and sea stars as well as elasmobranchs such as sharks and skates were identified, sexed if appropriate, measured, and released. Upon return to the laboratory, fish were identified to species and counted.

Figure A1: Beam trawl used for capturing juvenile groundfish and epibenthic invertebrates.

Videography

The video lander (Figure A2) was used on September 13, 2013 (during deployment) and on October 29, 2013 (after removal of the Ocean Sentinel but with the anchors still in place). In September, two drops were made at each of the three Ocean Sentinel anchors and two drops were made at each of three sandy reference stations to the north. In October, drops were made at the anchors, the sandy reference stations, and at three reference stations on the very small reef to the south. The lander was dropped off the stern and allowed to remain on the bottom for ten minutes. Upon return to the laboratory, the video was reviewed and all macrofauna were noted.

Data Analysis

Two-way ANOVAs were used to investigate differences in individual physical characteristics (water and sediment) across depth at the site and over time (from June 2010 to October 2013). Tukey's HSD *post hoc* tests were used to identify specific differences over time, particularly before, during, and after the Ocean Sentinel deployment in 2013.

For fish species assemblage analyses, Shannon–Weaver diversity (H') and species richness (S) were calculated for each sample. Indices were compared using two-way ANOVAs with the factors depth and month (from June 2010 to October 2013). Tukey's HSD *post hoc* tests were used to identify specific differences over time, particularly before, during, and after the 2013 deployment. Fish data were square root transformed for multivariate analyses. Cluster analysis was conducted on the transformed density datasets for each 'assemblage' in order to produce groups of similar stations based on the species abundances. The SIMPROF routine was run in Primer 6 (Clarke 1993). This routine conducts a series of

permutation tests to determine if clusters in the dendrogram have statistically significant structure. Samples within a cluster that cannot be significantly differentiated are considered to be a genuine group. Multidimensional Scaling (MDS) was used to analyze the transformed density data to examine species composition and proportions across stations. Data were analyzed using the MDS function in Primer 6 (Clarke 1993). Fish data are displayed in MDS plots such that samples that form a genuine cluster, as determined using the SIMPROF routine, have the same symbol on the plot.

Figure A2: Video lander ready to be dropped near the Ocean Sentinel anchor.

RESULTS

Water Column Sampling

In June 2013 waters were significantly warmer than June 2011 or 2012 (Figure A3), and dissolved oxygen concentrations were higher in June 2013 than in 2010 and 2011 (Figure A4). **Temperature, salinity, and dissolved oxygen values for August 2013 (during operation) did not differ significantly from values measured in August 2010 - 2012.** October temperature and dissolved oxygen levels were similar to 2010 and 2012, with 2011 being warmer with higher oxygen concentrations than other sampled years.

Sediment Characteristics

The median grain size of the sampling stations over the course of the study ranged from 171 µm to 687 µm, with 30-meter stations having significantly smaller median grain size than 40- and 50-meter stations ($p < 0.001$). The average grain sizes at all depths were slightly smaller in 2013 than in previous years. However, this was true starting in June (prior to deployment of the Ocean Sentinel) and the differences were not statistically significant. **No significant differences in median grain size were detected at the 12 established grab locations across all sampling months from June 2010 through October 2013 ($p = 0.6138$)**. While no significant differences were found over time, the most seasonal and inter-annual variability in median gran size is observed at the 50-meter stations (Figure A5; black line), which are outside the Ocean Sentinel device deployment depth. A similar pattern was found in the percent silt/clay in the sediment with significant differences among depths ($p = 0.0264$). From June 2010 to August 2013 there were no significant differences over time. However, in October of 2013 an unusually high proportion of silt was present in mid-core of the 50-meter sample off Beverly Beach, resulting in a significant effect of time ($p = 0.0145$). However, no unusual amount of silt was in the top-layer of

sediment from the same sample. Because this difference was detected deeper than the Ocean Sentinel deployment depth, at a station 2 km north of the Ocean Sentinel location, and only at this station, this is likely not related to the Ocean Sentinel deployment but rather an extreme example of the greater variability historically seen at the 50-meter stations.

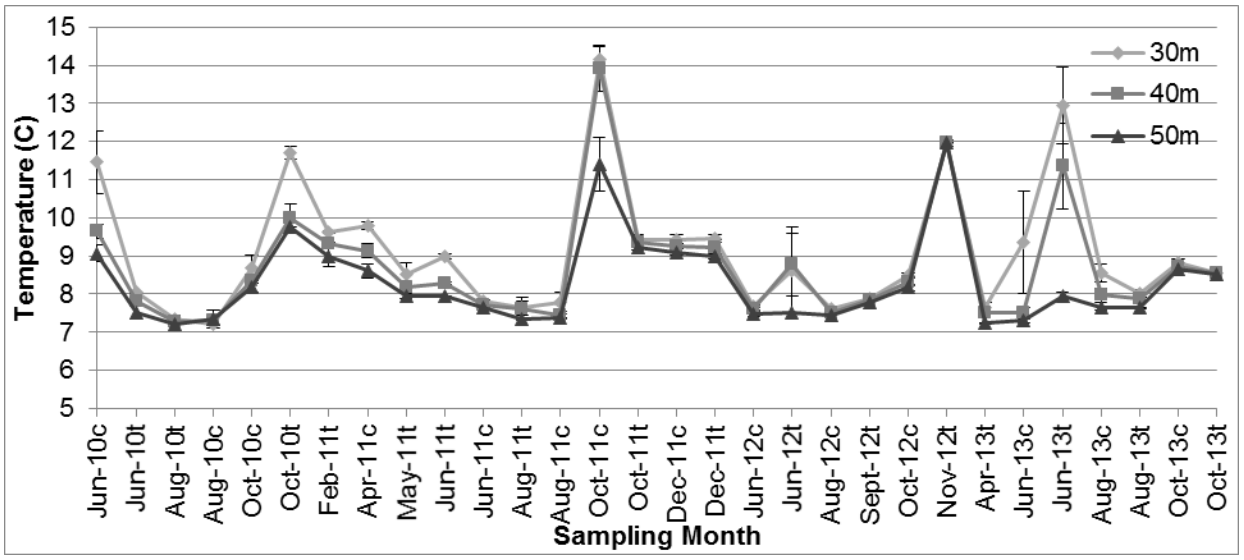

Figure A3: Temperature measured at the bottom of the CTD cast to approximate conditions at the seabed. X-axis labels are month-year of sampling followed by 'c' or 't' to indicate samples taken while coring or trawling. Values are means with standard deviations for the 3 trawls or 4 – 8 cores taken at each depth on each visit.

