Northwest National Marine Renewable Energy Center

Report #8
June 19 2013

2012 Annual Operations & Monitoring Report: North Energy Test Site

Sarah K. Henkel, Joseph H. Haxel, Adam Schultz & Anna Hofford

UNIVERSITY of WASHINGTON

Oregon State UNIVERSITY

NNMREC
Northwest National Marine Renewable Energy Center

Oregon State University

Belinda Batten
Director
541-737-9492
belinda.batten@oregonstate.edu

Brenda Langley
Program Manager
541-737-6138
brenda.langley@oregonstate.edu

nnmrec.oregonstate.edu

University of Washington

Brian L. Polagye
Co-Director
206-543-7544
bpolagye@uw.edu

depts.washington.edu/nnmrec

Suggested Citation: Henkel, S.K., J.H Haxel, A. Schulz & A. Hofford. 2013. 2012 Annual Operations & Monitoring Report: North Energy Test Site. NNMREC Report #8. Corvallis: NNMREC. 117 pp.

Partial funding for this material was provided by U.S. Department of Energy and the Oregon Wave Energy Trust (OWET).

OWET is funded in part with Oregon State Lottery Funds administered by the Oregon Business Development Department. It is one of six Oregon Innovation Council initiatives supporting job creation and long-term economic growth.

U.S. DEPARTMENT OF ENERGY

OregonWaveEnergy TRUST

Northwest National Marine Renewable Energy Center
North Energy Test Site

2012 Annual Operations & Monitoring Report

DRAFT: November, 30 2012

REVISED: May 16, 2013

FINAL: June 19, 2013

Table of Contents

1 Introduction

The first wave energy test at the Northwest National Marine Renewable Energy Center's (NNMREC) North Energy Test Site (NETS) off the coast of Newport, OR took place in 2012 with the deployment of the WET-NZ wave energy conversion (WEC) device and the Ocean Sentinel instrumentation buoy. The WET-NZ and Ocean Sentinel were deployed from late August to early October 2012; several monitoring surveys were performed at the test site prior to, during and after the deployment. The 2012 test activities and monitoring are summarized in Table 1 below.

Table 1: 2012 Test Center Activities

ACTIVITY/STRUCTURE	***Installation***			***Deployment***		***Removal***	
Ocean Sentinel	August 19					October 5	
WET-NZ	August 23					October 5	
Anchors & Mooring Systems	August 16 – 22					October 9 – 11	
Operations Inspection	August 23, 28, 31; September 28						
	Installation			***Deployment***		***Post-Installation***	
Opportunistic Observation Recordings	August 14, 16, 19, 22			August 23, 28, 31 September 17, 18, 28		October 5, 11	
Box Core	June 6			August 24		October 12	
Beam Trawl	June 29			September 27		November 15	
Videography	July 19			Sept. 17	Sept. 18	-	
CTD Cast	June 19	June 29	July 19	August 24	Sept. 27	October 12	November 15
EMF Survey	-			Sept. 20	Sept. 21	-	
Acoustics Survey	-			August 30		-	
ROV Survey	-			Sept. 17	Sept. 18	-	

In accordance with the NNMREC Adaptive Management Framework (AMF), NNMREC provided the Annual Operations and Monitoring Report (Annual Report) to the Adaptive Management Committee (Committee or AMC) on November 30, 2012, as well as summary reports of the acoustics, electromagnetic fields (EMF) and marine mammal monitoring activities. A summary of the benthic monitoring activities was provided on December 26, 2012. On January 15, 2013, NNMREC convened the

Committee to discuss the Annual Report and make recommendations for monitoring, operations, and adaptive management plans associated with the test center. The Committee also considered the 2012 WET-NZ/Ocean Sentinel Adaptive Mitigation Plan (AMP) in the annual review of monitoring results and test center operations.

On January 23, 2013, NNMREC sent the Committee members the Acoustic, EMF and Benthic reports and presentations, the draft Acoustics Monitoring manuscript (in revision with the Journal of the Acoustical Society of America), and the meeting notes, which summarized the group discussion and recommendations. In accordance with the annual review process procedures, NNMREC asked Committee members to review and provide questions and feedback on these materials by February 28, 2013. On February 27, the Oregon Department of Fish and Wildlife (ODFW) sent preliminary comments to NNMREC. On February 21, the National Marine Fisheries Service (NMFS) requested a short extension, and on March 11, 2013, NMFS submitted preliminary comments. NNMREC added the preliminary comments from ODFW and NMFS to the online project folder and sent an email to the rest of the Committee members notifying them that the comments were available on March 12, 2013. No other Committee members provided comments on the Annual Report or monitoring reports.

Under the provisions of the AMF, NNMREC, in consultation with NMFS, US Fish and Wildlife Service (USFWS) and ODFW, considers the Committee's recommendations in determining whether any additional mitigation measures are needed by March 31 of each year. As noted in the AMF, the purpose of this deadline is to ensure that previous year's test information can be used to inform any permitting, adaptive management or other review processes for future WEC tests. However, no WEC tests are planned for 2013, and NNMREC felt that additional time was needed to fully consider the comments from NMFS and ODFW. On March 29, 2013, NNMREC sent a memo to NMFS, USFWS, ODFW and the U.S. Army Corps of Engineers (the Corps) proposing to extend the March 31 deadline for a period of 90 days. On April 2, 2013, the Corps approved the request for the extension.

Subsequent to the deadline extension, NNMREC revised this Annual Report to address comments from NMFS and ODFW. In addition, the Principle Investigators updated the initial monitoring reports that were provided to the Committee in 2012; the updated monitoring reports are provided as Attachments.[1] On May 16, 2013, NNMREC sent the revised Annual Report to NMFS, ODFW and USFWS for their review. USFWS did not have any comments on the revised report. On June 12, 2013, NNMREC, NMFS and ODFW had a conference call to review the revised report and discuss final comments. On June 17, 2013, NNMREC provided an advance copy of the Final 2012 Annual Report to NMFS and ODFW, and on June 19, 2013, NNMREC prepared the Final 2012 Annual Report for submittal to the Corps, DOE and the other Committee members.

[1] Per the June 12, 2013 conference call with NMFS and ODFW, NNMREC will coordinate a meeting or conference call between the agencies and the Principle Investigator to further discuss certain sections of the 2012 EMF Monitoring Report.

The main body of this revised report (Section 2: Monitoring & Thresholds) includes a more thorough comparison of the monitoring results to the 2012 WET-NZ/ Ocean Sentinel AMP thresholds and AMF thresholds. Finally, general findings and considerations for potential modifications to adaptive mitigation and adaptive management provisions are provided in Section 4: Overall Conclusions & Recommendations. It is important to note that the considerations and recommendations in this report have been provided by NNMREC and do not constitute any changes to the Adaptive Management Framework.

2 Monitoring & Thresholds

This section is organized by topic area: Benthic Habitat, Derelict Gear, Marine Mammals & Entangled/Injured Species, Acoustics and Electromagnetic Fields (EMF). Each topic area has four subsections, beginning with a summary of the monitoring methods and results, along with considerations for future monitoring. The second subsection consists of a comparison of the monitoring results to the thresholds outlined in the 2012 Ocean Sentinel/WET-NZ Adaptive Mitigation Plan, as well as recommendations for future Adaptive Mitigation Plans (AMP). Similarly, a comparison of monitoring results to the thresholds in the Adaptive Management Framework (AMF) is provided in the third subsection of each topic area, along with recommendations for modifications to adaptive management thresholds and measures.

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 test facility. The ITS was included with the Biological Opinion (BiOp), which concludes that sound pressure, 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 the WET-NZ test and future wave energy tests. As such, a fourth subsection comparing the monitoring results to the ITS thresholds is included in Benthic Habitat (Section 2.1), Acoustics (Section 2.4), and EMF (Section 2.5).

2.1 BENTHIC SPECIES AND HABITAT

2.1.1 Monitoring Summary

Benthic surveys of sediment and water characteristics, infaunal and epifaunal invertebrates, and groundfishes in sedimentary habitats surrounding the test site have been conducted since May 2010 to characterize spatial and temporal variability in these habitat and biological components. Monitoring was conducted before, during, and after the 2012 Ocean Sentinel/WET-NZ test to determine if physical characteristics and species distributions were consistent with patterns observed at the site in the previous two years. In June 2012, prior to deployment of the WET-NZ and Ocean Sentinel, the site was sampled for invertebrates using the box core and for fish using the beam trawl. In July 2012, the future anchor locations and reference locations were surveyed using the video lander. During deployment, the site was sampled again with the box core and the beam trawl.

Water quality sampling using was conducted prior to, during and after the 2012 deployment using a Sea-Bird Electronics unit (CTD+). In collaboration with the National Renewable Energy Laboratory (NREL)

and the Navy Facilities Engineering Command (NAVFAC), the devices, mooring systems and seafloor were surveyed with an ROV September 17 – 18, 2012. Following removal of the devices, anchors and mooring systems, the site was sampled again with the box core and the beam trawl. Adverse weather conditions were frequent after removal of the devices, making it unfeasible to conduct another videography survey in 2012. The 2012 monitoring surveys are summarized in Table 2 below.

Table 2: 2012 Benthic Monitoring Surveys

	Pre-Installation			***During Deployment***		***Post-Installation***	
Box Core	6/9/12			8/24/12		10/12/12	
Beam Trawl	6/29/12			9/27/12		11/15/12	
Videography	7/19/12			9/17/12	9/18/12		
CTD Cast	6/19/12	6/29/12	7/19/12	8/24/12	9/27/12	10/12/12	11/15/12

Benthic habitat monitoring with species identifications and analyses was provided in an initial report on December 21, 2012 and in the revised Benthic Monitoring report (see Attachment 1). Physical conditions at the twelve established sampling stations during deployment and following removal of the devices did not vary from observations made in the same seasons in previous years. No infaunal species losses were detected, relative to previous years. Although a few new infaunal species were detected in 2012, they were detected in the pre-installation monitoring (prior to the 2012 WET-NZ/Ocean Sentinel test).

Fish numbers and diversity were consistent with seasonal patterns observed in previous years. ROV surveys conducted during the deployment showed fish aggregating around subsurface components of project structures, as well as some mobile benthic invertebrates on the concrete anchors. There were no substantial differences or significant trends in benthic habitat or associated ecological communities between the Project-affected sites and reference sites as a result of the 2012 WET-NZ/Ocean Sentinel test.

Considerations for Future Monitoring

As discussed in the 2012 Benthic Monitoring Report (Attachment 1), NNMREC proposes the following considerations for future monitoring:

- *Confine surveys to before-during-after sediment sampling; if a change in sediment characteristics is detected, or new information indicates a need, sample infaunal organisms to look for changes in species densities and/or distributions.*
- *If future ROV survey opportunities allow, conduct measured transects to enable quantification of fishes observed near project structures.*

2.1.2 Adaptive Mitigation Thresholds: 2012 Test

There were no adaptive mitigation thresholds for benthic habitat associated with the 2012 WET-NZ/Ocean Sentinel test. However, in consideration of potential modifications to benthic monitoring (as described in Section 2.1.1 above), NNMREC proposes the following adaptive mitigation thresholds and measures be considered for future tests:

- ***Adaptive Mitigation Threshold and Measure 1:*** *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.*
- ***Adaptive Mitigation Threshold and Measure 2:*** *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).*

2.1.3 Adaptive Management Thresholds

The Adaptive Management Framework (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 ESA, 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 2012 WET-NZ/Ocean Sentinel 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 described in Section 2.1.1 above).*

2.1.4 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[2] (188

[2] Baseline conditions are described as "fine to coarse sand with small to median sizes occurring more frequently in the 30 m depth stations and the larger sizes being more prevalent at the 40-50m depth stations (Henkel 2011)".

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 2012 WET-NZ/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.*

2.2 DERELICT GEAR

2.2.1 Monitoring Summary

NNMREC staff made opportunistic visual observations from the water surface at the project site during installation, maintenance, removal and other project activities to detect the presence of any derelict gear (as shown in the Table 1). In addition, NNMREC conducted an ROV survey of the site on September 17 – 18, 2012 which was provided to Committee members on March 14, 2013. The ROV survey involved examined all aspects practical to inspect, including all anchors, mooring lines, the Ocean Sentinel and the WET-NZ device in test.

Results of the opportunistic visual observations and ROV survey showed no derelict gear on project structures or within the project site. The ROV traveled up the anchor chains to the subsurface floats at approximately 24 m depth. Many unidentifiable fish were observed around the subsurface floats. 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.

While no derelict gear was detected in the immediate project area, derelict crab pots found within the one nautical mile NNMREC test site were removed during deployment operations by a collaborating member of Fishermen Involved in Natural Energy (FINE). The crab pots were removed and returned; however, since it was not detected within the project site or on project structures during or upon conclusion of the installation, deployment or the removal activities associated with the 2012 test, the General Procedures for derelict gear were not implemented. As such, the need to communicate with ODFW in regards to lost or entangled gear did not present itself.

Considerations for Future Monitoring

NNMREC has and will continue to consult with NMFS and ODFW (through their participation in the AMC) 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 FINE meetings and engage directly with members of the fishing community.

- *Based on results of and experienced gained in the 2012 WET-NZ test, 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.*

2.2.2 Adaptive Mitigation Thresholds: 2012 Test

For the 2012 WET-NZ/Ocean Sentinel test, NNMREC performed underwater visual monitoring prior to device deployment and during active deployment. 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.

2.2.3 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 measure have been implemented.

- *Based on results of and experienced gained in the 2012 WET-NZ/Ocean Sentinel deployment, NNMREC proposes to modify the following provisions of the General Procedures for Derelict Gear:*
  - ***Detection**: NNMREC will make visual observations from the water surface during all visits to the project site to identify any derelict gear, 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).*

2.3 MARINE MAMMALS & ENTANGLED OR INJURED SPECIES

2.3.1 Monitoring Summary

Prior to the 2012 test, NNMREC coordinated with NMFS, USFWS and ODFW to develop a standard form to use in recording and reporting opportunistic observations of marine species made from the water surface during visits to the project site. Opportunistic observations were recorded on the standard form and are summarized in Table 3 below. Thirteen different opportunistic observations were recorded during the approximately 8-week deployment period, as documented in the observation forms in Attachment 2 of this report. 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 project structures.

Table 3: Marine Mammal Monitoring Reports Summary Table

Report #	Observation & Report Generated By	Date	Activity	Observed
1	Sean Moran	August 14, 2012	OSU Anchor Deployment	None
2	Sean Moran	August 16, 2012	OSU Anchor Deployment	None

Report #	Observation & Report Generated By	Date	Activity	Observed
3	Sean Moran	August 19, 2012	Ocean Sentinel Deploy	None
4	Pat Kight	August 22, 2012	WET-NZ Deployment	None
5	Sean Moran	August 22, 2012	WET-NZ Deployment	None
6	Sean Moran	August 23, 2012	Deployment Observation	None
7	Ean Amon	August 28,2012	Deployment Inspection	1 Seal passing
8	Dr. Annette von Jouanne	August 31,2012	Deployment Inspection	None
9	Sean Moran	September 17, 2012	ROV Survey	1 Seal 5 ft
10	Sean Moran	September 18, 2012	ROV Survey	None
11	Sean Moran	September 28, 2012	NNMREC Day Inspection	None
12	Sean Moran	October 5, 2012	Ocean Sentinel Recovery	None
13	Sean Moran	October 11,2012	Mooring Recovery	None

Considerations for Future Monitoring

Per ODFW and NMFS feedback, NNMREC has revised the observation form and procedures as described below. (The updated observation instructions and form are provided in Appendix A of Attachment 2.)

- *Observation reports to include seabirds, any listed species (not just marine mammals), and derelict gear, full species name, as well as photos or video to assist with species ID, if possible.*
- *Observation report form modified to include local weather conditions, number of individuals observed, behavior, and approximate distance from and proximity to project structures.*

2.3.2 Adaptive Mitigation Thresholds: 2012 Test

The AMP for the 2012 WET-NZ/Ocean Sentinel 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 **i**f 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.*

2.3.3 Adaptive Management Thresholds

The AMF provides that if Annual Reports indicate observations of pinnipeds hauled out on the Ocean Sentinel, NNMREC will implement one or more actions (as described in the AMF) to ensure Project compliance with 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.*

2.3.4 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.

2.4 ACOUSTICS

2.4.1 Monitoring Summary

Using seafloor mounted hydrophone lander platforms, NNMREC collected long-term, continuous passive acoustic data from 2010 – 2011 to characterize the low frequency (10-840 Hz) baseline ambient noise levels at the project site, as well as the dominant natural and anthropogenic sources contributing to the overall sound budget in the area. Shortly following the installation of the WET-NZ and Ocean Sentinel in August 2012, NNMREC made passive acoustic recordings at the project site to provide a rapid measurement of noise emissions and evaluate the potential exceedance of marine mammal acoustic thresholds (as described in the 2012 Acoustic Monitoring Plan). The rapid assessment recordings were made over a three hour period on August 30, 2012 using a cabled, calibrated hydrophone system deployed from a "silent", drifting vessel while recording continuously at a sample rate of 64 kHz. Multiple drifts were performed at different distances from the devices and their mooring systems.