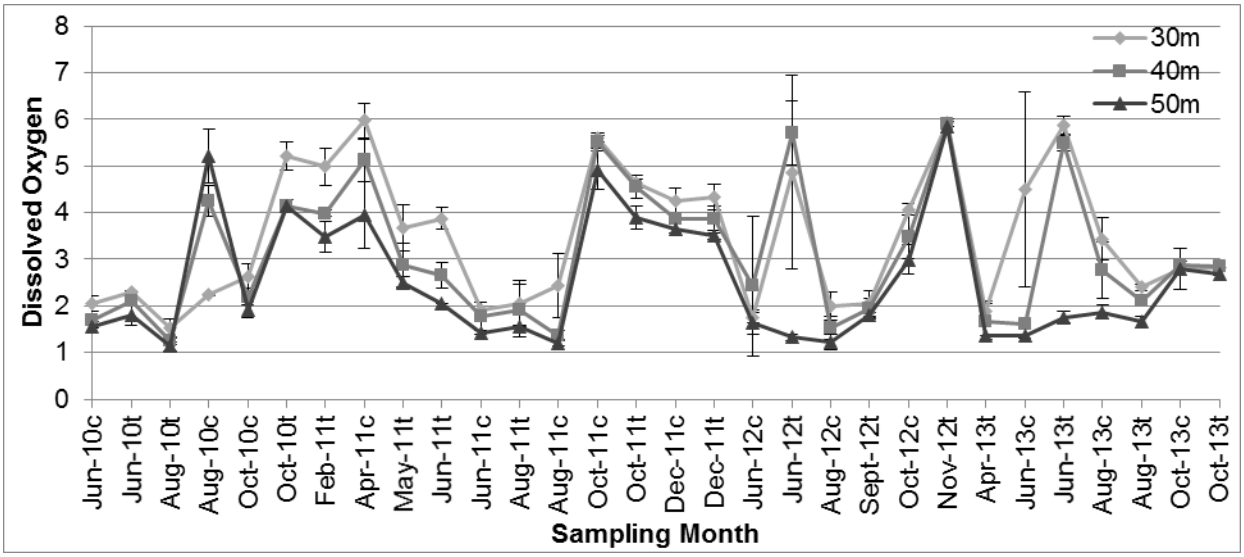

Figure A4: Dissolved oxygen measured at the bottom of the CTD cast to approximate conditions at the seabed. X-axis labels are month-year of sampling followed by 'c' or 't' to indicate samples taken while coring or trawling. Values are means with standard deviations for the 3 trawls or 4 – 8 cores taken at each depth on each visit.

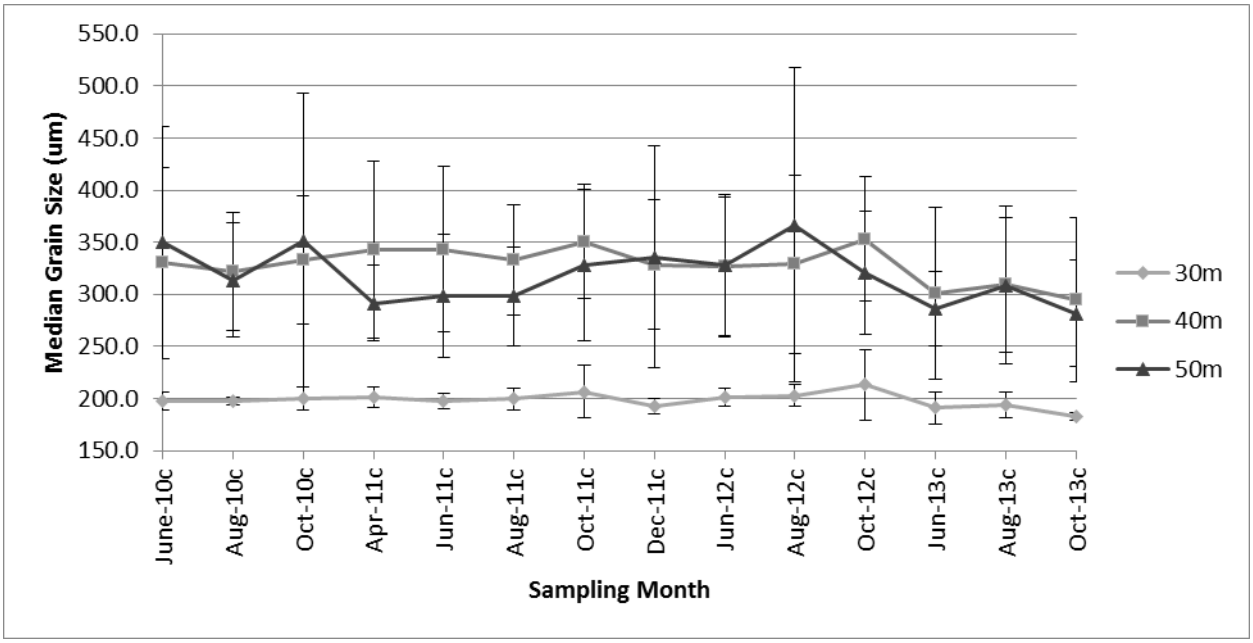

Figure A5: Median Grain Size of collected sediment. Values are means (with standard deviation) of 4-8 grabs at each depth. Sediment characteristics during Ocean Sentinel testing (August 2013) and after device removal (October 2013) were not statistically different from observations during the prior years of sampling.

Trawling

Fish collections made in spring and summer 2013 were mostly unique from previous years. In our surveys warm water and high dissolved oxygen levels were present in June 2013, a combination typically not seen in summer in this region. Coast-wide, it was a year of extremely high rockfish recruitment, a phenomenon that we detected even in our sandy benthos trawls. We collected 10 species (3 rockfish species) that we had not previously observed within the study area (8 of these species were collected in April and/or June before deployment of the Ocean Sentinel). See Table A4, at the end of this section, for complete fish species list for 2013. These additional species did not result in significantly higher H' diversity, as the spring and summer catches were still overwhelmingly dominated by flatfish species, as in years past (Table A2, top values per row). Within 2013, June surveys had significantly more species (S = 14.1) than April (S = 10.4) and August (S = 9.3), which were all significantly higher than previous summers (but not October 2010 and 2011). October 2013 assemblages (post buoy removal but with anchors in place) were similar to previous collections.

Cluster and multidimensional scaling analyses indicated that in terms of species composition and number, no significant differences in assemblages could be detected between the pre-deployment summer surveys (June) and the during-deployment summer surveys (August) as samples from these two collections clustered together (Figure A6). The most unique fish assemblages were collected in April 2013; however, this likely is due to large numbers of Sanddab spp., which are 'not present' in later samples because they have grown to a size that they could be identified to species.

Two notable differences were seen in the trawl-collected invertebrates. We collected the mysid species, *Neomysis rayii*, which we have not collected since 2010, the last time water temperatures were this warm in June. We also collected enormous numbers of crab 'recruits' (~ 1 cm carapace width). This recruitment event was also seen statewide as reported by SCUBA divers and ROV surveys conducted by other entities. See Table A5, at the end of this section, for complete invertebrate species list.

Table A2: Fish diversity (Shannon-Weaver H', log base e) and number of species (S); values are means of 7 to 9 trawls for each sampling time. Empty cells are month-year combinations that were not sampled.

Month	Fish Diversity # of Species	2010	2011	2012	2013
February	H’		1.470		
	S		7.3		
April/May	H’		1.474		1.376
	S		6.7		10.4
June	H’	1.176	1.114	1.558	1.676
	S	6.8	5.3	6.9	14.1
August/September	H’	1.288	1.457	1.264	1.253
	S	6.2	7.8	5.8	9.3
October	H’	1.798	1.823		1.176
	S	8.4	8.7		4.9
November	H’			1.137	
	S			4.6	
December	H’		0.865		Collected Dec. 11; IDs pending
	S		5.0		

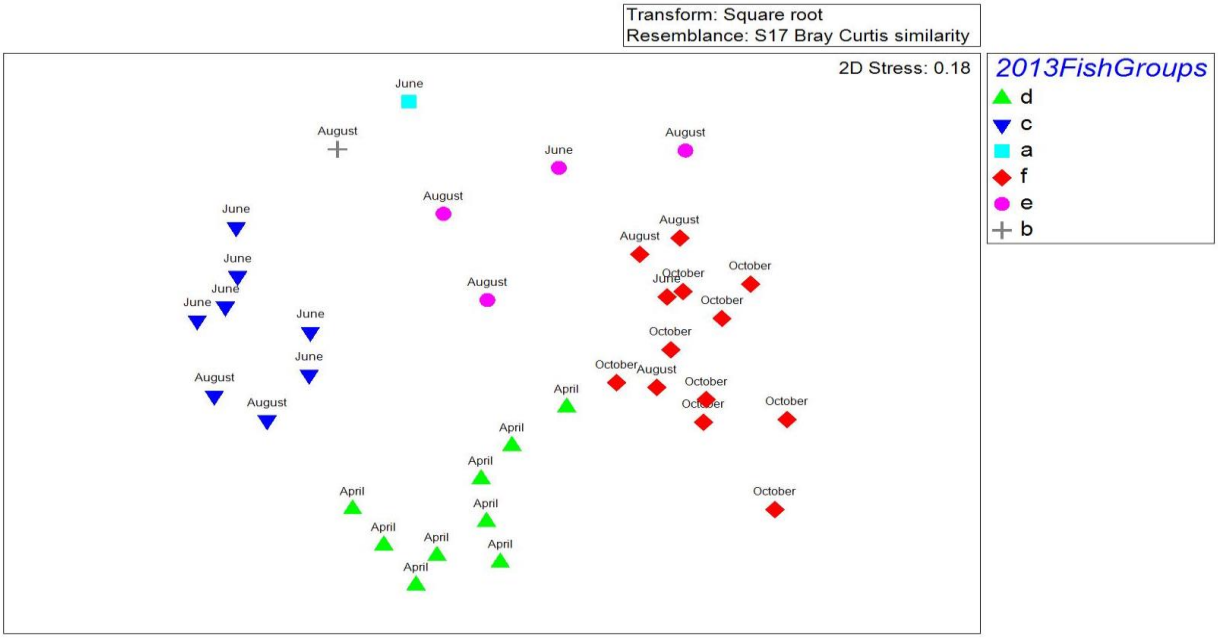

Figure A6: Multidimensional scaling plot of fish species assemblages collected around the NETS in 2013. Samples that have the same symbol are not significantly different from one another.

Videography

In the laboratory, each video taken from the lander in September and October 2013 was reviewed and all observed organisms noted. In September, orange sea pens were observed in the sand near the anchors and in the sandy reference locations; no motile invertebrates or fishes were observed. Organisms observed in October are reported in the Table A3.

Table A3: Organisms observed by video lander in October 2013.

Stations	Invertebrates	Fishes
Reef Reference Stations	1 *Metridium* (white plumose anemone) 1 hermit crab	1 spotted ratfish 5 juvenile rockfish
Ocean Sentinel Anchors	2 hermit crabs	None
Sandy Reference Stations	None	2 flatfish

CONCLUSIONS

Sediment conditions at the twelve established sampling stations around the Ocean Sentinel deployment location during operations and after removal of the device did not vary from observations made in the same seasons in previous years. Since no changes to the sediment characteristics were observed, we hypothesize that the device installation, operations, and removal likely also did not affect the infaunal assemblages surrounding the site. Because of the increased shell hash surrounding the anchors observed in the 2012 ROV footage, we made sediment collections near the Ocean Sentinel anchors after removal of the buoy in late fall 2013. These samples have not yet been analyzed, but qualitative differences in sediment (increased shell hash) are seen. These very localized changes to the sediment may have potential effects on infauna, which we will investigate and report on in early 2014.

Despite the increased number of species observed in the spring and summer in the vicinity of the test berth (related to ocean conditions), by October (after removal of the buoy) fish assemblages at the nine sampling stations were not different from those collected at these stations in previous years. Thus, we conclude the device installation, operations, and removal did not affect the fish assemblages in sedimentary habitats surrounding the site.

Considerations for Future Monitoring

As a lack of seasonal variability in sediment characteristics was again observed in 2013, future sampling for this community could be performed less frequently. However, because we did see a large recruitment of polychaete worms in 2012 previously had been recorded in 2000 and 2008, there apparently are inter-annual differences. Thus, we recommend both infaunal and sediment samplings occur at least in summer each year. If desired, additional sediment collections could occur in additional seasons. Sediment-only collection can be executed more quickly and under a wider range of conditions, and processing can be done within a week. Because of the qualitative differences observed in the amount of shell hash surrounding the anchors, if effects on the very near-field are of interest, additional sediment and infaunal samples should be attempted near deployed anchors (prioritizing safety of the approaching vessel and protection of deployed components). If/when ROV surveys are conducted for other purposes, NNMREC should use that opportunity to investigate fish attraction (FAD) effects of

different WEC devices and the Ocean Sentinel. If survey time allows, measured transects should be done near the devices to enable quantification of fishes associated with devices.

ACKNOWLEDGEMENTS

The Henkel lab would like to acknowledge Captain Mike Kriz and Kody of the *R/V Elakha* aboard which all benthic collections were carried out.

REFERENCES

Clarke, K.R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18:117-143.

Timpe GL, Van de Voorde N (1995) Nomad buoys: An overview of forty years of use. OCEANS '95 MTS/IEEE Challenges of Our Changing Global Environment Conference Proceedings, p 309-315 vol.301.

TRAWL SPECIES LIST

Table A4: Numerical abundance of fish collected in 2013 beam trawl samples. Species shaded blue are new collections at this site. Most were collected before deployment (April and/or June).