Sound Pressure Level (SPL) measurements averaging over 15 seconds and taken at a distance of 100 m (± 2 m) was 112 dB *re* 1 µPa for the WET-NZ and 110 dB *re* 1 µPa for the Ocean Sentinel. In addition, underwater SPL recorded at 10 m and 85 m from the devices and their mooring systems were below NMFS threshold criteria for Level B marine mammal harassment (120 dB). These reported SPL values are inclusive of all pressure signals recorded by the hydrophone, and they likely represent an

overestimate of the propagating sound energy levels emitted by the devices as a result of signal contamination from flow noise and the cabled, moving sensor (further described in Attachment 3).

While the SPL measurements did not exceed any thresholds, the acoustic recordings were made during calm sea states and low power output of the WET-NZ device; as such, some uncertainty remains as to the acoustic signature of the device during higher sea states and power outputs. Recordings taken over a range of sea states can provide a more complete understanding of acoustic outputs, which is important in ensuring adequate evaluation of project-related SPL against thresholds. As such, NNMREC will coordinate with the AMC to ensure that information about sea state and power output/activity level of WEC devices under test is included in future acoustic survey reports to provide a better understanding of how different conditions are related to acoustic outputs.

Recordings were limited to a single expedition due to environmental conditions which decreased the quality of the acoustic data collected with the cabled hydrophone. In particular, waves interacting with the vessel hull and turbulent flow noise around the boat were nearly continuous, often masking the targeted acoustic signals. In addition, the low frequencies recorded (particularly below 1 kHz) with this method were frequently contaminated by system noise, significantly reducing the number of quality measurements of the WET-NZ and Ocean Sentinel and making comparative measurements from different recording conditions difficult.

Despite data contamination problems inherent to the cabled approach used here, the short-term monitoring objective to confirm that noise levels were below marine mammal threshold criteria was fulfilled. Additionally, the recordings allowed for a time and frequency dependent characterization of sounds transmitted by the project devices operating under specific environmental conditions. As noted in the acoustics monitoring report, the acoustic signature of the project devices has a modulated harmonic frequency structure, most likely oscillating as a function of wave period.

Considerations for Future Monitoring

Based on the evaluation and assessment described in the revised Acoustics Report (Attachment 3), NNMREC will utilize technological improvements of instrumentation and data collection methodology during future WEC testing to provide high quality acoustic measurements in a variety of environmental conditions. Technological improvements for a 2nd generation hydrophone system will allow us to expand the recorded frequency range up to 13 kHz for future baseline recordings and device testing sound level measurements. In addition, 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:

- *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 lander 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.

If funds and opportunities allow, NNMREC would like to deploy a four-element array of seafloor-mounted hydrophones around the project site to collect continuous, fixed range measurements prior to, during, and after installation and operation of test devices. This will allow for localization of discrete signals (to discriminate among sound sources) and increase data on sound level frequencies above 840 Hz.

2.4.2 Adaptive Mitigation Thresholds: 2012 Test

The 2012 AMP provides that if monitoring indicates that sound pressure levels attributable to the WET-NZ and/or Ocean Sentinel device at a distance of 100m 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 scientists and Ocean Test Facility Manager would develop and implement a response plan that outlines the appropriate mitigation action within 14 days of acquiring monitoring results. Monitoring indicated sound pressure levels below the Adaptive Mitigation Thresholds and, therefore, no mitigating actions were required.

- *NNMREC recommends that the adaptive mitigation thresholds and measures for acoustics be maintained for any test conducted in 2013.*

The 2012 AMP also provides that acoustic monitoring results will be made available to NMFS and ODFW within seven days of completion of monitoring. The acoustic monitoring results were made available to NNMREC test facility management on September 10, 2012; however, the results were not provided to NMFS and ODFW until the Annual Report was submitted in December 2012. Further, NNMREC did not contact the agencies with an explanation of the delay and updated schedule. To address these issues, NNMREC proposes the following considerations:

- *Hire an Environmental Compliance Manager to maintain ongoing communication and coordination with the agencies and Adaptive Management Committee and ensure timely results reporting.*
- *For future adaptive mitigation plans, modify the reporting timeframe such that initial acoustic monitoring results, or an updated schedule and explanation of delay, would be provide to NMFS and ODFW within 14 days of completion of initial monitoring (rather than 7 days).*

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.

2.4.3 Adaptive Management Thresholds

The AMF provides that if acoustic monitoring indicates that sound pressure levels attributable to the Ocean Sentinel or a WEC device similar to the type proposed for future testing 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 100m, NNMREC would implement one or more of the actions specified in the AMF. Monitoring indicated sound pressure levels 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 maintained.*

2.4.4 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 2012 test show that sound (SPL) measured at a distance of 100 m from the devices was 112 dB re 1 uPa for the WET-NZ and 110 dB re 1 uPa for the Ocean Sentinel. Although the measurements were obtained during a low sea state, the measured sound pressure levels did not exceed exposure thresholds provided in the ITS.*

2.5 ELECTROMAGNETIC FIELDS

2.5.1 Monitoring Summary

Monitoring electromagnetic fields (EMF) for marine renewable energy is a newly emerging application, and mission-specific instrumentation is needed. NNMREC has designed, and originally planned to use, an advanced 2nd generation EMF monitoring instrument to characterize the ambient EMF at the project site and measure the EMF during an energized WEC test. For reasons discussed in the EMF Monitoring Report (Attachment 4), we executed the 2012 EMF survey using the 1st generation, rather than 2nd generation EMF instrument. Functionally, however, all EMF monitoring goals as originally identified for this survey were met by using the 1st generation EMF system.

The EMF monitoring was performed to 1) evaluate the ability to detect EMF generated from the project and 2) measure the levels produced at various distances. The 2-day survey was conducted on September 20 – 21, 2012, at which time the WET-NZ device was in operation, presumably actively generating and dissipating power on the Ocean Sentinel. The sea state was so low, however, that the peak power output of the WET-NZ on Day 1 of the survey was 40 watts, with zero watts being more characteristic. Day 2 was an even lower sea state day than day 1. Although the sea state was extremely low, ocean surface currents carried the survey vessel too close to project structures to safely deploy the EMF sensor closer than about 45 m from indicated midpoint. As a result, the survey team used somewhat greater standoff distances from the devices than originally planned, and a small number of survey points closest in to the midpoint of the survey grid were omitted.

Data analysis reveals that the predominant electrical and magnetic frequencies observed are at 1 Hz are due to the EMF instrumentation system itself, and frequencies observed at 38 Hz are likely due to the boat used to deploy the EMF instrumentation system. However, as discussed in the EMF Monitoring Report, the 38 Hz modulation remains of indeterminate cause. EMF frequencies observed at 10 – 11 Hz are unidentified as of yet, but may be associated with the Ocean Sentinel or WET-NZ. As described in the study plan, NNMREC anticipated performing the "operational" (i.e., during deployment of energized WEC device) survey in September 2012, followed by a "baseline" (i.e., WEC not present or not energized) survey in 2013. Given the low sea states during the survey period, however, it is possible this data could be considered an ambient baseline survey rather than an operational WEC survey. Per discussions with NMFs and ODFW in June 2013, NNMREC will coordinate a meeting with the agencies to further evaluate the 2012 EMF survey findings and determine whether they could be considered as baseline data. Since no WEC tests are planned for 2013, the 2nd generation EMF instrumentation system is being optimized for future surveys, and further review of the 2012 survey results may be warranted, NNMREC does not plan to conduct an EMF survey in 2013.

Considerations for Future Monitoring

The AMF provides that NNMREC will: 1) validate the effectiveness of an EMF Propagation Model and assess its efficacy in measuring EMF for future tests and recommend modifications to the model, if necessary; and 2) consider both the ability to detect and the level of EMF from the project devices and determine whether there is a meaningful source of EMF from the Project. These considerations are discussed in the Conclusion of the updated EMF report, which is provided in Attachment 4. Additionally, NNMREC proposed the following considerations for future EMF monitoring:

- *Closer coordination with the NNMREC test facility manager with regards to the data logging capabilities onboard the Ocean Sentinel, as well as better advance knowledge of the predicted electric characteristics of the grid simulator and WEC under test.*
- *Maintain at least 1 kHz continuous sampling of voltages and currents onboard the Ocean Sentinel to provide source waveforms that we can then correlate against for our sea floor measurements.*
- *Care must be taken to avoid or to digitally filter instrument-induced or ship-related noise from baseline and WEC-related EMF measurements.*
- *Perform EMF time-series measurements at fixed locations, as well as spot measurements over a survey grid. If measurements are taken only when the sea-state is calm, the WEC may not be producing maximum output. To compensate, continuous seafloor monitoring should be considered to measure engineering state-of-health of shielding and connectors and to obtain measurements over a broad range of sea states and WEC output levels.*

- *Investigate geologic characteristics (using existing information or a survey of the seafloor) to determine the potential influence of geology on propagation of EMF at the NETS.*
- *Develop and maintain a compendium of relevant EMF studies/analysis to help inform study plan development and survey analysis for future WEC tests. The 2012 EMF Study[3] sponsored by OWET and the references provided in the Ocean Renewable Energy knowledgebase[4] could serve as starting points for this information set.*

2.5.2 Adaptive Mitigation Thresholds: 2012 Test

Post monitoring data analysis was completed within the 90 day period originally stipulated, and the results were written up in a summary that was submitted with the Annual Report on November 30, 2012. Additional analysis was provided to the Adaptive Management Committee in the form of a PowerPoint presentation, which was shared at the Annual Meeting in January 2013 and archived in the online project folder. In addition, an updated report is provided in Attachment 4.

The 2012 AMP provides that if monitoring results indicate that EMF attributable to the project components is in excess of levels known to have an adverse impact on marine life, NNMREC will develop and implement a response plan that outlines the appropriate mitigation action any 2013 Ocean Sentinel/WET-NZ test. Given the post-monitoring analysis necessary for EMF, results were not available during the test period and, therefore, no mitigating actions were required.

- *No WEC tests are proposed for 2013; therefore, NNMREC proposes to coordinate with NMFS and ODFW to further evaluate an EMF propagation model and develop a refined study plan by December 31, 2013.*

2.5.3 Adaptive Management Thresholds

As with the 2012 AMP, the AMF provides that if monitoring indicates that EMF attributable to the project components is in excess of levels known to have an adverse impact on marine life, NNMREC will develop and implement a response plan that outlines the appropriate mitigation action. Monitoring results do not indicate EMF attributable to the project components that is in excess of levels known to have an adverse impact on marine life.

- *NNMREC recommends that this threshold remain in place for future tests.*

2.5.4 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 m radius that is attributable to the project components is the

[3] Available at http://www.oregonwave.org/wp-content/uploads/OWET-EMF-on-Marine-Species_FINAL_Full_web1.pdf

[4] Available at http://www.oceanrenewableenergy.com/content/electromagnetic-fields#References

level that has been documented to have an adverse impact on marine life. NNMREC conducted monitoring during the 2012 deployment to characterize the EMF generated by the project, including measurements taken at a distance of 500 m from the WET-NZ and Ocean Sentinel devices.

- *Monitoring data and analysis of measurements taken at various distances from the project structures indicate that EMF attributable to the project did not reach measurable levels within a 500 m range. Although the measurements were obtained when the WET-NZ was in a low- to de-energized state, there were no detectible EMFs associated with the project; therefore, the exposure threshold for EMF levels was not exceeded.*

3 Future Test Plans

NNMREC plans to conduct short-term, scientific research at NETS in 2013 to: 1) optimize the Ocean Sentinel instrumentation buoy; 2) conduct a mooring system study; and 3) monitor environmental conditions within and near the project site. Project structures include the Ocean Sentinel instrumentation buoy, the TriAXYS wave measurement buoy, associated anchors and mooring systems, and environmental monitoring equipment. Research activities include optimizing the Ocean Sentinel instrumentation buoy's onboard systems (communications, data acquisition, monitoring systems, etc.). A mooring system study is also planned, utilizing inline load cells on the Ocean Sentinel mooring lines to capture line tensions in various sea states. Data from these activities will be utilized to optimize the Ocean Sentinel for future WEC tests and to validate mooring system designs. In addition, benthic and acoustics monitoring will be conducted, as well as a potential Remotely Operated Vehicle (ROV) survey. Activities planned for 2013 do NOT involve deployment of any WEC devices. A complete description of the planned activities will be provided in the 2013 Research, Monitoring and Adaptive Mitigation Plans, which will be shared with the Committee.

4 Overall Conclusions & Recommendations

As discussed at the annual meeting and in various sections of this report, NNMREC did not do the best job on reporting monitoring data. To address these issues and ensure better coordination in the future, NNMREC has hired an Environmental Compliance Manager. NNMREC proposes to convene a meeting with the Committee and the Compliance Manager to collectively review the modifications presented in this report and make any necessary changes to the AMF.

4.1 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 2012 test. NNMREC recommends that the adaptive mitigation thresholds and measures for future tests consider the potential modifications discussed in Section 2 of this report.

4.2 Adaptive Management Thresholds

The thresholds and measures provided in the AMF are designed to consider single- and multi-year data from the test center. However, only 2012 test data are considered in this report since it was the first year of test center operations. As discussed in Section 2, none of the adaptive management thresholds were triggered during the 2012 test period; accordingly, no adaptive management measures were implemented. Considerations for potential modifications to the General Procedures for Derelict Gear are discussed in Section 2.2.3. As noted above, NNMREC proposes to coordinate with the AMC to collectively review and consider any changes to the Adaptive Management Framework.

4.3 Annual Report & Review Process

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 could be performed at the next Annual Meeting (in January 2014); regardless, any modifications to the Annual Report & Review Process should be made prior to the next WEC test.

Attachment 1: Benthic Report

Benthic Conditions at the Northwest National Marine Renewable Energy Center Ocean Test Facility

Provided by:

Sarah K. Henkel

Hatfield Marine Science Center

Oregon State University

Submitted: December 21, 2012

Revised: May 7, 2013

Background

Potential impacts from wave energy conversion (WEC) device installation and operation on marine ecosystems are not well understood and remain an important environmental concern for the developing marine hydrokinetic renewable energy industry. On August 22, 2012 the Northwest National Marine Renewable Energy Center (NNMREC) at Oregon State University (OSU) conducted a WEC test the ocean test facility off the coast of Newport, Oregon (Figure 1), which involved deployment of the WET-NZ WEC device, the Ocean Sentinel instrumentation buoy, anchors and mooring systems. The test site is located approximately along the 'b' transect between the 40 m and 50 m benthic sampling stations (Figure 2). Sampling has been conducted at this site for two years (2010 – 2011) to characterize benthic conditions, fish, and invertebrates. Detailed baseline observations for 2010 and 2011 can be found in the report submitted to the Oregon Wave Energy Trust available at www.oregonwave.org. Pre-installation sampling was conducted in June 2012 prior to deployment of WET-NZ, Ocean Sentinel, anchors and mooring systems. Surveys were again conducted during the deployment and after removal of the devices, anchors and mooring systems. The main objective of these measurements was to determine if sediment characteristics, invertebrate, and/or fish assemblages differed during the deployment of the devices or after removal, as compared to previous observations. This report details observations from 2012 and compares patterns and metrics to 2010 and 2011 findings.

Figure 1: The WET-NZ device and nearby Ocean Sentinel buoy deployed at the NNMREC/OSU ocean test facility off the coast of Newport, Oregon.

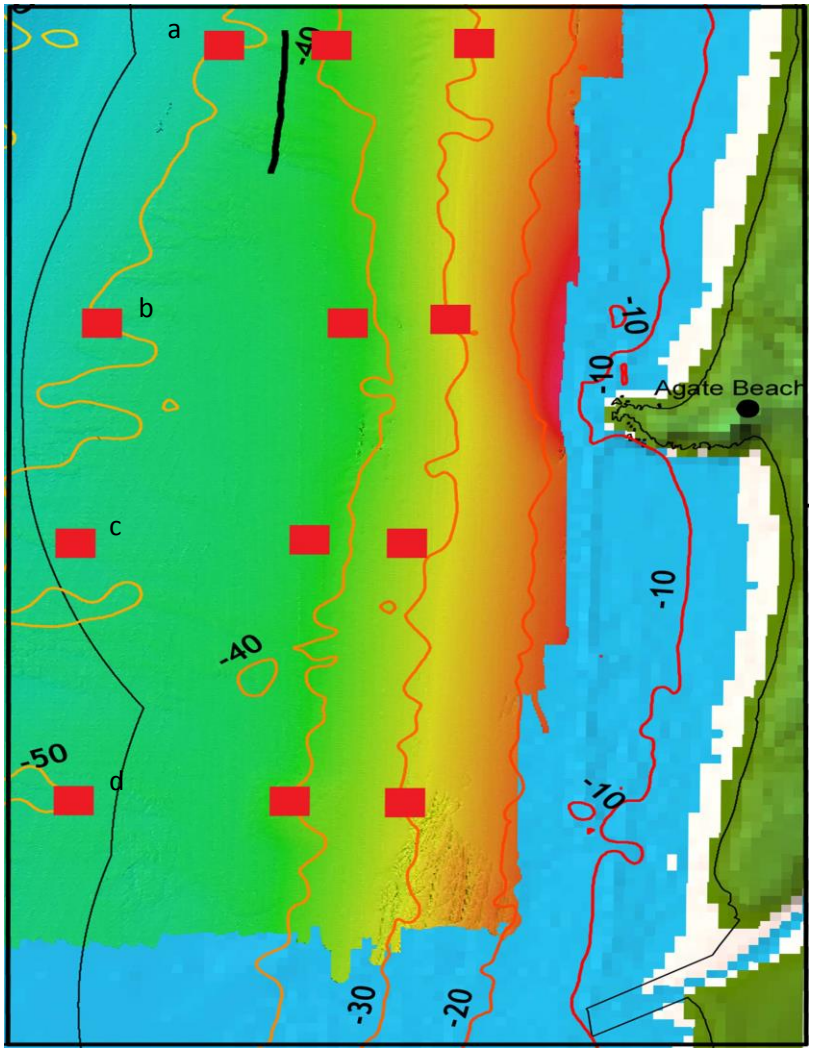


Figure 2: Twelve sampling stations off Newport, Oregon, near the NNMREC/OSU Ocean Test facility. Transects are labeled a – d, north to south.

Methods

An overview of survey types and dates are provided in the table below.

Table 4: 2012 Benthic Monitoring Surveys

	Pre-Installation			*During Deployment*		*Post-Installation*	
Box Core	6/9/12			8/24/12		10/12/12	
Beam Trawl	6/29/12			9/27/12		11/15/12	
Videography	7/19/12			9/17/12	9/18/12		
CTD Cast	6/19/12	6/29/12	7/19/12	8/24/12	9/27/12	10/12/12	11/15/12

Box Coring

Infaunal invertebrates and sediment for grain size and total organic carbon samples were collected using a modified Gray-O'Hare 0.1 m^2 box core (Figure 3). Two grabs were taken at each of the 12 stations (Figure 2). These two grabs were not used as replicates for each station but rather were used to investigate fine scale spatial variability in the samples. Upon landing the box corer on the boat, a sub-sample of sediment was taken from the undisturbed top layer of the collected sample. The remaining sediment was sieved onboard through a 1.0 mm screen in order to collect all organisms greater than 1 mm. Collected organisms were preserved in 5 % buffered formalin.

Upon return to the laboratory, rose Bengal was added to the samples in buffered formalin to stain the organisms. After 48 hours samples were transferred to 70 % ethanol. Benthic infauna were sorted into major taxonomic groups and identified by trained laboratory staff using a stereomicroscope and, when necessary, a compound microscope. 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. Additional sediment sub-samples were analyzed for percent total organic carbon.

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 4). Tows were conducted for five 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 June and September 2012 (transects 'a' through 'c'). Those stations on the southern-most transect lie at the edge of a reef, and it is too risky for the net and the reef organisms to sample those stations. In November 2012, adverse weather prevented the completion of the survey and only seven stations were sampled. 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 4: Beam trawl used for capturing juvenile groundfish and epibenthic invertebrates.

Videography

The video lander was deployed on July 19, 2012 (prior to device installation) at the four stations that would become future reference stations, as well as at the site of the planned installation location of the Ocean Sentinel and WET-NZ. The lander was dropped off the stern and allowed to remain on the bottom for ten minutes. After this time the lander was brought back aboard the vessel and the video was transferred to a computer. In collaboration with the National Renewable Energy Laboratory (NREL) and the Navy Facilities Engineering Command (NAVFAC), the devices, mooring systems and seafloor were surveyed with an ROV September 17 – 18, 2012. An overview of and pictures from the ROV survey are provided in Appendix B to this report.

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).

Data Analysis

Environmental Variability

Two-way ANOVAs were used to investigate differences in individual physical characteristics across depth at the site and over time (from June 2010 to October 2012). Tukey's HSD *post hoc* tests were used to

identify specific differences over time, particularly before, during, and after the WET-NZ/Ocean Sentinel deployment.

Box Core and Trawl Assemblages

For species assemblage analyses (conducted separately for box core invertebrates and trawl fishes), taxa for which there was just one individual collected for the entire dataset were removed so as not to skew the data based on rare species. Shannon–Weaver diversity (H') was calculated for each sample. Indices were compared using two-way ANOVAs with the factors depth and month (from June 2010 to October 2012). Tukey's HSD *post hoc* tests were used to identify specific differences over time, particularly before, during, and after the 2012 deployment.

Data were square root transformed for the following multivariate analyses. Cluster analysis was conducted on the transformed density datasets for each 'assemblage' (infaunal invertebrates from box cores and fish from trawls) 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. MDS is an ordination technique where a small number of axes are selected prior to analysis and data are fitted to those dimensions, but no axes are hidden from variation (Holland 2008). 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. Following MDS analysis of the organism data, the BEST function in Primer was used. The BEST function is based on the BIO-ENV procedure, which uses all the available environmental variables to find the combination that corresponds best to the patterns in the biological data.

Fish Condition and Gut Contents

Collected flat fish larger than or equal to 90 millimeters were measured for total length and weighed. After weighing and measuring the fish, their guts were dissected and weighed for stomach fullness; their guts were then excised, and gut contents weighed. These guts were then dissected and emptied of their contents. These contents were weighed and identified to the lowest taxonomic level using a stereomicroscope.

Body condition (which indicates overall growth and relatively long-term feeding history) of the fish was determined using Fulton's K-value (K = 100 (W/L^3) where W is the body mass in milligrams and L is the total length). Fulton's K value is a morphometric index using weight and length of a fish, assuming heavier fish for a given length are healthier fish, as an indication for its condition. The prey frequency was expressed as a frequency of occurrence, or the number of times the prey occurred compared to the total number of guts analyzed.

Results

Box Coring

Physical Characteristics

The median grain size of the sampling stations over the course of the study ranged from 188 µm to 687 µm. Significantly smaller ($p < 0.001$; average = 202.1 µm) median grain sizes were found at the 30 m stations, while larger grain sizes (average = 332.2 µm) were found at the 40 and 50 m stations with no significant differences between 40 m and 50 m ($p = 0.9983$). **No statistically significant differences across all sampling months from June 2010 through October 2012 were detected ($p = 0.7450$)**. While no significant differences were found over time, the most (seasonal) variability in median grain size was observed at the 50 m stations (Figure 5; black line), which is outside the Ocean Sentinel and WET-NZ device deployment depth. The same patterns were found in the percent silt/clay in the sediment with significant differences across depth ($p = 0.0002$) but not over time ($p = 0.3434$). Overall, silt/clay percentages were low with all stations being comprised of 80 to 100 % sand.

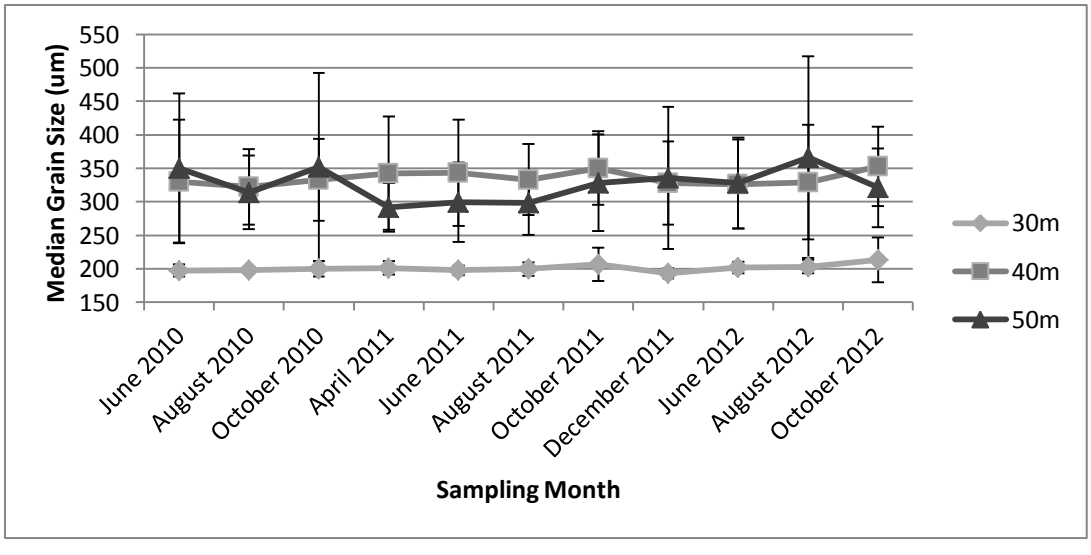


Figure 5: Median Grain Size of collected sediment. Values are averages (with standard deviation) of 8 grabs at each depth. Sediment characteristics during testing (August 2012) and after device removal (October 2012) were not different from observations during the two prior years of baseline sampling.

Infaunal Invertebrates

The diversity (H') of infaunal invertebrates collected from the site in June 2012 (prior to deployment of the devices) was not significantly different from 2011 ($p = 0.9999$) or 2010 ($p = 0.9999$) (Table 5). In August 2012 (during deployment), the overall diversity of invertebrates was lower than that observed in August 2011 ($p < 0.0001$) and 2010 ($p < 0.0001$) and was also different than observed in June 2012 (prior to deployment; $p < 0.0001$) and October 2012 (after removal; $p = 0.0021$). Likewise, October 2012 diversity was lower than October 2011 ($p = 0.0003$) and 2010 ($p < 0.0001$). **Although infaunal invertebrate diversity was lower in August and October 2012 than previously observed, this was not due to loss of species**. The numbers of species (S) collected in during and after operations were actually the highest (Table 5). The reduction in Shannon-Weaver diversity values was due to the presence of unusually large numbers of the polychaete worm, *Spiophanes norrisi*, dominating the assemblage.

Table 5: Infaunal invertebrate diversity (Shannon-Weaver H', log base e) and number of species (S); values are means of 24 grabs at 12 stations for each sampling time.

		2012	***2011***	***2010***
June	H’	2.264	2.318	2.359
	S	23.2	17.9	20.6
August	H’	1.200	2.565	2.456
	S	23.3	20.5	19.6
October	H’	1.623	2.246	2.507
	S	26.6	18.4	22.4

Cluster analysis revealed that the species present at the 40 and 50 m stations in June 2012 were indistinguishable from those collected throughout 2010 and 2011. However, the assemblage of invertebrates collected from the 30 m stations in June 2012 was unique, as we began to observe recruitment of the polychaete, *Spiophanes norrisi*. Invertebrates collected in August and October 2012 formed clusters that were separate from previous collections but were interspersed with each other, indicating that the organisms found in August and October 2012 were similar to each other. Again, these patterns were due to recruitment of *Spiophanes norrisi,* which was the dominant species at all twelve sampled stations from the Newport north jetty to Beverly Beach.

The BEST function indicated that the highest resemblance between the ordination of the stations based on the biological variables (infaunal invertebrate densities) and the ordination of the stations based on the environmental variables was achieved when just two of the environmental variables were used: depth and median grain size. This resulted in a correlation of 0.581.

Trawling

In general (patterns from 2010 to 2012), fish diversity and number of species are moderate in summer (May – September) when flatfish (specked sanddab, English sole, butter sole, and Pacific sanddab) dominate the catch, highest in October when the summer flatfish as well as poacher (pricklebreast, tubenose, and warty) and sculpin (Pacific staghorn) species are present, and lowest in winter (November and December) when flatfish are rare and whitebait smelt and Pacific tomcod dominate the catch.

Fish collected in June 2012 (prior to deployment) were not significantly different in diversity than fish collected in June 2011 ($p = 0.1928$) or 2010 ($p = 0.3077$) (Table 6). Due to weather conditions and gear issues, we were not able to collect fish in August and October as we had in 2011 and 2010. Instead, we collected fish during device testing in September 2012 and after removal in November 2012. **Fish collected in September 2012 (during deployment) were not different in diversity from collections made in August 2011 (p 0.9660) and August 2010 ($p = 1$), nor were the number of collected species different ($p = 0.3553$ vs. August 2011; $p = 0.9999$ vs. August 2010)** (Table 6).

Fish collected in November 2012 were significantly lower diversity and number than seen in October 2011 ($p_{H'}$ = 0.0014; p_S = 0.0006) and October 2010 ($p_{H'}$ = 0.0056; p_S = 0.0036) (Table 6). **In November 2012, fish collected were higher in diversity but not significantly different in diversity or number than December 2011** ($p_{H'}$ = 0.8103; p_S = 0.9999) (Table 6), indicating that the November collection is more similar to the winter assemblage observed in December 2011 than the fall assemblages observed in previous Octobers. Lists of fish and epi-faunal invertebrate species and their numerical abundances for the 2012 survey are in Appendix A. The OWET report lists all species collected 2010-2011.

Cluster and multidimensional scaling analyses indicated that in terms of species composition and number, fish collected in 2012 did not form any unique assemblages but rather clustered with fish collected in previous years (Figure 6).

Table 6: 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.

		2012	***2011***	***2010***
February	H' S		1.470 7.3	
May	H' S		1.474 6.7	
June	H' S	1.558 6.9	1.114 5.3	1.176 6.8
August	H' S		1.457 7.8	1.288 6.2
September	H' S	1.264 5.8		
October	H' S		1.823 8.7	1.798 8.4
November	H' S	1.137 4.6		
December	H' S		0.865 5.0	

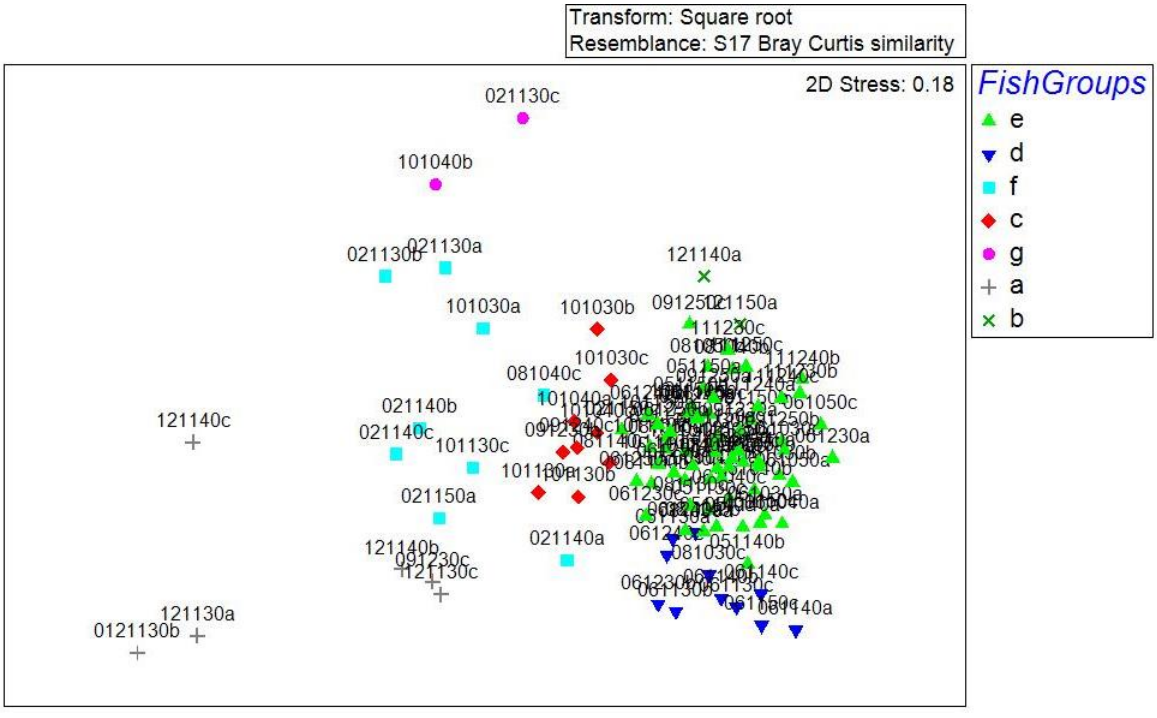


Figure 6: Multidimensional scaling plot of fish species assemblages collected at the NNMREC/OSU Ocean Test Facility location from 2010 to 2012. Data labels codes are the month, year, depth, and transect from which the collection was made. For example: 121140a is the sample collected in December 2011 at 40 m at the 'a' (northernmost) transect (the Ocean Test Facility lies along the 'b' transect). It is not possible to distinguish the 2012 samples from others, indicating that the species assemblages before, during, and after the WET-NZ/Ocean Sentinel test were not different than previously collected.

Fish Gut Content Analysis

Numbers of fish collected in June 2012 (before deployment) that met the criteria for gut content analysis (≥ 90 mm) were too low to be analyzed and compared to previous June collections. **Fish collected in September 2012 (during deployment) had similar diversities of prey found in the guts in previous late summer collections (August 2010 and August 2011;** Table 7**).** All sampled flatfish species had crab larvae or juvenile crab parts, Crangon shrimp, mysid shrimp, and polychaete worms in their guts. English and butter sole had more diverse diets than sanddabs with greater frequency of molluscs (both bivalves and gastropods), sand dollars, and brittle stars in their guts.