Common Name	Latin Name	13-Apr Before	13-Jun Before	13-Aug During	13-Oct After
English sole	*Parophyrs vetulus*	1,577	119	190	89
Speckled sanddab	*Citharichthys stigmaeus*	274	167	489	156
Pacific Sanddab	*Citharichthys sordidus*	83	259	522	79
Butter sole	*Isopsetta isolepis*	123	330	193	34
Juvenile Smelt	*Osmeridae spp.*	11	137	490	-
Pacific Tomcod	*Microgadus proximus*	138	377	58	2
Sanddab spp.	*Citharichthys spp*	220	-	-	-
Sole sp.	*Pleuronectidae*	-	128	-	-
Pacific sandlance	*Ammodytes hexapterus*	3	22	3	18
Snake Prickleback	*Lumpenus sagitta*	46	-	-	-
Sand Sole	*Psettichthys melanostictus*	26	10	9	-
Pacific Staghorn	*Leptocottus armatus*	3	12	25	1
Lingcod	*Ophiodon elongatus*	-	30	9	-
Whitebait smelt	*Allosmerus elongatus*	15	22	-	-
Snailfish sp.	*Liparidae spp.*	-	17	13	-
Pricklebreast Poacher	*Stellerina xyosterna*	1	3	16	-
Night smelt	*Spirinchus starksi*	-	19	-	-
Warty Poacher	*Chesnonia cerrucosa*	1	9	7	-
Canary Rockfish	*Sebastes pinniger*	-	10	4	-
Irish Lord	*Hemilepidotus sp.*	5	13	-	-
Tubenose Poacher	*Pallasina barbata*	-	-	6	2
Showy Snailfish	*Liparis pulchellus*	-	7	-	-
Blue Rockfish	*Sebastes mystinus*	-	6	1	-
Arrowtooth flounder	*Atheresthes stomias*	-	4	1	1
Big Skate	*Raja binoculata*	1	2	2	1
Widow Rockfish	*Sebastes entomelas*	-	6	-	-
Rex sole	*Glyptocephalus zachirus*	3	-	2	-
Smooth Alligatorfish	*Anoplagonus inermis*	-	1	3	-
Dover Sole	*Microstomus pacificus*	-	2	2	-
Yellowtail Rockfish	*Sebastes flavidus*	-	4	-	-
Pygmy Poacher	*Odontopyxis trispinosa*	2	-	-	1
Northern ronquil	*Ronquilus jordani*	-	3	-	-
Petrale Sole	*Eopsetta jordani*	-	1	-	-
Saddleback gunnel	*Pholis ornata*	-	-	1	-
N. spearnose poacher	*Agonopsis vulsa*	-	-	1	-
Starry Flounder	*Platichthys stellatus*	-	-	-	1

Table A5: Numerical abundances of epi-benthic invertebrates collected in 2013 beam trawl samples.

Common Name	Latin Name	13-Apr Before	13-Jun Before	13-Aug During
Crangon shrimp	*Crangon alaskensis*	2,019	698	10,132
Crangon shrimp	*Crangon stylirostris*	14	34	1,544
Crangon shrimp	*Crangon franciscorum*	95	48	85
Crangon shrimp	*Crangon alba*	5	1	176
Mysid shrimp	*Neomysis kadiakensis*	1,175	51,206	111,684
Mysid shrimp	*Pacifacanthomysis nephrophthalma*	747	5	356
Mysid shrimp	*Alienacanthomysis macropsis*	8	124	76
Mysid shrimp	*Archaeomysis grebnitzkii*	13	-	-
Mysid shrimp	*Neomysis rayii*	-	1,902	-
Side-striped shrimp	*Pandalopsis sp*	-	-	-
Broken-back shrimp	*Heptacarpus sp*	-	-	5
Krill	*Thysanoessa spinifera*	-	-	10
"Other" Shrimp	*Decapoda*	40	20	-
Crab larvae	Crab megalopae	16	110	123
Crab recruit	Crab recruit	-	85,068	3,712
Dungeness juvenile	*Metacarcinus magister* juvenile	1	108	-
Dungeness adult	*Metacarcinus magister* adult	1	-	1
Hermit crab	*Pagurus sp.*	35	24	366
Amphipods	*Amphipoda*	133	5	204
Cumacea	*Cumacea*	700	52	345
Isopods	*Isopoda*	21	13	46
Sea pen	*Ptilosarcus gurneyi*	11	-	56
Sea anemone	*Actinaria sp.*	3	3	18
Sea cucumber	*Paracaudina chilensis*	9	19	74
Sand dollar	*Dendraster excentricus*	6	11	150
Short-spined sea star	*Pisaster brevispinus*	3	7	7
Mud/sand star	*Luidia foliolata*	1	-	-
Sunflower star	*Pycnopodia sp.*	-	-	3

7 APPENDIX B: ACOUSTICS REPORT

Underwater acoustic measurements near the Ocean Sentinel at PMEC's North Energy Test Site (NETS) Facility

A report for the

Northwest National Marine Renewable Energy Center (NNMREC)

Oregon State University

Provided by

Joseph Haxel

Cooperative Institute for Marine Resources Studies

Oregon State University

October 26, 2013

BACKGROUND

On September 26, 2013 passive acoustic recordings were made with a drifting hydrophone near NNMREC's Ocean Sentinel at the North Energy Test Site (NETS) off the central Oregon coast (Figure B1). The deployment of the Ocean Sentinel and facility marker buoys, in the absence of an operational wave energy converter (WEC) device, provide an opportunity to measure effects on ambient noise levels primarily from sound generated by the motion of mooring hardware (chains, etc.) within the testing facility. The project objectives of the acoustic measurements include quantitative estimates of range dependent root mean square sound pressure levels (SPL_{rms}) integrated across the 60Hz - 13 kHz frequency band. Additionally, time dependent spectral analysis is focused toward identifying the frequency content of acoustic emissions generated from the testing facility.

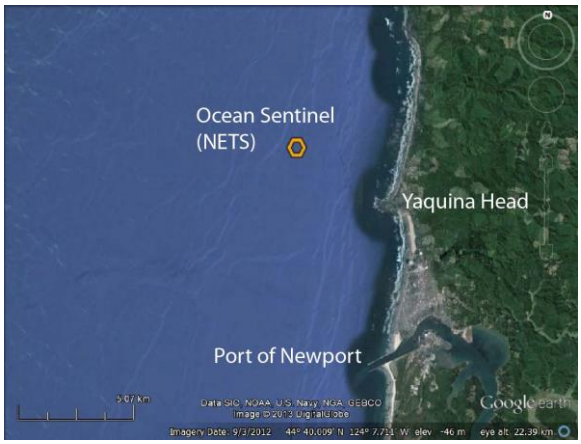

Figure B1: Map showing the location of the NNMREC Oregon State University Ocean Sentinel (orange hexagon) moored at the North Energy Test Site (NETS) north of the Port of Newport on the central Oregon coast.

During the acoustic recording operation the Ocean Sentinel was located at 44° 41.835'N, 124° 07.631'W within the NETS designated facility. Acoustic measurement operations were conducted on site from 12:55 to 13:55 PDT on September 26, 2013. Results reported here represent an acoustic "snapshot" measurement in the vicinity of the OS limited to the environmental conditions listed in Table B1. Significant wave heights slightly decreased during the acoustic recording operation measuring from 2.4 - 2.1 m with average periods of ~7 - 8 seconds and dominant periods up to 12 seconds. Meanwhile, wind conditions remained steady around 3 - 4 m/s gusting to 4.6 m/s. Environmental conditions experienced during this acoustic recording operation were more energetic than previous recording missions providing a good test of the newly developed acoustic drifter system.