Table 7: Number of unique prey types found in guts of 5 flatfish species using fish > 90 mm total length

	Butter Sole	English Sole	Pacific Sanddab	Sand sole	Speckled sanddab
Aug 30, 2010	16	16	3	4	6
Aug 21, 2011	9	11	9	3	12
Sept 27, 2012	9	17	12	3	9

Videography

In the laboratory, each video taken from the lander in July 2012 (prior to device installation) was reviewed but no fish counts were conducted since we used a different videographic method during the deployment of the Ocean Sentinel and Wet-NZ devices. Video obtained from the ROV survey in September 2012 (during deployment) indicated that the expected flatfish and occasional poachers, Dungeness crabs, and sea stars (all appeared to be *Pisaster brevispinus*) were found in the sedimentary habitat surrounding the anchors of the devices at approximately 42 m depth. A skate was observed in the footage from 18 September. A large *Pycnopodia helianthoides* (sunflower star) was observed on one of the anchors, and there appeared to be tubeworms that had colonized the anchor block. Surrounding the concrete anchors, there appeared to be a lot of shell hash. The ROV traveled up the anchor chains to the subsurface floats at approximately 24 m depth. Many unidentifiable fish were observed around the subsurface floats. No fishing or other gear appeared to be entangled in the anchor chains or cables. These videos have been reviewed and observations reported; however, organisms have not been quantified since regular transects were not conducted.

Water Column Sampling

Monthly and depth-wise differences were observed in water column parameters such as temperature, salinity, dissolved oxygen, and pH as expected (Figure 7). **Temperature, salinity, and dissolved oxygen values for August 2012 (during operation) did not differ significantly from values measured in August 2011.**

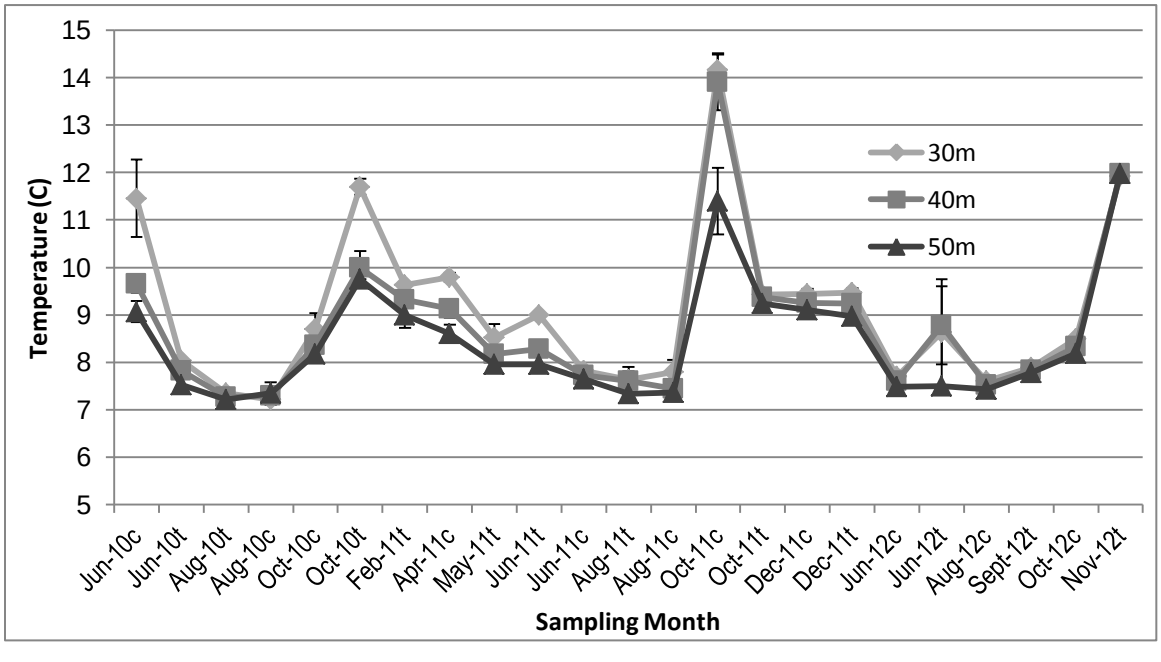


Figure 7: Temperature measured at the bottom of the CTD cast to approximate conditions at the seabed. X-axis labels are month of sampling followed by 'c' or 't' to indicate samples were taken while coring or trawling.

Conclusions

Physical conditions at the twelve established sampling stations during operations and after removal of the devices did not vary from observations made in the same seasons in previous years. The benthic infaunal invertebrate assemblages collected from the twelve stations in August and in October 2012 were different than previously observed at the site during OSU sampling since 2010. However, this was not due to any loss of species but rather due to the recruitment of one species of polychaete worm (*Spiophanes norrisi*; which was previously found at the site but in lower density). Such large recruitment events are not unprecedented, as similar recruitment events were recorded in the area in 2008 and 2000 by U.S. Army Corps of Engineers sampling of dredge disposal and reference locations off Newport, Oregon. Further, since large numbers of the polychaete were first observed in June 2012 (densities approximately 10-fold higher than observed in 2010 and 2011), and then later seen with even higher densities in subsequent months at all stations (not just those near the test facility), we do not attribute this recruitment to the installation of the devices. Since no change to the sediment characteristics and no loss of species were observed, we conclude that the device installation, operations, and removal did not affect the infaunal assemblages surrounding the site. However, since no collections were made within the boundaries of the installation, we cannot determine if there were near-field effects on the sediment and infauna. The shell hash observed around the anchors in the ROV footage may indicate some very localized changes to the sediment character with potential effects on infauna.

Fish assemblages at the nine sampling stations were not different from those collected at the reference stations in similar seasons in previous years. Thus, we conclude the device installation, operations, and removal did not affect the fish assemblages in sedimentary habitats surrounding the site. Furthermore, no unusual species or numbers of fish were observed around the anchors on the ROV footage. Since a number of fish were observed on the ROV footage around the subsurface floats and fishermen did report the presence of large numbers of rockfish and salmon surrounding the WET-NZ buoy (but not around the Ocean Sentinel buoy), vertical components of the devices in the water column may be serving as fish attraction devices.

Considerations for Future Monitoring

As a lack of seasonal variability in sediment characteristics and infaunal assemblages has been established, future sampling for this community could be performed less frequently. Sediment-only collection can be executed more quickly and under a wider range of conditions, and processing can be done within a week. Because infaunal organisms' distributions are closely tied to depth and sediment characteristics, a potential modification to future monitoring would be to sample sediment only. If a change in sediment characteristics is detected, or other information indicates a need, then infaunal organisms then could be sampled to look for changes in species densities or distributions. 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 the collaboration of Dr. Waldo W. Wakefield of NOAA and Dr. Lorenzo Ciannelli of OSU. We would also like to acknowledge Captain Mike Kriz and Kody of the R/V Elakha aboard which all benthic collections were carried out and the captain and crew of the R/V Pacific Storm aboard which the ROV surveys were carried out.

References

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

Holland, S.M. 2008. Non-metric multidimensional scaling (MDS). Department of Geology, University of Georgia, 1-7.

Appendix A: Trawl Species Lists

Table 8: Numerical abundance of fish collected in 2012 beam trawl samples. *Reduction in sanddab spp. from June to September and increased numbers of speckled and Pacific sanddab is because fish were larger and able to be identified to species. The same transition is the case for smelt. Some reductions in total fish caught from summer to November are due to only conducting 7 tows, rather than the usual 9, due to inclement weather.

Common Name	Latin Name	Jun-12 (Before)	Sep-12 (During)	Nov-12 (After)
Butter sole	*Isopsetta isolepis*	130	20	6
English sole	*Parophyrs vetulus*	77	47	56
Speckled sanddab*	*Citharichthys stigmaeus*	80	149	65
Pacific sanddab*	*Citharichthys sordidus*	9	35	23
Sanddab spp.*	*Citharichthys spp*	36	7	3
Sand sole	*Psettichthys melanostictus*	37	7	1
Pacific Tomcod	*Microgadus proximus*	43	46	0
Pacific sandlance	*Ammodytes hexapterus*	3	4	0
Whitebait smelt	*Allosmerus elongatus*	0	12	0
Juvenile smelt	*Osmeridae spp.*	2	0	0
Pacific staghorn sculpin	*Leptocottus armatus*	1	3	0
Showy snailfish	*Liparis pulchellus*	1	0	0
snailfish sp.	*Liparidae spp.*	2	0	0
Warty poacher	*Chesnonia verrucosa*	5	0	1
Tubenose poacher	*Pallasina barbata*	0	0	2
Big skate	*Raja binoculata*	0	1	2
Spotted ratfish	*Hydrolagus colliei*	0	1	0
Rex sole	*Glyptocephalus zachirus*	1	0	0
Dover sole	*Microstomus pacificus*	0	1	0
Bay pipefish	*Syngnathus leptorhynchus*	0	1	1
Canary rockfish	*Sebastes pinniger*	0	1	0
Black rockfish	*Sebastes melanops*	0	0	0
		(Summer)	(Summer)	(Winter)

Table 9: Numerical abundances of epi-benthic invertebrates collected in 2012 beam trawl samples. Some reductions in total individuals caught from summer to November are due to only conducting 7 tows in November, rather than the usual 9, due to inclement weather.

Common Name	Latin Name	Jun-12 (Before)	Sep-12 (During)	Nov-12 (After)
Crangon shrimp	*Crangon alaskensis*	34	13404	193
Crangon shrimp	*Crangon stylirostris*	0	4476	1389
Crangon shrimp	*Crangon franciscorum*	27	6	18
Crangon shrimp	*Crangon alba*	0	19	0
Mysid (opossum) shrimp	*Neomysis kadiakensis*	1787	8147	29
Mysid (opossum) shrimp	*Pacifacanthomysis nephrophthalma*	999	397	7
Mysid (opossum) shrimp	*Alienacanthomysis macropsis*	0	30	0
Mysid (opossum) shrimp	*Disacanthomysis dybowskii*	0	8	0
Mysid (opossum) shrimp	*Archaeomysis grebnitzkii*	0	2	0
Side-striped shrimp	*Pandalopsis sp*	19	10	0
Broken-back shrimp	*Heptacarpus sp*	34	1	0
Krill	*Thysanoessa spinifera*	1	1	0
"Other" Shrimp	*Decapoda*	154	14	2
Crab larvae	Crab zoea	146	0	0
Crab larvae	Crab megalope	445	131	0
Dungeness crab juvenile	*Metacarcinus magister* juvenile	358	166	21
Dungeness crab adult	*Metacarcinus magister* adult	7	5	0
Hermit crab	*Pagurus sp.*	97	96	35
Amphipods	*Amphipoda*	214	55	44
Cumacea	*Cumacea*	268	805	14
Isopods	*Isopoda*	65	37	4
Sea pen	*Ptilosarcus gurneyi*	0	0	3
Sea anemone	*Actinaria sp.*	129	0	0
Sea cucumber	*Paracaudina chilensis*	5	3	6
Sand dollar	*Dendraster excentricus*	5	27	1
Short-spined (pink) sea star	*Pisaster brevispinus*	8	3	7
Mud/sand star	*Luidia foliolata*	0	1	0
Sunflower star	*Pycnopodia sp.*	0	0	0

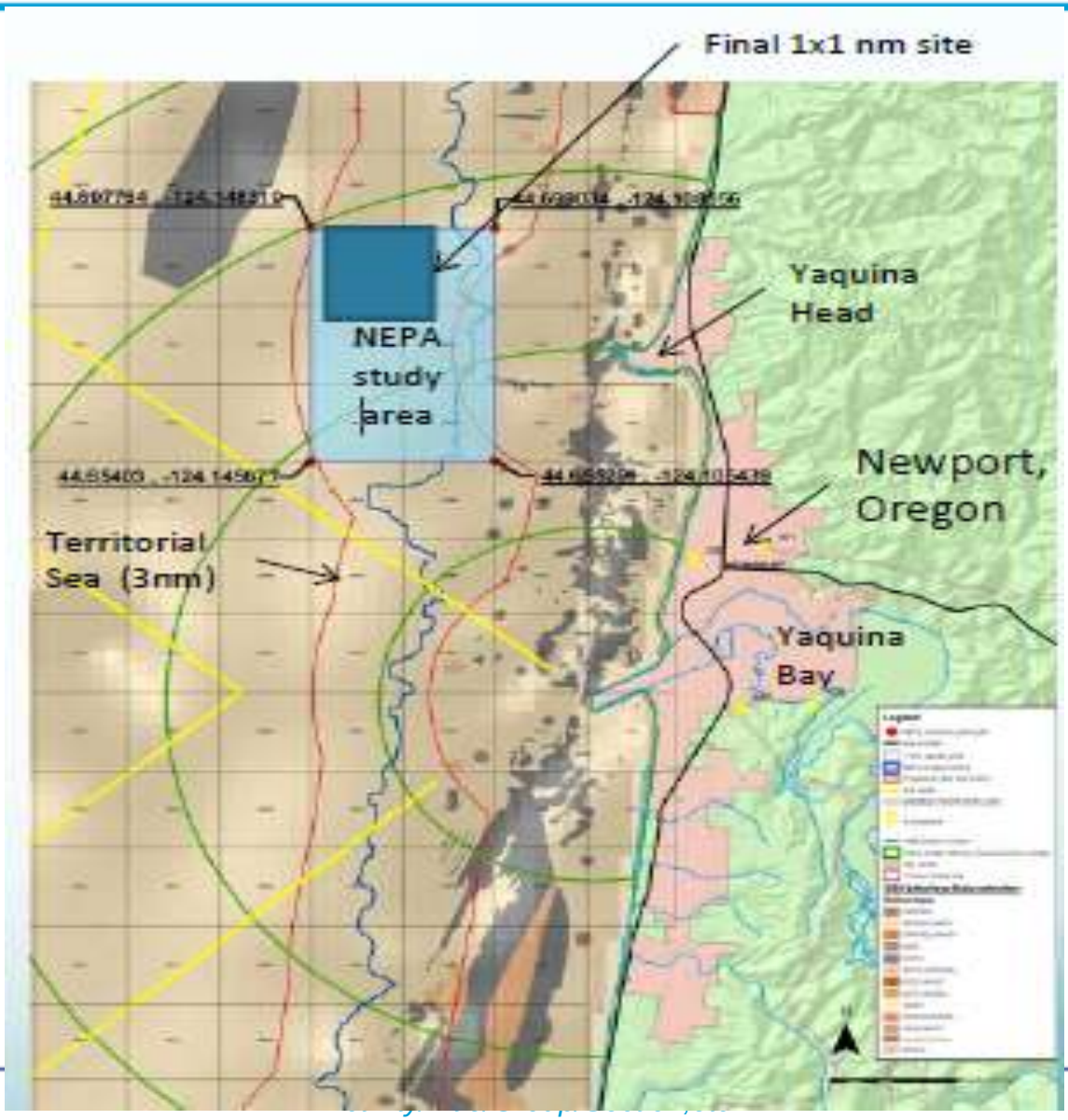
NAVFAC
Naval Facilities Engineering Command
ENGINEERING AND EXPEDITIONARY WARFARE CENTER

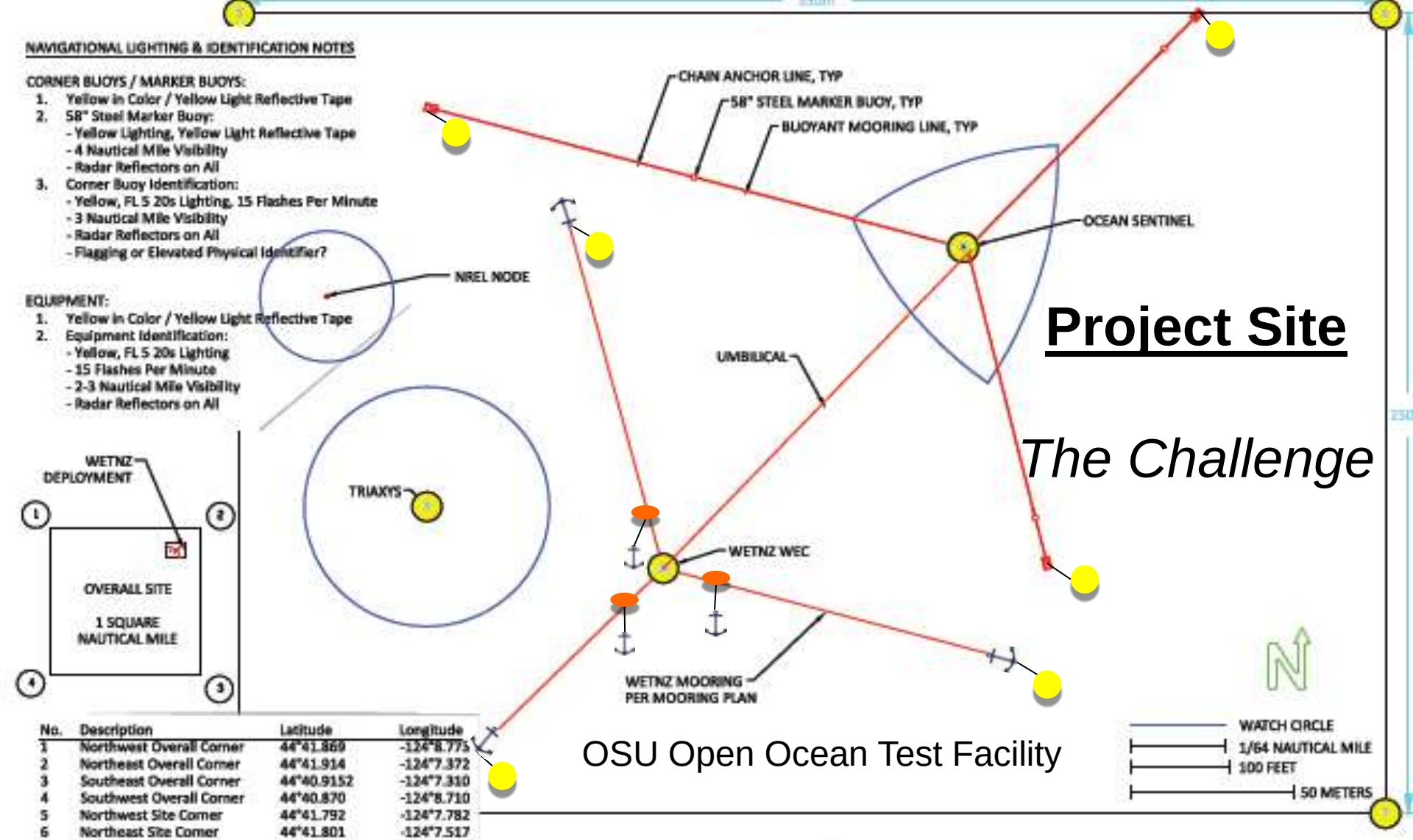
Oregon State University (OSU) Ocean Sentinel & WET-NZ Mooring Inspections