METHODS

Acoustic measurements were made using a 24 foot fiberglass hulled vessel (*Gracie Lynn* – Oregon Coast Aquarium) with a newly developed autonomous drifting underwater hydrophone (ADUH) buoy system deployed and retrieved in a series of two free floating drifts (Figures B2 and B3) near and down-current of the Ocean Sentinel and marker buoys. Since the drift of ADUH cannot be controlled, caution was taken to deploy the recording system "downstream" to avoid entanglement. The *Gracie Lynn*'s engines and electronics were powered down during the free drifting mode in order to reduce further noise contamination. Each of two drifts with the acoustic buoy package was started as near as safely possible to the Ocean Sentinel, drifting in the dominant current direction northward for 20 minutes and ranging from 138 - 800 m of the Ocean Sentinel hull (Figure B3). The average drift speed of the ADUH was 0.6 m/s during each drift.

Table B1: Environmental conditions measured from nearby meteorological and wave buoy stations on September 26, 2013.

Station	Time (UTC)	WvHt (m)	Tp (sec)	Ap (sec)	Wspd (m/s)	Wgst (m/s)
46050	19:50	2.4	11	7.8		
	20:50	2.1	12	7.1		
NWP03	19:00				3.6	4.1
	20:00				4.1	4.6
	21:00				3.6	4.6

Figure B2: A photograph of the autonomous drifting underwater hydrophone (ADUH) buoy system deployed for acoustic recordings near the Ocean Sentinel at the NETS on September 26, 2013.

The ADUH system consists of a 3 m long spar buoy with GPS logger, shock cord, static line, damping disc and a hydrophone instrument suspended 10 m below the sea surface (Figure B4). A drifting approach was used to avoid “pseudo-sound” contamination of the recordings resulting from non-propagating acoustic fluctuations at the hydrophone typical of cabled systems tethered to a floating vessel. The drifter is designed to decouple surface wave motion from the hydrophone and has limited surface area above the waterline to reduce “sail” effects that cause the hydrophone system to move faster through the water than the mean current. This design therefore minimizes data contamination from flow noise generated by wind induced lateral movement of the hydrophone and/or vertical motion resulting from surface waves.

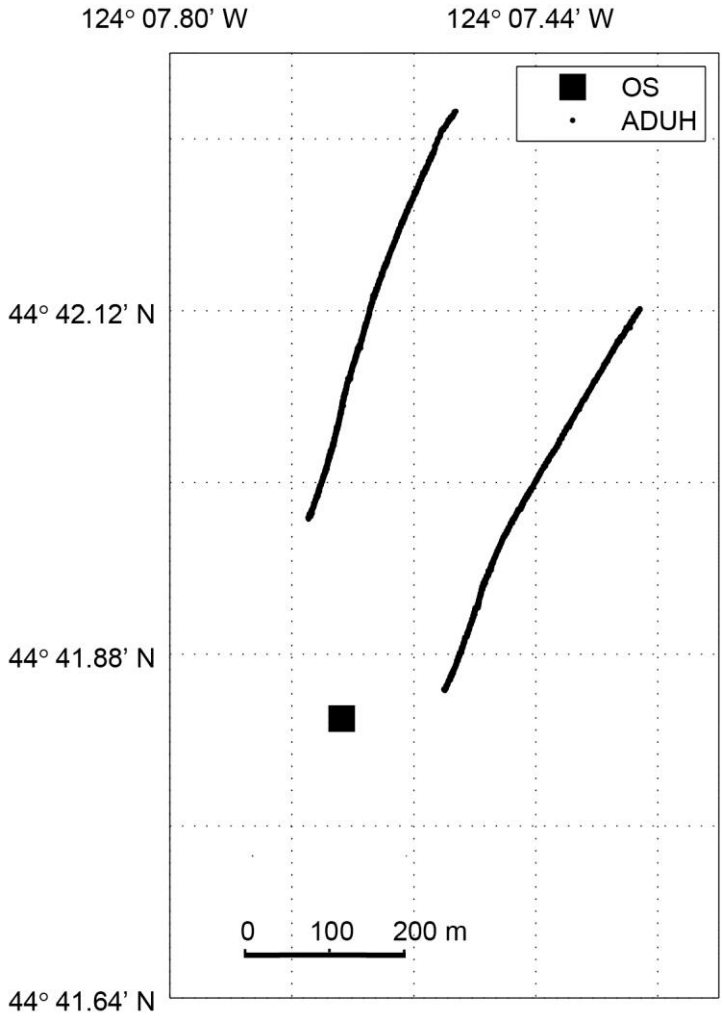

Figure B3: A map of ADUH drifts around the Ocean Sentinel at NETS on September 26, 2013.

The hydrophone instrument is a low-power 16-bit data acquisition system and pre-amplifier using an omni-directional hydrophone from High Tech Inc. (HTI-92-WB) with sensitivity -174.4 dB re µPa V^{-1} and a built in 1 pole high pass filter with a 50 Hz corner frequency. The system records continuously at a sample rate of 32 kHz, storing data to compact flash memory. Prior to analog-to-digital conversion, the signal is pre-conditioned by a pre-amplifier with a pre-whitening filter that helps de-emphasize the ambient noise spectrum below 20 Hz so that the 16-bit dynamic range can be fully utilized. The last stage of the pre-amplifier is an 8-pole elliptical anti-aliasing filter with a cut-off frequency (f_c) at 13 kHz. For SPL_{rms} and spectral energy content analysis included in this report, the recorded signal is first converted to sound pressure relative to µPa by removing these pre-amplifier and instrument responses in the frequency domain.

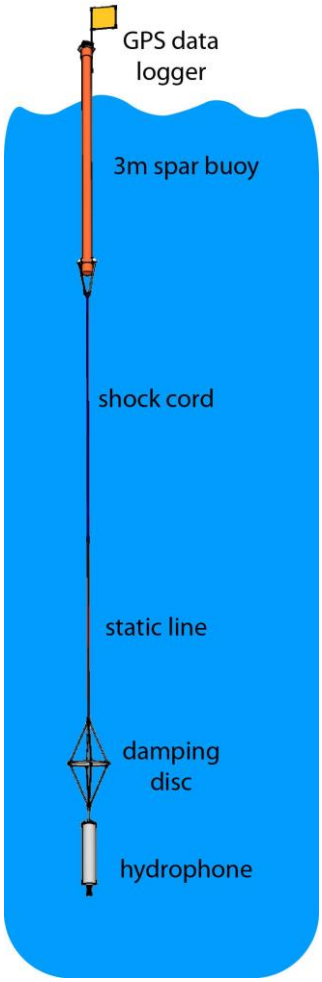

Figure B4: A schematic diagram of the autonomous drifting underwater hydrophone (ADUH) buoy system used for data collection.