EXWC PHANTOM Remotely Operated Vehicle (ROV) Operations

David Wicklund
EXWC
9/19/12
(805) 982-1191

Newport, Oregon OSU Open Ocean Test Facility





No.	Description	Latitude	Longitude
1	Northwest Overall Corner	44°41.869	-124°8.775
2	Northeast Overall Corner	44°41.914	-124°7.372
3	Southeast Overall Corner	44°40.9152	-124°7.310
4	Southwest Overall Corner	44°40.870	-124°8.710
5	Northwest Site Corner	44°41.792	-124°7.782
6	Northeast Site Corner	44°41.801	-124°7.517
7	Southeast Site Corner	44°41.666	-124°7.509
8	Southwest Site Corner	44°41.657	-124°7.773
9	TriAXYS Buoy	44°41.711	-124°7.734
10	WetNZ Device	44°41.702	-124°7.678
11	Ocean Sentinel Buoy	44°41.759	-124°7.613
12	OS – NW Anchor	44°41.778	-124°7.737
13	OS – NE Anchor	44°41.800	-124°7.561
14	OS – SE Anchor	44°41.706	-124°7.561
15	WetNZ – NW Anchor	44°41.759	-124°7.704
16	WetNZ – SE Anchor	44°41.690	-124°7.596
17	WetNZ – SW Anchor	44°41.658	-124°7.735
18	NREL Node	44°41.746	-124°7.760

DESIGNER: SEAN MORAN, PE | QA: REVIEWED BY STM | TEMPLATE #: STANDARD

DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED. LINEAR TOLERANCES ARE: X ±0.1, X.X ±0.03, X.XX ±0.01, X.XXX ±0.003. ANGULAR TOLERANCES ARE: X.X ±0.1°, X.XX ±0.05°. MATERIAL: — FINISH: —

NORTHWEST NATIONAL MARINE RENEWABLE ENERGY CENTER, OREGON STATE UNIVERSITY

MOBILE OCEAN TEST BERTH

WETNZ NAVIGATIONAL LIGHTING & MOORING PLAN

SCALE: NTS | DRAWN BY: STM | DATE: 08/08/12

OSU WETNZ NAV LIGHT PLN | Sheet 1 of 1 | SIZE A | DRAWING NUMBER WETNZ6 | REV 06

Challenge Accepted

Successfully inspected Ocean Sentinel and WET-NZ anchors, bottom of WET-NZ buoy, WET-NZ clump anchors, mooring lines and nearby seafloor - 9 anchors (3 embedment and 6 clump)

1. WET-NZ SW drag embedment anchor and surrounding seafloor, mooring line to subsurface float, clump anchor line down to clump anchor, and clump anchor and surrounding seafloor.
2. WET-NZ SE drag embedment anchor and surrounding seafloor, mooring line to subsurface float, clump anchor line down to clump anchor, and clump anchor and surrounding seafloor.
3. Bottom of WET-NZ buoy
4. Ocean Sentinel NE clump anchor and surrounding seafloor.
5. Ocean Sentinel SE clump anchor and surrounding seafloor.
6. Ocean Sentinel NW clump anchor and surrounding seafloor.
7. WET-NZ NW drag embedment anchor and surrounding seafloor, mooring line to subsurface float, clump anchor line down to clump anchor, and clump anchor and surrounding seafloor.

Schedule

Fri, 14 Sept: Checked-in with OSU Ship Operations, OSU project and R/V Pacific Storm personnel. Finalized schedule and logistics.

Sat, 15 Sept: Moved R/V Pacific Storm from commercial Dock 5 to OSU Ship Operations dock. Loaded all equipment onto the R/V Pacific Storm. Ship moved back to commercial Dock 5. Set up ROV, TrackPoint3 USBL subsea navigation system, and depressor weight. Conducted dry test of ROV. Launched ROV and conducted wet test in the harbor while ship tied dockside.

Sun, 16 Sept: Transited to test site (OSU Open Ocean Test Facility) and observed configuration of all surface buoys. Discussed detailed procedures for ROV dives (ship positions, ROV approach, and inspection procedures). Launched ROV with ship station keeping in harbor. Practiced launch and recovery of ROV. All systems checked out.

Mon, 17 Sept: Inspected WET-NZ SW and SE anchors and mooring lines.

Tue, 18 Sept: Inspected Ocean Sentinel NE, SE and NW clump anchors. Inspected WET-NZ NW anchors and mooring line. Demobilized all equipment from the R/V Pacific Storm and packed the equipment into the EXWC ROV transport van.

Wed, 19 Sept: Picked up ROV equipment shipped to OSU Ship Operations and packed the equipment into the transport van. Set up shipment of the van to California.

Video

Remotely Operated Vehicle (ROV) and surface video will be copied to DVDs and sent to OSU and ship project personnel during the last week of September.

Project Support Vessel

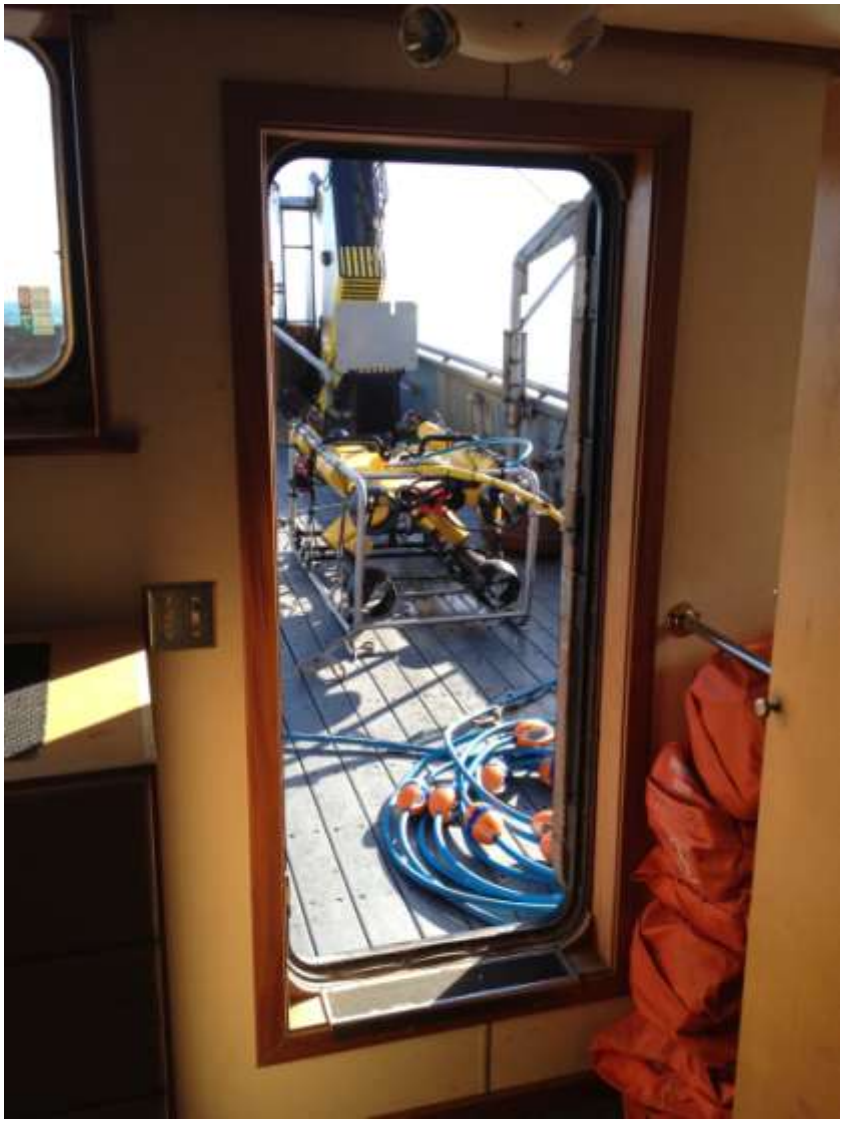
Mobilization

Mobilization

Mobilization

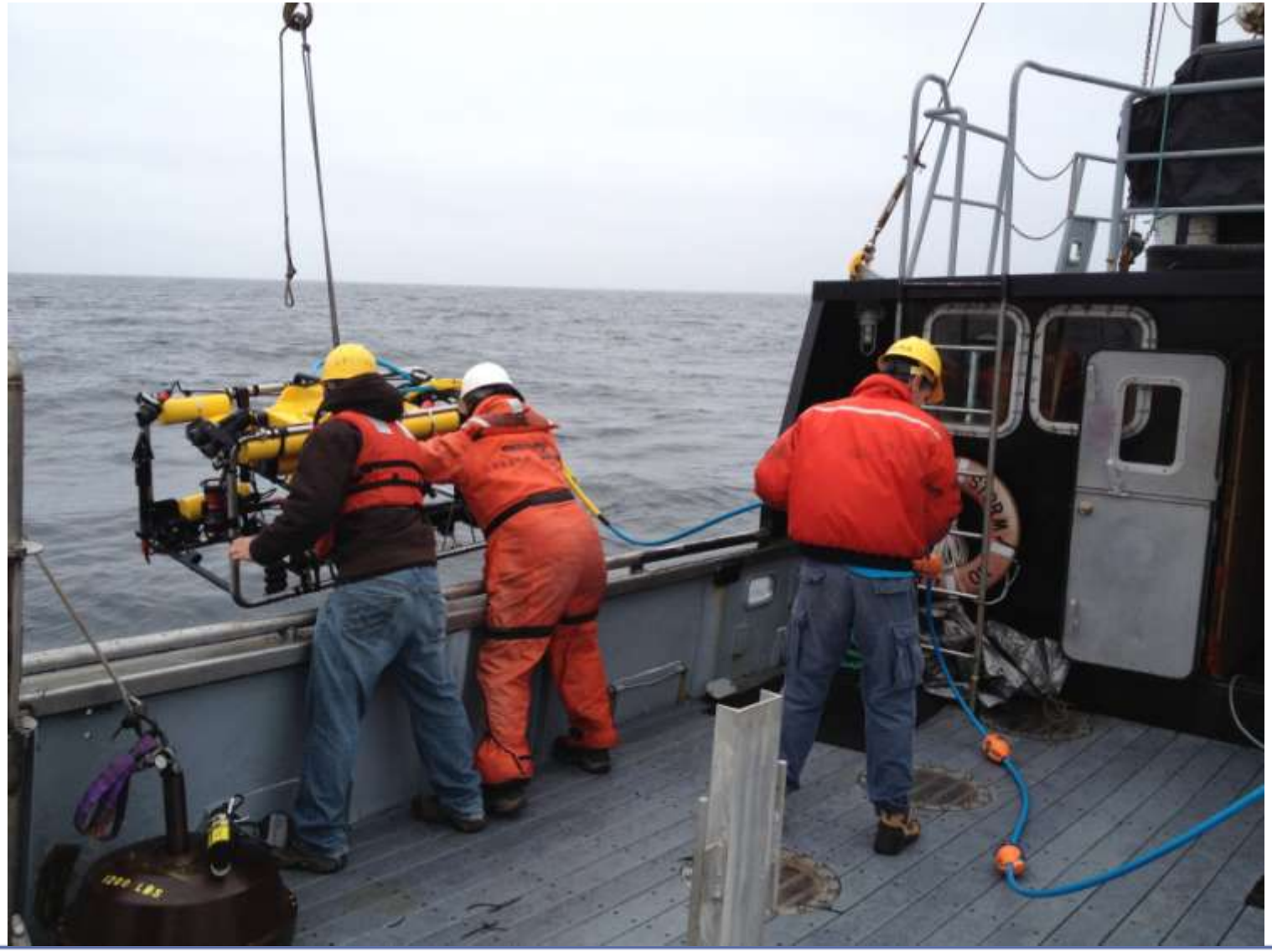
Departing the Dock for Harbor Testing

Departing Yaquina Bay for Offshore Site

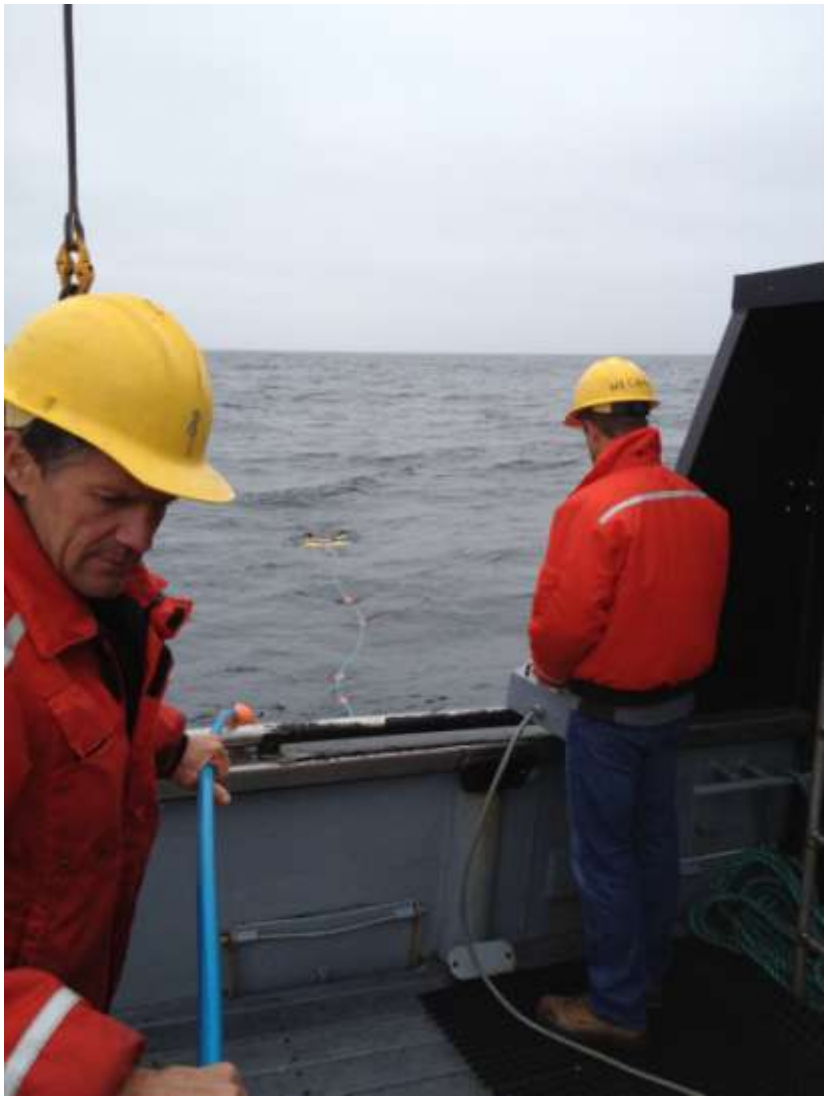


WET-NZ and Ocean Sentinel

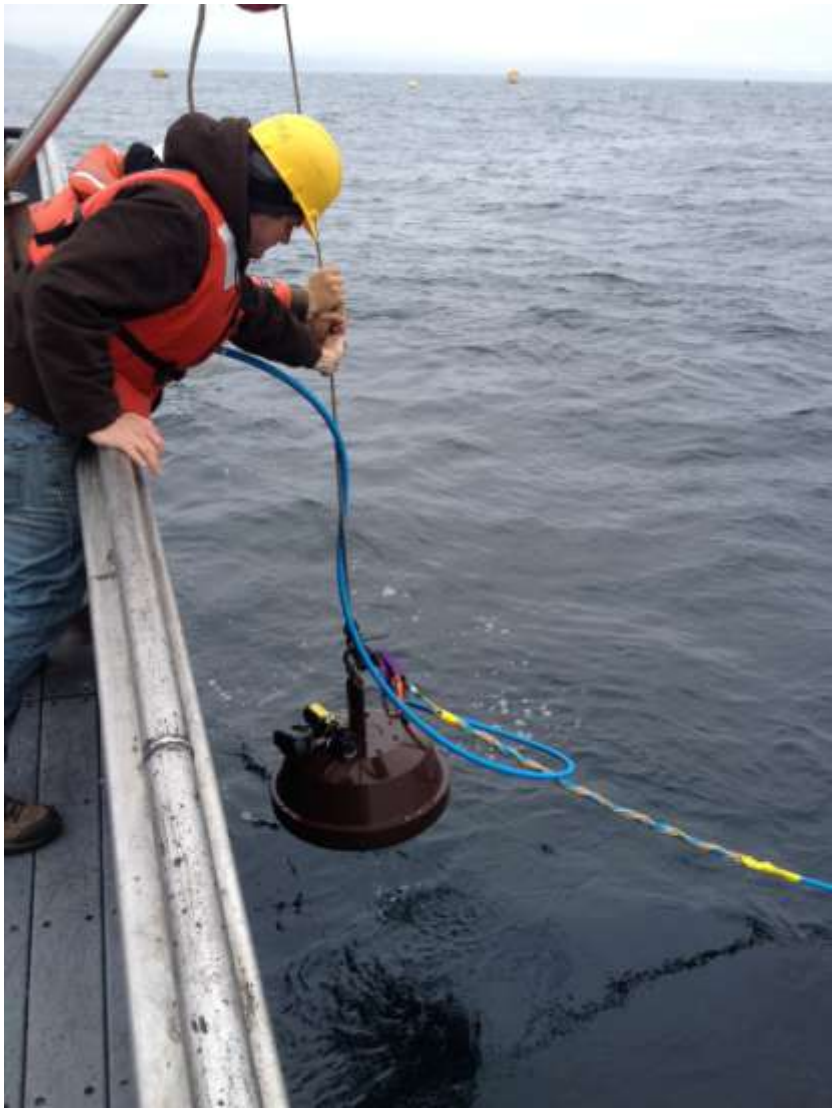
ROV Deployment

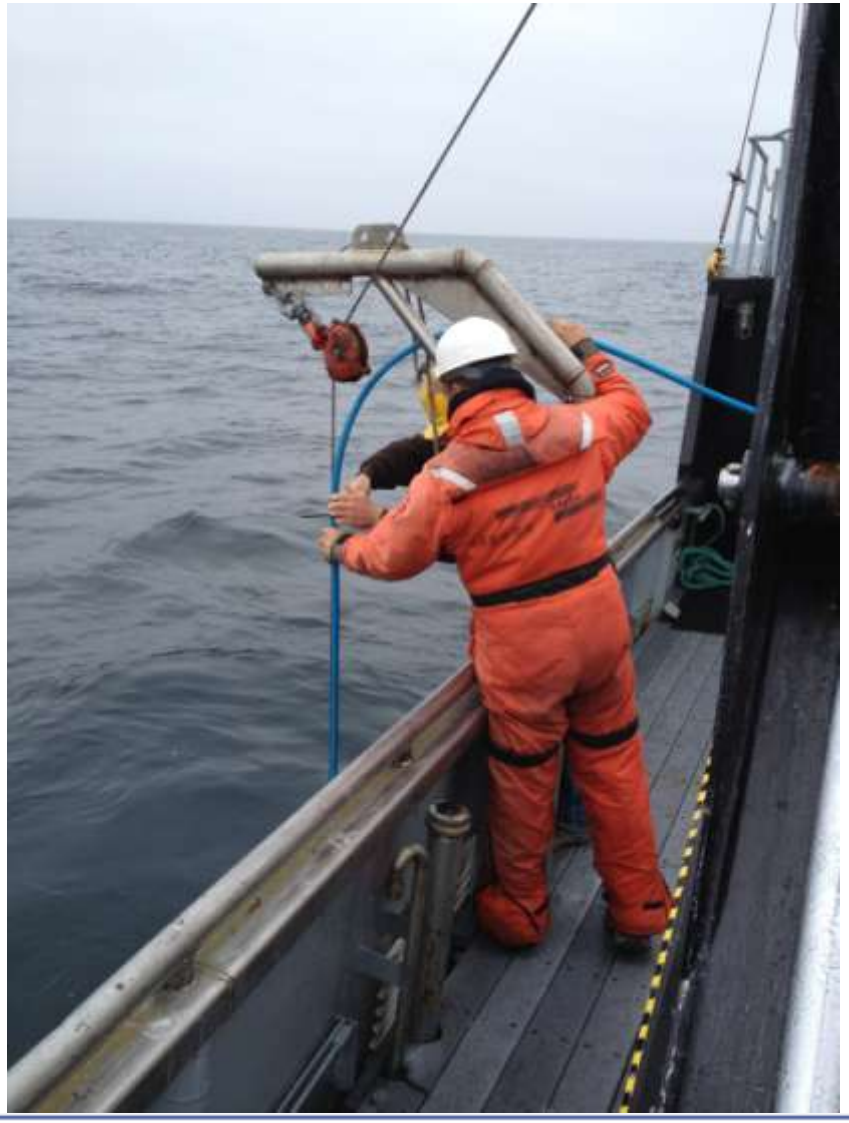


ROV Deployment



Depressor Weight Deployment





Vehicle Control in Lab Area

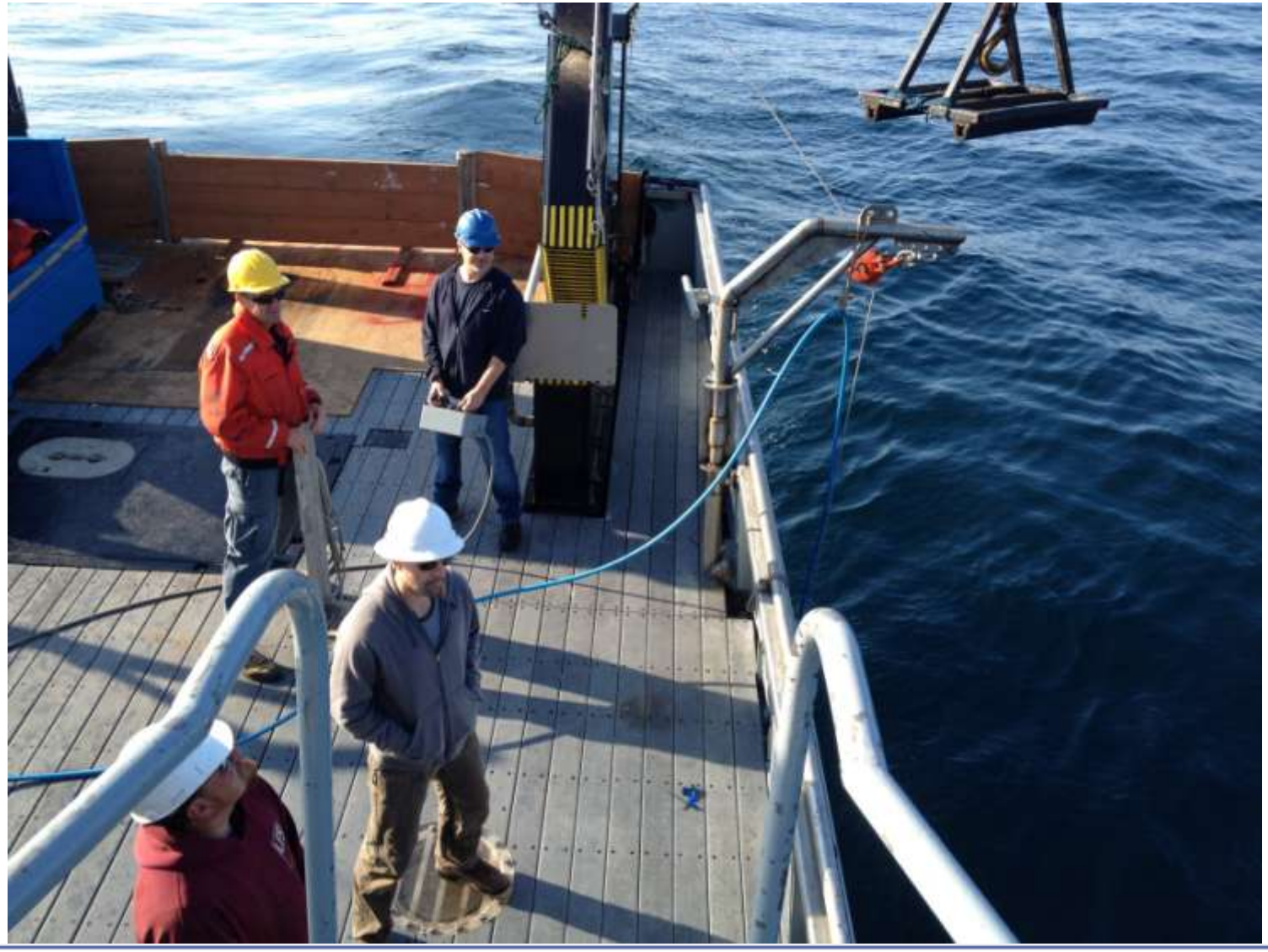
Vehicle Control in Lab Area

Vehicle Control in Lab Area

Vehicle Controlled to Inspect WET-NZ Buoy

Vehicle Controlled to Inspect WET-NZ Buoy

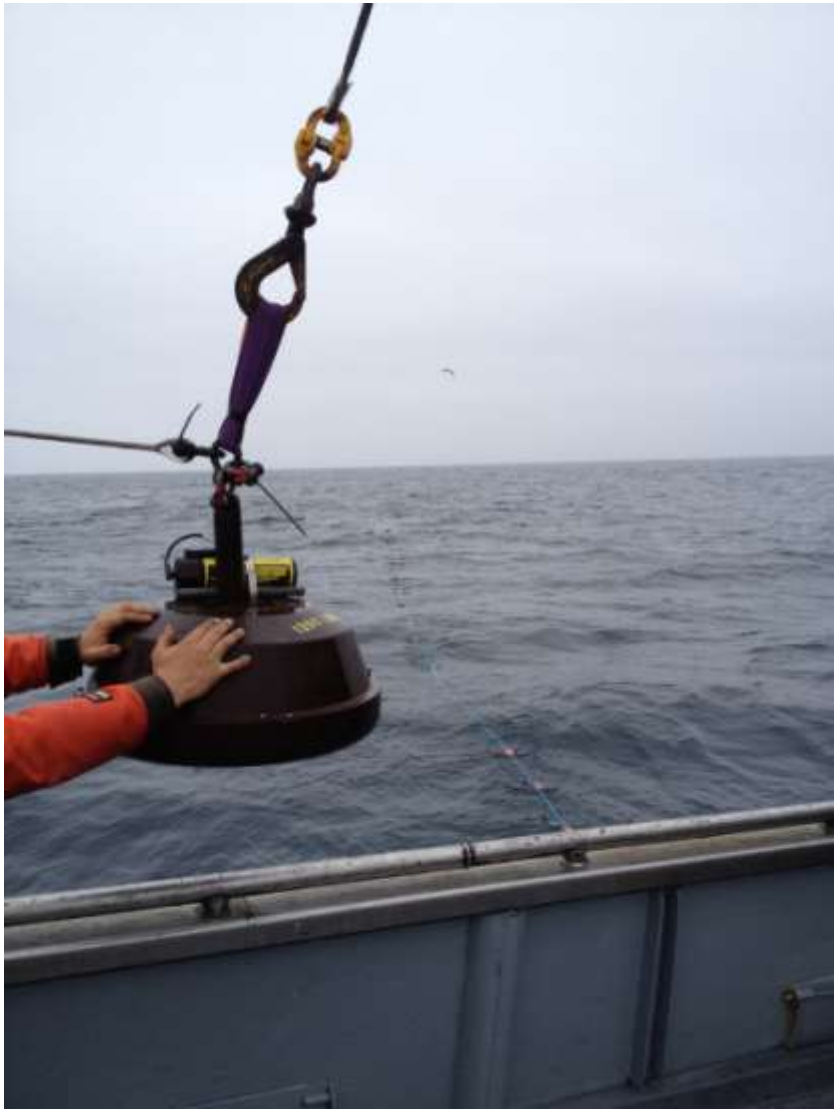
Vehicle Controlled to Inspect WET-NZ Buoy