ANALYSIS METHODS

Range Dependent Sound Pressure Levels

Root mean square sound pressure levels (SPL_{rms}) integrated across the 60 Hz - 13 kHz frequency band are calculated over 12 second data intervals and reported in units of dB *re* 1 µPa. SPL_{rms} is calculated as:

$$SPL_{rms} = 20 \log_{10} (p_{rms}/p_{ref})$$

Where p_{rms} is the root mean square pressure calculated over 12 seconds and p_{ref} is the standard underwater reference pressure 1 µPa @ 1 m. The 12 second data window is used to time average noise variability generated over the measured dominant wave period (swell @ 12 sec.).

Spectral Analysis

Spectral levels are calculated from 32000 point (1 sec.) data windows, tapered using a Hanning window with no overlap and Fast Fourier Transformed (FFT) to provide the frequency/amplitude content of the acoustic record from each drift.

RESULTS

SPL_{rms} values from each drift are plotted as a function of distance to the Ocean Sentinel in Figure B5. Mean SPL_{rms} over the length of the recording drifts reach 94 dB and 105 dB respectively for drifts 1and 2. Although drift 1 shows a decreasing trend in sound pressure levels with distance from the OS and the NETS, suggesting ambient levels may be influenced at these ranges by mooring hardware or other site related sound sources, a closer look at the spectral levels from drift 1 (Figure B6) shows the majority of the energy decrease occurs in frequencies below f < 500 Hz, not associated with the higher frequency signals attributed to hardware generated noise. Mooring chain noise recorded during both drifts has a distinctive spectral signature with 5 energy peaks focused at 4.6 - 5.0 kHz, 5.2 - 5.5 kHz, 9.0 - 9.4 kHz, 10.0 - 10.6 kHz, and 12.1 - 13 kHz (Figures B6, B7 and B8). Time-averaged spectral plots comparing the average energy at each frequency during the drifts show the persistent frequency structure of the observed mooring hardware generated sounds (Figure B8).

Recordings from drift 2 are contaminated by noise from an approaching vessel (~2 - 3 km range, Figure B7), with spectral levels showing a strong increase in received energy below f < 4 kHz attributed to noise emissions from the approaching ship. SPL_{rms} estimates from drift 2 are on average ~10 dB higher than the drift 1 recordings and reveal an increasing trend with distance from the Ocean Sentinel/NETS area (Figure B5) suggesting noise generated by nearby vessel traffic is the dominant sound source within the recorded frequency range. Despite the contribution from noise radiated by nearby vessel traffic, SPL_{rms} levels integrated across the 60Hz - 13kHz frequency range recorded at a range of distances from the Ocean Sentinel/NETS facility were below NMFS threshold criteria for marine mammal harassment (120 dB) throughout the recording period.

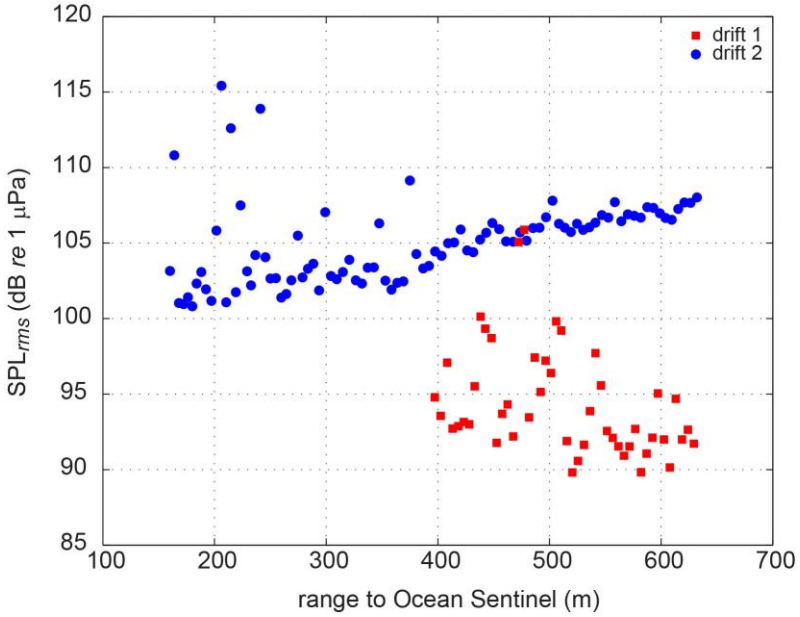

Figure B5: PL_{rms} averaged over 12 second data intervals and plotted against distance to the Ocean Sentinel buoy. Values are color and symbol coded according to drift number.

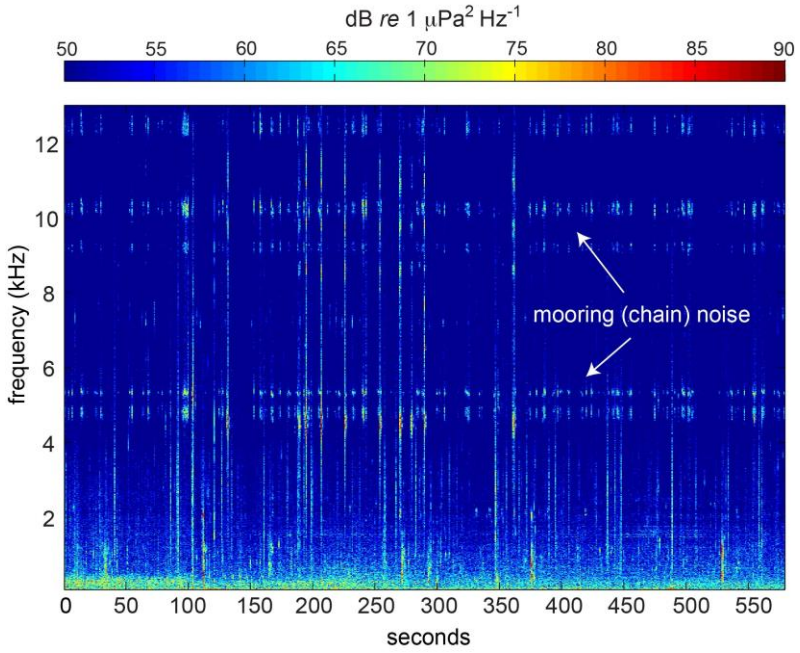

Figure B6: Spectrogram showing spectral levels recorded during drift 1 of the recording period (32000 pt. window, hanning, no overlap).

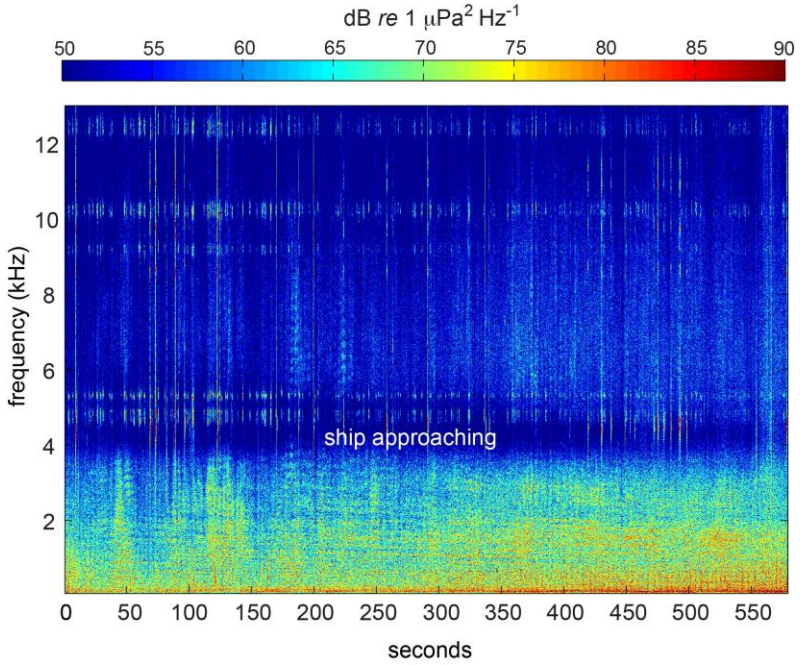

Figure B7: Spectrogram showing spectral levels recorded during drift 2 of the recording period (32000 pt. window, hanning, no overlap).

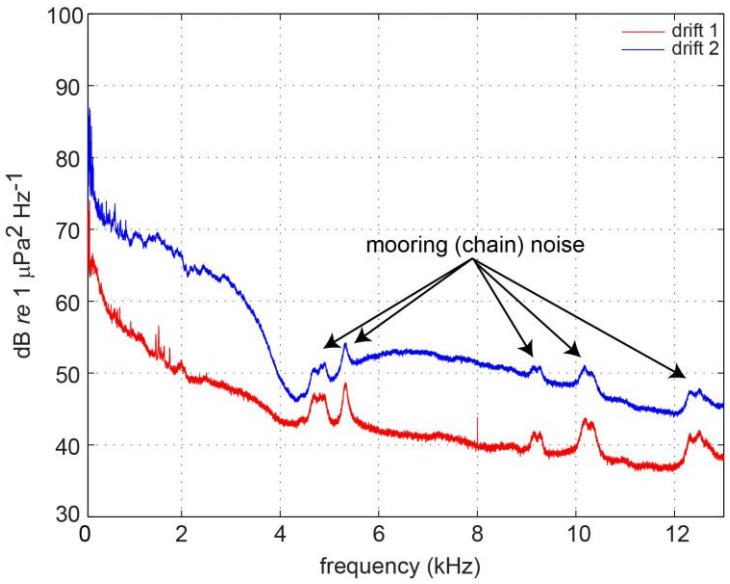

Figure B8: Time-averaged spectra calculated over each drift showing the strong influence of vessel generated noise on ambient levels increasing from drift 1 to drift 2. Also evident are the localized peaks in acoustic energy associated with mooring (chain) hardware generated sounds from the NETS.

SUMMARY

Underwater sound pressure levels were recorded around the Ocean Sentinel and NETS facility from a range of distances (138 - 800 m) using a newly developed free drifting hydrophone buoy system on September 26, 2013. Received energy levels indicate ambient noise levels are strongly influenced by acoustic emissions from nearby vessel traffic in the area. The spectral signature of sounds generated by the motion of mooring hardware (chain noise) associated with the NETS facility was detected and identified as a set of 5 localized spectral peaks (4.6 - 5.0 kHz, 5.2 - 5.5 kHz, 9.0 - 9.4 kHz, 10.0 - 10.6 kHz, and 12.1 - 13 kHz) observed at a range of distances. Despite the contribution of these sound sources to ambient levels, SPL_{rms} integrated across the 60Hz - 13 kHz frequency range remained below NMFS threshold criteria (120 dB) throughout the recording period. Additionally, results show a vast improvement in data quality provided by the new drifting hydrophone approach versus previous tethered recordings.

8 APPENDIX C: OPPORTUNISTIC OBSERVATIONS INSTRUCTIONS AND FORM

Observations & Reporting Instructions

Information should be coordinated with Sean Moran, NNMREC Ocean Test Facility Manager ***541-404-3729***

INTRODUCTION & INSTRUCTIONS

As a matter of practice, NNMREC staff will make visual observations from the water surface during **ALL visits** to the project site and at least monthly during project deployment. If project devices (i.e. Ocean Sentinel, WEC) are not deployed but anchors and mooring lines remain in place during the April/May/June gray whale migration, NNMREC will perform visual observations at least bi-weekly during that period. NNMREC will record all opportunistic observations of marine mammals, sea turtles seabirds, listed species, and/or derelict gear and include them in the Annual Report provided to the Adaptive Management Committee, NMFS and ODFW.

Injured or Stranded Species: If marine organisms (excluding marine mammals, sea turtles or listed species) are observed entangled, injured or impinged on derelict gear, NNMREC will remove the derelict gear as soon as feasible, notify NMFS, USFWS and ODFW within 48 hours, and provide a report with all available information on the case. NNMREC will then, after consulting with NMFS, USFWS and ODFW, modify the project and/or monitoring plans if necessary. If marine mammals, sea turtles, sea birds or listed species are observed entangled, injured or impinged at the project structure, NNMREC will immediately follow the Reporting Protocol for Injured or Stranded Marine Mammals (listed below) and give NMFS and ODFW all available information on the incident. In addition, NNMREC will contact NMFS and ODFW as soon as practical within 24 hours to consult with them regarding modifying the project and/or monitoring plans.

Reporting Protocol for Injured or Stranded Marine Mammals and Sea Turtles: NNMREC will implement the following NMFS protocols in the event an injured or stranded marine mammal is observed:

i. *Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.*

Capability to respond to free swimming animals is very limited and relocation is a major issue. In addition, medical treatment facilities for marine mammals and sea turtles are for the most part non-existent in Oregon. Therefore, we recommend that monitors record the sighting as part of the monitoring report and provide the information to the Stranding Network. The data should include: 1) any photos or videos, if possible; 2) species or common name of the animal involved; 3) time and date of observation; 4) location (lat/long in decimal degrees); 5) description of injuries or unusual behavior.

ii. *Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.*

The marine mammal disentanglement network in Oregon is based at Hatfield Marine Science Center - contact Jim Rice at 541-867-0446 or Barb Lagerquist at 541-867-0322. The national network is available at 877-SOS-WHALE (877-767-9425). Contact should be made immediately if an entanglement is observed and, if possible the reporting vessel should remain on scene while contact is made. Report should include the following information: 1) species or common name of animal involved; 2) location (lat/long in decimal degrees); 3) whether the animal is anchored by the gear or swimming with the gear in tow; 4) a description of the entangling gear (line size, line color, size number and color of floats if attached, presence or absence of pots or webbing); 5) if animal is towing gear, give direction of travel and current speed; 6) local weather conditions (sea state, wind speed and direction); 7) whether the vessel can stand by until someone is able

to get there. The disentanglement network will determine whether or not a response can be mounted immediately and will advise the reporting vessel on next steps. Please note time of observation as well.