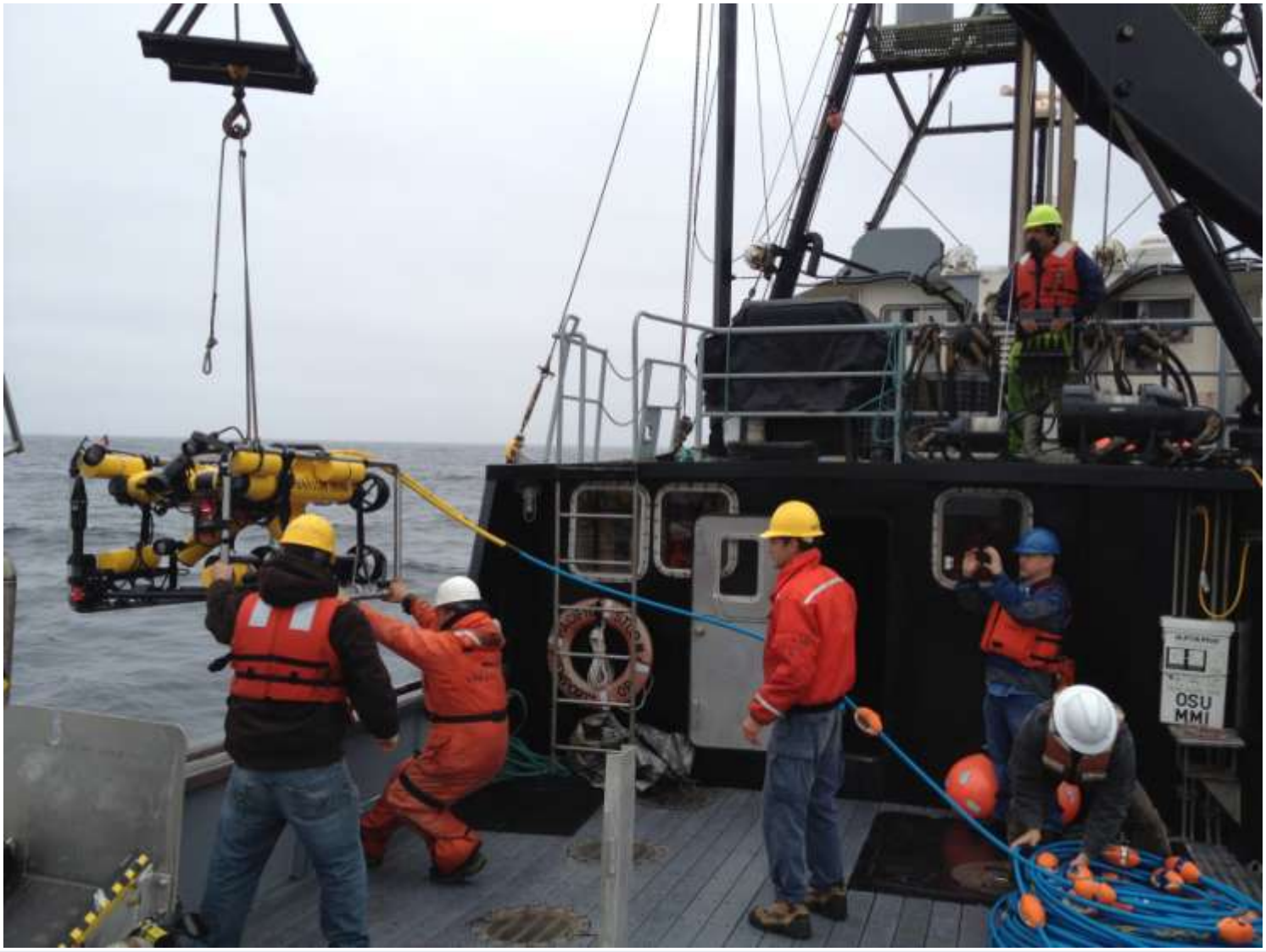
Captain keeping us out of trouble

USBL Hydrophone Head Recovered

Depressor Weight Recovery



Vehicle Recovery, A Team Effort

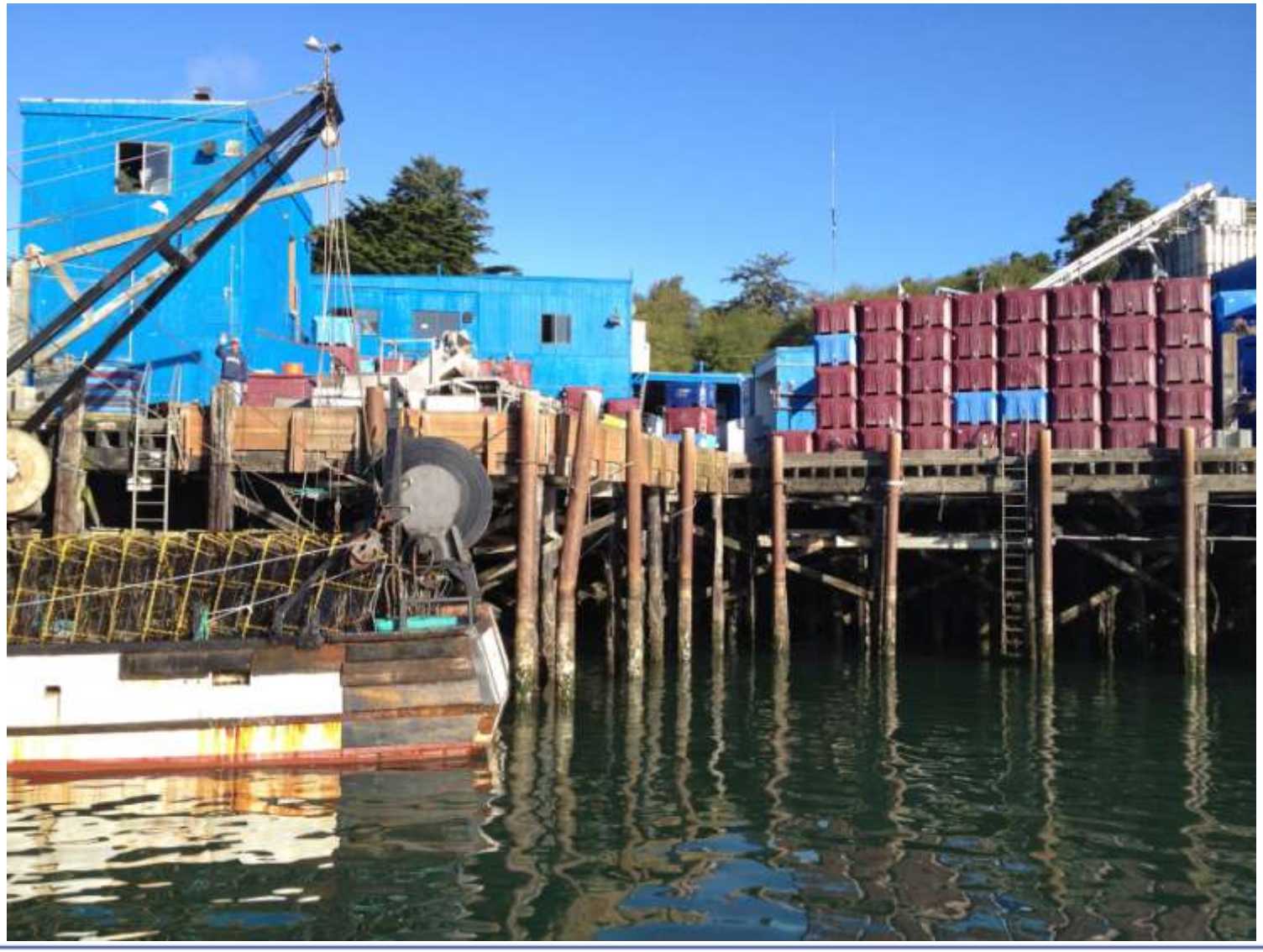


Vehicle Recovery

Returning to Port

Yaquina Bay, Newport, OR

Yaquina Bay, Newport, OR



Yaquina Bay, Newport, OR

Yaquina Bay, Newport, OR

Yaquina Bay, Newport, OR

Returning to Dock 5 After Day of ROV Ops


The End

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: August 14, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): OSU Anchor Deployment

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: August 16, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): OSU Anchor Deployment

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: August 19, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): Ocean Sentinel Deployment

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

OBSERVATION RECORD SHEET

1. Observer Name:____**Pat Kight**_____ Date: __**8/22/12**_ Time: approx. 8 am-3pm
2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	☐	Maintenance
☐	Routine Inspection	X	Other (explain):_**Observing and photographing WetNZ deployment from escort vessel Pacific Surveyor**

3. Are marine mammals or turtles present? ~~Yes~~ **No**

No marine mammals were observed today.

a. If yes, fill out the following:

Species:_____ Number present:_____

Distance (approx.):_____ Behavior/activity: _____

b. Do any of the following cases apply? **NO**
If yes, see reporting procedures in instructions and contact

Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

Live marine mammals or sea turtles observed swimming but appearing debilitated or injured. Live marine mammals or sea turtles observed entangled in fishing gear or marine debris. Dead marine mammals or sea turtles observed floating at sea. Dead protected species found entangled or otherwise impinged at the project.

c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:

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. Note next steps:

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: August 22, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): WetNZ Deployment / Umbilical

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: August 23, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): Deployment Observation

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name:__Ean Amon_____ Date: _8/28/2012__Time:_8am-10am_____

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance (test umbilical connection)
☐	Routine Inspection	X	Other (explain):Inspect TRIAXYS and WET-NZ motion

3. Are marine mammals or turtles present? ■ Yes ▫ No
   a. If yes, fill out the following:

   Species:_seal_____ Number present:__one_____
   Distance from project (approx.):_30m_____ Behavior/activity: _passing through, not interested_

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ▫ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ▫ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ▫ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ▫ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name:__Annette von Jouanne _____ Date: _8/31/2012__Time:_11:30am-1pm_____

2. Purpose of Site Visit (circle one):

[X]	Monitoring (acoustic/benthic/EMF/other)	[ ]	Maintenance
[ ]	Routine Inspection	[X]	Other (explain):Inspect TRIAXYS, and WET-NZ motion

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: September 17, 2012 Time: 1:28pm

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): ROV Survey

3. Are marine mammals or turtles present? ■ Yes ▫ No
   a. If yes, fill out the following:

   Species: Seal Number present: 1
   Distance from project (approx.): 5 feet Behavior/activity: Playful (video available)

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ▫ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ▫ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ▫ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ▫ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: September 18, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): ROV Survey

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: September 28, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): NNMREC day for OWET Conference

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: October 5, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): Ocean Sentinel Recovery

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

MARINE MAMMAL OBSERVATIONS

OBSERVATION RECORD SHEET

(Use at the project site not on approach)

1. Observer Name: Sean Moran Date: October 11, 2012 Time: All day

2. Purpose of Site Visit (circle one):

☐	Monitoring (acoustic/benthic/EMF/other)	X	Maintenance
☐	Routine Inspection	X	Other (explain): Anchor / Moorings Recovery

3. Are marine mammals or turtles present? ☐ Yes ☐ No
   a. If yes, fill out the following:

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   Species:_____ Number present:_____
   Distance from project (approx.):_____ Behavior/activity: _____

   b. Do any of the following cases apply? If yes, see reporting procedures in instructions and contact Sean Moran, NNMREC Ocean Test Facility Manager, at (541)737-5315, (541)404-3729 or sean.moran@oregonstate.edu :

   - ☐ ***Live marine mammals or sea turtles observed swimming but appearing debilitated or injured.***
   - ☐ ***Live marine mammals or sea turtles observed entangled in fishing gear or marine debris.***
   - ☐ ***Dead marine mammals or sea turtles observed floating at sea.***
   - ☐ ***Dead protected species found entangled or otherwise impinged at the project.***

   c. If entanglement or impingement is observed, document & photograph (if possible) the sighting, including:
   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. Note next steps:_____

4. Are pinnipeds present on one of the project structures? If yes, identify species/location_____
   Follow pinniped haulout protocol in instructions.

Appendix A: Updated Observations Instructions & Record 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 pinnipeds present on project structures are an ESA-listed species (e.g., Steller sea lions), NNMREC will not pursue any directed take or intentional harassment, and will remain at least 100 yards from the structure so long as the ESA-listed species is present.

iv. 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

☐ Marine Debris

☐ Project Structure (specify):

☐ 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: _____

_____

_____

_____

Attachment 3: Acoustics Report

Underwater acoustic measurements at the Northwest National Marine Renewable Energy Center Ocean Test Facility

Provided by:

Joseph H. Haxel

Cooperative Institute for Marine Resources Studies

Oregon State University

Initial Report: September 7, 2012

Revised Report: May 7, 2013

Background

Potential impacts from sound transmitted by wave energy conversion (WEC) devices on marine ecosystems are not well understood and remain an important environmental concern for the developing marine hydrokinetic renewable energy industry. On August 23, 2012 the Northwest National Marine Renewable Energy Center (NNMREC) at Oregon State University (OSU) commenced WEC testing at its ocean test facility off the coast of Newport, Oregon (figure 9). The 2012 test, which involved deployment of the WET-NZ WEC device and Ocean Sentinel instrumentation buoy, provided the first opportunity to measure acoustic changes in the ambient sound field resulting from test center operations at the project site. The main objective of the acoustic monitoring described in this report was to provide a rapid measurement of noise emissions associated with project operations and determine if the test devices transmit acoustic energy above National Marine Fisheries Service (NMFS) marine mammal harassment thresholds.

Comparisons of measured noise levels in the vicinity of the project devices with year-long baseline recordings provide a context for detecting changes in acoustic levels associated with WEC devices and test center operations. Continuous, background long-term passive acoustic measurements of ambient sound levels (1 Hz – 2 kHz) were collected from March 2010 – April 2011 at the project site (figure 2). These baseline recordings provide an acoustic characterization of background levels and sound sources over a range of sea states, environmental conditions, and vessel traffic intensity. Baseline results indicate the ambient noise field in the area consists primarily of sounds emanating from breaking waves, winds, rain, ship and small boat traffic, and marine mammals (*Haxel et al. 2013*).

The WET-NZ and Ocean Sentinel were deployed at 44°41.702'N and 124°07.678'W within the designated project site (Figure 1), near the site of the baseline acoustic recordings (Figure 2), as described in Haxel et al. (*2011*) and Haxel et al. (*2013*). Acoustic measurements of the devices were made from 07:52 to 10:30 PDT on August 30, 2012 before winds began to increase, limiting the quality of the recordings.

Figure 8: The WET-NZ and Ocean Sentinel deployed at the NNMREC/OSU ocean test site in 2012.

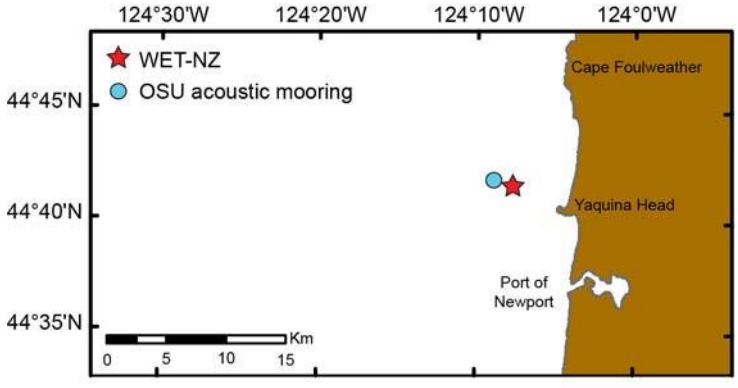


Figure 9: Map of the WET-NZ/Ocean Sentinel deployment location and the mooring location of the baseline acoustic recordings (March 2010 – April 2011) at the NNMREC NETS ocean test site.

Methods

Acoustic measurements were made from a 24 foot fiberglass vessel (*Gracie Lynn* – Oregon Coast Aquarium) using a cabled hydrophone lowered to a depth 10 m below the water surface. The boats' engines and electronic instruments were powered down in free drifting mode in an effort to reduce noise contamination of the acoustic recordings. The cabled acoustic recording system consists of a Reson TC 4032 hydrophone with an effective sensitivity of -172.7 dB re 1 µPa V^{-1} @ 1 m. The hydrophone was routed through an RME Fireface 400 audio interface to a Windows 7 PC using Adobe Audition software for data acquisition and storage. The frequency response of the hydrophone system is flat up to 120 kHz with a low frequency cut off at 10 Hz.

The day before field measurements were taken, the hydrophone and data acquisition system were calibrated in the lab with a G.R.A.S. Pistonphone Type 42AC. On August 30, 2012, five free-drift acoustic recordings were made with 64 kHz continuous sample rate and digitized at 16-bit resolution. Each of five drifts started north of the deployment location, following the dominant current direction southward for up to 30 minutes and ranging from 10 m to 750 m of the devices and their mooring systems. However, recordings were limited to a single expedition since the quality of the acoustic data collected using this method was negatively affected by increasing environmental energy conditions.

Results

Various factors inherent to this cabled and free drifting acoustic data acquisition technique strongly influence noise contamination levels, thereby limiting the capabilities of the system. Non-propagating pressure fluctuations at the hydrophone surface (flow noise) results from a towing effect caused by the difference in the drift speed of the boat verses the prevailing current, which introduces significant non-acoustic low frequency energy below 100 Hz. Additionally, cable tug resulting from the heave and pitch of the vessel in swell and waves introduces sharp, broadband spikes in energy.

Another strong source of system noise contamination occurs as waves interact with the vessel hull. Hull slap and turbulent flow noise around the boat (induced by breaking wind waves and swell motion) are nearly continuous, often masking the targeted acoustic signals. Environmental conditions largely influence the quality of the recording system, making comparative measurements from different recording conditions difficult. The low frequencies recorded (particularly below 1 kHz) with this method

were frequently contaminated by system noise, significantly reducing the number of quality measurements of the project devices. Despite data contamination problems inherent to the cabled approach used here, the short-term monitoring objective to confirm that noise levels were below marine mammal thresholds was fulfilled. Additionally, recordings allowed for a time and frequency dependent characterization of sounds transmitted by the WET-NZ and Ocean Sentinel operating under specific environmental conditions.

Thirty-second spectrograms of the underwater acoustic recordings near the WET-NZ and Ocean Sentinel at distances of 10 m and 85 m are shown in figures 3 and 4. Power spectral densities (PSD) are calculated from 8192 point data windows, tapered using a Hanning window, overlapped 50% and Fast Fourier Transformed. Spectral levels at both 10 m and 85 m distances indicate acoustic transmissions from the devices primarily occur in frequencies below 1 kHz. The harmonic frequency structure modulations transmitted by the devices are assumed to oscillate as a function of the incident wave period, similar to acoustic results from a $1/7^{th}$ scale WEC test presented by Bassett et al. (*2011*). Contamination from previously mentioned noise sources (e.g. flow noise, cable tug) is readily observed in frequencies below 100 Hz, potentially masking signals in these lower frequencies.

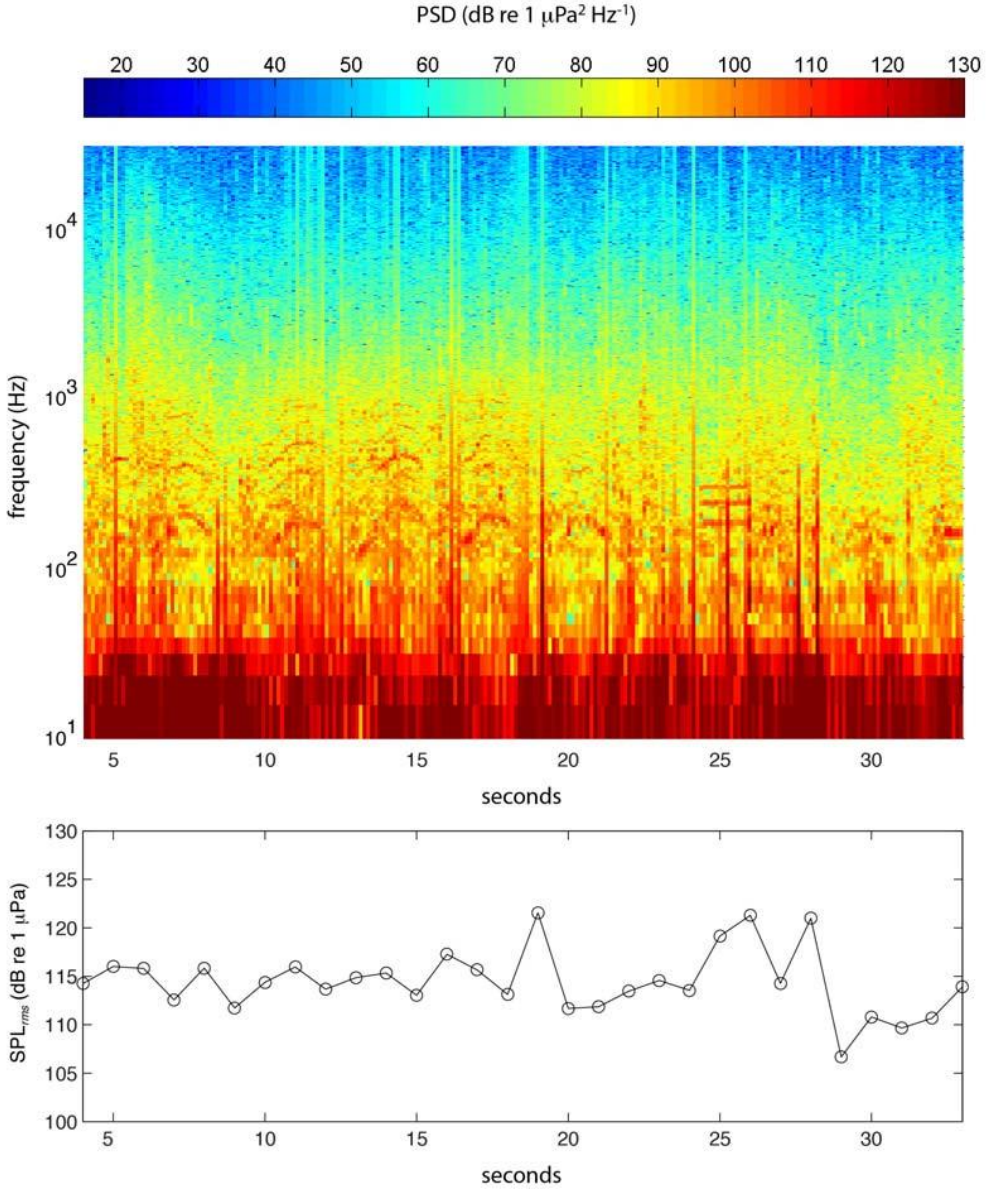


Figure 10: (top) Spectrogram from a recording made at 10 m distance from the WET-NZ and Ocean Sentinel; (bottom) the broadband (60 Hz – 32 kHz) SPLrms calculated from 1 second intervals.