iii. *Dead marine mammals or sea turtles observed floating at sea.*

Dead floating marine mammals fall within the definition of "stranded" under the MMPA. To report strandings off central Oregon coast contact the Oregon Marine Mammal Stranding Network (Jim Rice) 541-867-0446.

iv. *Dead protected species found entangled or otherwise impinged at the project.*

These should be reported as part of the monitoring report to NMFS and ODFW, giving all available information on the case. The report should include the following information: 1) species or common name of animal involved; 2) location (lat/long in decimal degrees); 3) whether the animal was found on a project device or anchoring system; 4) a description of injuries or entanglement observed; if derelict fishing gear or other debris was involved, give a description of the gear (line size, line color, size number and color of floats if attached, presence or absence of pots or webbing); photographs if possible. In the event derelict gear is involved, the presence of protected species entangled in the gear should be included in the report initiating gear removal planning and coordination.

Pinniped Haulout: If pinnipeds are identified on one or more of the project structures, NNMREC will implement the NMFS haulout protocols listed below. In addition, NNMREC will notify NMFS and ODFW within two weeks of the haul-out incident.

- NMFS: Keith Kirkendall, Water Diversion Branch, 503-230-5431, keith.kirkendall@noaa.gov
- ODFW: Delia Kelly, Ocean Energy Coordinator, 541-867-0300, delia.r.kelly@state.or.us

Pinniped Haulout Protocols

i. If pinnipeds are present on one of the project structures, monitoring or maintenance activities will occur at minimum of 100 yards from the structure (in accordance with the current NMFS guideline of 100 yards for vessel approach of hauled out pinnipeds).

ii. If the pinnipeds do not leave the structure upon approach up to 100 yards and the pinnipeds are non-ESA listed species (e.g., California sea lions), NNMREC may proceed to deter the pinniped from project structures so long as such measures do not result in the death or serious injury of the animal (pursuant to Section 101(a)(4)(A) of the Marine Mammal Protection Act). NNMREC will follow NOAA guidance on deterring pinnipeds: http://www.nwr.noaa.gov/marine-mammals/seals-and-sea-lions/deterring-pinnipeds.cfm

iii. If NNMREC needs to perform emergency maintenance that requires immediate attention (e.g., closing an opened hatch, repairing a failed mooring or electrical fault) and deterrence of a listed species is necessary, NNMREC staff will request assistance from a government official (call NNMFS). The NNMREC Response Coordinator will provide an account of the incident to the appropriate staff at NMFS and ODFW as soon as possible.

NOTICE OF ADDITIONAL ACTIONS TO BE TAKEN BY NNMREC AND/OR DEVICE DEVELOPER:

In the event that any marine mammal is injured, stranded, or dead due to collision or entanglement from the project, OSU, in cooperation with DOE, will cease all project operations and testing activities and reinitiate ESA consultation with NMFS immediately. OSU will also initiate MMPA coordination with NMFS, in cooperation with DOE, to assess the need to apply for an Incidental Harassment Authorization. If it is determined that this is needed, operations will cease until the authorization is issued and a copy is sent to DOE. If NMFS determines that an authorization is not required, notification of this decision will be sent to DOE and project operations may recommence.

OBSERVATION RECORD FORM

(Use at the project site not on approach)

1) **OBSERVER NAME:** _____ **DATE:**_____ **TIME:** _____

2) **LOCAL WEATHER CONDITIONS** (sea state, wind speed/direction, temperature, visibility, etc.):

_____

_____

_____

3) **PURPOSE OF SITE VISIT** (check one):

☐ Monitoring (acoustic/benthic/EMF/other) ☐ Maintenance

☐ Routine Inspection ☐ Other (explain): _____

4) **OBSERVATIONS**

Are marine mammals, sea turtles, seabirds, listed species, and/or derelict gear present?

☐ Yes ☐ No

If no, no additional documentation needed.

If yes, document the sighting in the observations table and take photographs (if possible). If species is unknown or uncertain please make an effort to photograph the individual(s) to aid in identification. If derelict gear is observed, please note location/orientation and potential risks.

Species/Gear Type	Number of Individuals/Pieces of Gear (e.g. # pots/floats)	Location/Distance from Project	Behavior/Activity of Species Entanglement Risk

OBSERVATION RECORD FORM

(Use at the project site not on approach)

NOTE: FROM THIS SECTION ON IT IS ONLY NECESSARY TO FILL THIS OUT IF ANY OF THE CASES APPLY.

a. Debilitated/Injured/Stranded/Dead Marine Mammals or Sea Turtles

Do any of the following cases apply? If yes, follow the reporting protocols in the instructions and immediately contact the Marine Mammal Disentanglement Network at Hatfield Marine Science Center - Jim Rice at 541-867-0446 or Barb Lagerquist at 541-867-0322. The national network is available at 877-SOS-WHALE (877-767-9425).

☐ *Live marine mammals, sea turtles, seabirds or listed species observed swimming, but appearing debilitated or injured.*

☐ *Live marine mammals, sea turtles, seabirds or listed species observed entangled in fishing gear or marine debris.*

☐ *Dead marine mammals, sea turtles, seabirds or listed species observed floating at sea.*

☐ *Dead protected species found entangled or otherwise impinged at the project.*

If possible, the reporting vessel should remain on scene while contact is made. The disentanglement network will determine whether or not a response can be mounted immediately and will advise the reporting vessel on next steps. Explain whether the vessel can stand by until someone is able to get there and note next steps:

_____

_____

b. Entangled/Impinged/Injured Animals

If an entangled, impinged and/or injured animal is observed, photograph (if possible) and provide the following information. If marine mammals or sea turtles are observed entangled, impinged or otherwise debilitated, move to Section a, above.

Species (full name) _____

Location (lat/long in decimal degrees) _____

What is the cause of the entanglement/impingement?

☐ Derelict Fishing Gear ☐ Project Structure (specify): _____

☐ Marine Debris ☐ Other/Unknown (explain): _____

OBSERVATION RECORD FORM

(Use at the project site not on approach)

Description of the entangling gear/structure (line size and color; size, number and color of floats if attached, presence or absence of pots or webbing:

_____

_____

_____

_____

Is the animal is fixed by derelict gear or marine debris, or swimming with it in tow?

_____

_____

If animal is in motion, give approximate speed and direction of travel:

_____

_____

c. <u>Pinniped Haulout</u>

If pinnipeds are observed hauled out on one of the project structures, please follow the Pinniped Haulout Protocols and record the following information:

Species (full name): _____

Number of Individuals Present: _____

Haulout Location**:** _____

Additional Notes: _____

_____

_____

_____