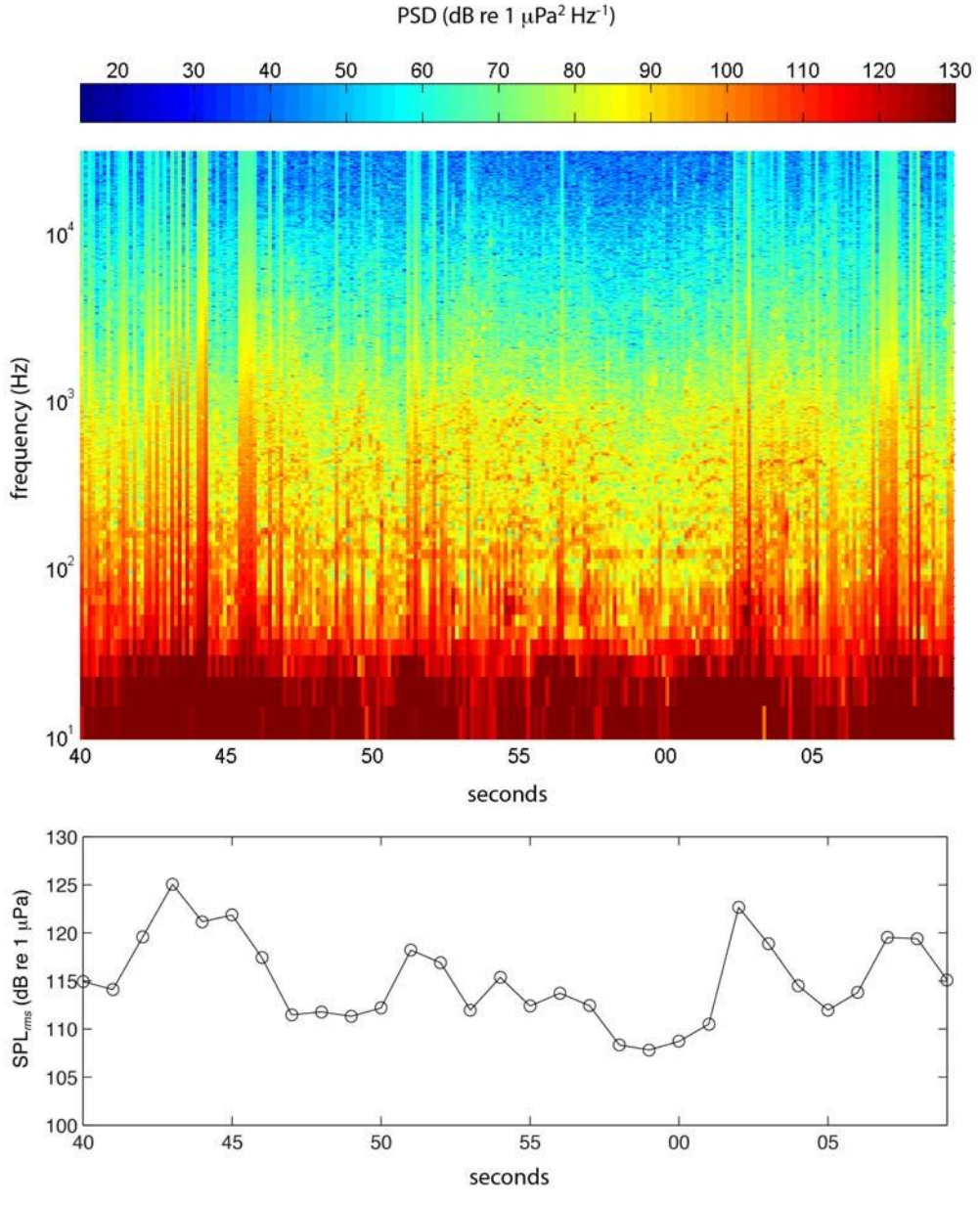


Figure 11: (top) Spectrogram from a recording made at 85 m distance from the WET-NZ and Ocean Sentinel; (bottom) the broadband (60 Hz – 32 kHz) SPL_{rms} calculated from 1 second intervals.

The bottom panels in figures 10 and 11 show the broadband (60 Hz to 32 kHz) received root mean square sound pressure level SPL_{rms} (dB re 1 uPa @ 1 m) calculated over one second intervals associated with thirty-second spectrograms. SPL_{rms} is calculated as:

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

Where prms is the root mean square pressure calculated over one second and pref is the standard underwater reference pressure 1 Pa @ 1 m. One-second SPL_{rms} values associated with the harmonic signals during peak signal to noise ratio intervals (times with the least amount of low frequency

contamination) average around 115 dB at 10 m and 112 dB at 85 m. SPL_{rms} levels exceed 120 dB only during instances where broadband spikes and other system noise contaminate the record. Additionally, average values of 115 dB at 10 m and 112 dB at 85 m likely represent an overestimate of the actual sound pressure levels at the receiver produced solely by the project devices. Despite using maximum signal to noise ratio sound intervals, a significant amount of energy in frequencies above 60 Hz from system noise is still included within these estimates.

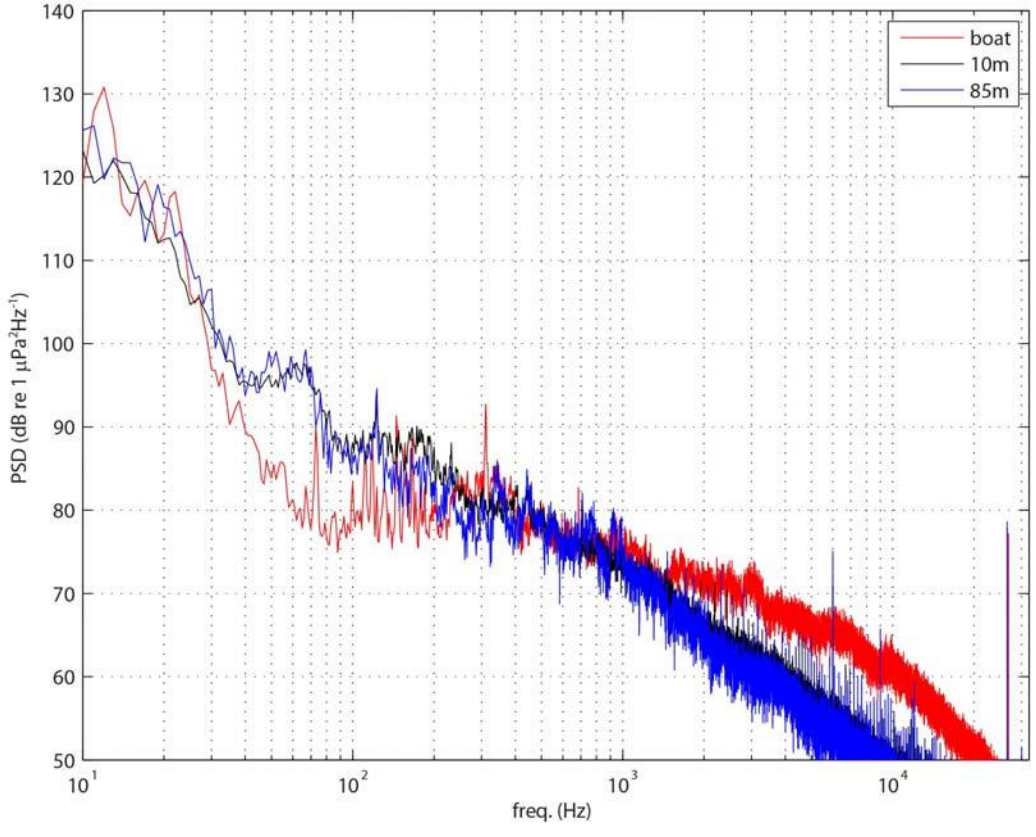


Figure 12: PSD estimates averaged over 30 s at 10 m (black) and 85m (blue) from the devices. Also shown is a PSD from baseline data at the NNMREC/OSU ocean test site recorded on July 31, 2012 that includes noise from an approaching fishing vessel.

A comparison of time averaged acoustic energy levels and frequency structure from the WET-NZ and Ocean Sentinel at distances of 10 m and 85 m averaged over 30 seconds is shown in Figure 12. Time averaging effectively reduces the resolution of frequency modulations from the PSD estimates observed in Figures 10 and 11. The power spectral density (PSD) estimate from the 10 m recording is on average slightly higher (~ 2-3 dB) than the 85 m recording, as expected from attenuation and scattering during propagation from the devices. A PSD estimate from a recording made on July 31, 2012 (prior to device deployment) using this cabled hydrophone system at the project site includes nearby small boat traffic, providing a reference for ambient levels during the 2012 test. Spectral levels diverge between the test devices and boat recordings beginning around 30 Hz. Higher energy levels associated with the test device recordings in these lower frequencies are attributed to a difference in environmental conditions during recording and, therefore, levels of system noise. Spectral levels begin to converge again around 200 Hz with energy levels from the July 31, 2012 recording exceeding both device estimates in frequencies beyond 1 kHz.

PSD estimates from the 10 m and 85 m WET-NZ/Ocean Sentinel acoustic recordings are plotted with percentile distributions of ambient sound levels from year-long baseline recordings in Figure 13. Percentile PSD distributions are calculated from 200 second averages of 1 second FFT windows during an entire year of recording at the project site. The baseline acoustic recordings taken from March 2012 – April 2011 were made from a bottom mounted mooring system and autonomous hydrophone instrument package (*Haxel et al., 2011*). In frequencies below 200 Hz, the 2012 WET-NZ/Ocean Sentinel acoustic levels recorded with the cabled, drifting hydrophone are significantly higher than ambient levels from the baseline moored system. This is an artifact of the large discrepancies in system noise between the drifting and moored data acquisition techniques. In frequencies above 200 Hz, the WET-NZ/Ocean Sentinel recordings more closely approach long-term mean levels of ambient noise in the region.

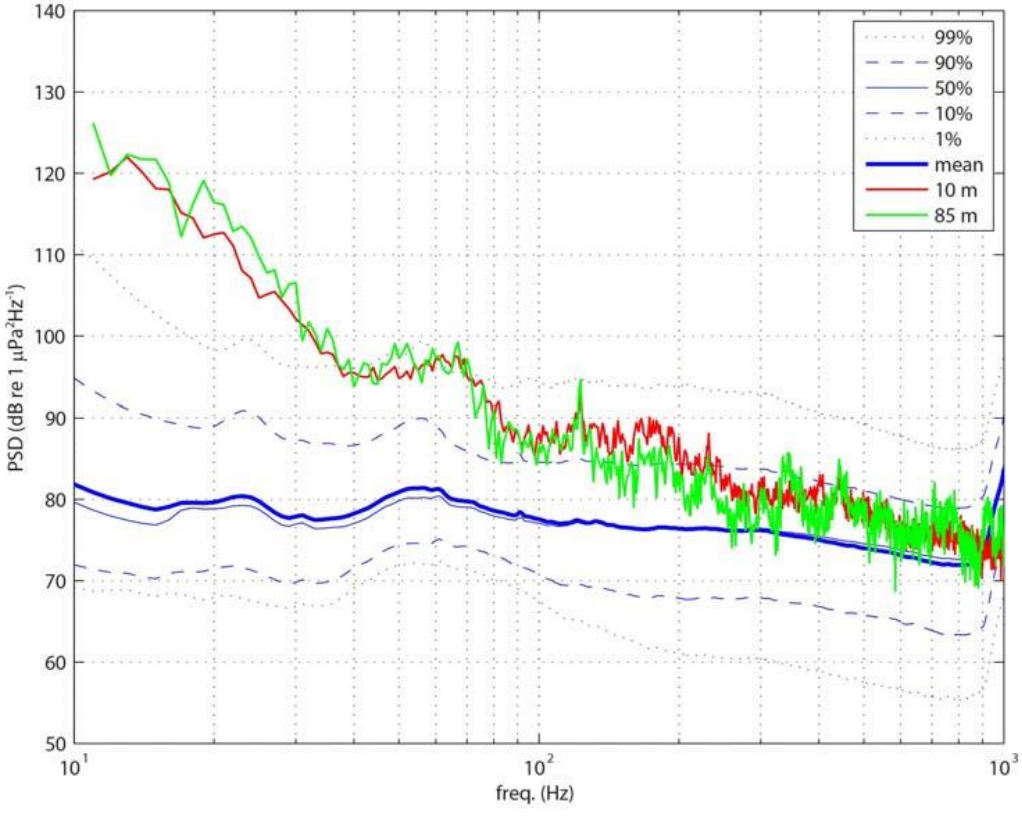


Figure 13: Percentile distributions of PSD estimates from moored, long-term acoustic measurements (March 2010 –April 2011) at the NNMREC/OSU ocean test site, and PSD's from recordings made at 10 m (red) and 85 m (green) from the WET-NZ and Ocean Sentinel.

Conclusions

Underwater sound pressure levels recorded at 10 m and 85 m from the WET-NZ and Ocean Sentinel at the NNMREC/OSU ocean test facility are below NMFS threshold criteria for marine mammal harassment (120 dB). The acoustic signature of the devices has a modulated harmonic frequency structure, most likely oscillating as a function of wave period. Although the free-drifting cabled hydrophone approach provides the capability for rapid acoustic data acquisition and assessment of sound pressure levels, it is

severely limited in the lower frequency range (< 300 Hz) by system noise contamination. In addition, variability in noise levels emitted by individual devices remains unknown.

While the SPL measurements did not exceed any thresholds, the acoustic recordings were made during calm sea states and low power output of the WET-NZ device; as such, some uncertainty remains as to the acoustic signature of the device during higher sea states and power outputs. Recordings taken over a range of sea states can provide a more complete understanding of acoustic outputs, which is important in ensuring adequate evaluation of project-related SPL against thresholds. Long-term assessment of underwater acoustic impacts of WEC operations is best performed with moored instrumentation. In addition, information about sea state and power output/activity level of WEC devices under test could help provide a better understanding of how different conditions are related to acoustic outputs.

Sufficiency of Acoustic Monitoring Techniques in Assessing Potential Effects of Different Technologies

Various factors inherent to this cabled and free drifting acoustic data acquisition technique strongly influence noise contamination levels, thereby limiting the capabilities of the system. Non-propagating pressure fluctuations at the hydrophone surface (flow noise) introduce significant non-acoustic low frequency energy below 100 Hz. Additionally, cable tug resulting from the heave and pitch of the vessel in swell and waves introduces sharp, broadband spikes in energy. Overall, the cabled hydrophone approach used during the 2012 test proved to be problematic and will not be used in future acoustic monitoring at the test facility. Future acoustic monitoring of WEC device testing at the facility will include deployment of a newly designed autonomous, drifting hydrophone recording system capable of providing rapid, high quality sound level measurements at the project site under a broad spectrum of incident wave and wind conditions.

Confidence in Study Ability to Assess Device Noise

Acoustic recordings from the 2012 test indicate sound energy transmitted by the devices appears to oscillate with wave period and primarily occur in frequencies below 1 kHz. This result is consistent with acoustic recordings of a WEC device in Puget Sound (Bassett et al., 2011), providing confidence in our ability to detect, measure and characterize noise emitted by devices under test at the project site.

Need for Acoustic Testing of All Devices & Applicability of Study Results to Future Tests

The 2012 acoustic monitoring study may be informative for future tests, but continued monitoring and characterization of the acoustic signatures of WEC devices will provide valuable information for comparisons of impacts on ambient noise levels, as well as potential scaling associated with a commercial build out of WEC devices.

Considerations for Future Monitoring

Future acoustic monitoring of WEC devices at the test facility should include use of the following methods to provide information on changes in noise levels due to device operation in a variety of environmental conditions:

- Implement 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.

- *Deploy the seafloor-mounted hydrophone lander 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.*

If funds and opportunities allow, NNMREC would like to deploy a four-element array of seafloor-mounted hydrophones around the project site to collect continuous, fixed range measurements prior to, during, and after installation and operation of test devices. This will allow for localization of discrete signals (to discriminate among sound sources) and increase data on sound level frequencies above 840 Hz.

Acknowledgements

The author would like to thank Captain Jim Burke of the *R/V Gracie Lynn* and the Oregon Coast Aquarium for outstanding vessel based support as well as Dr. Holger Klinck at Oregon State University for his assistance with acoustic recording system hardware.

References

Bassett, C., Thomson, J., Polagye, B., and Rhinefrank,K. (2011)."Underwater noise measurements of a 1/7th scale wave energy converter, "In Proceedings of MTS/IEEEOCEANS. Kona, USA. September 2011, 1-6.

Haxel, J.H., Dziak, R.P., and Matsumoto, H. (2011). "Obtaining baseline measurements of ocean ambient sound at a mobile test berth site for wave energy conversion off the central Oregon coast," In Proceedings of MTS/IEEEOCEANS. Kona, USA. September 2011, 1-5.

Haxel, J.H., Dziak, R.P., and Matsumoto, H. (2013) Observations of shallow water marine ambient sound: The low frequency underwater soundscape of the central Oregon coast. The Journal of the Acoustical Society of America 133:2586-2596

Attachment 4: EMF Report

Electric and Magnetic Field Measurements at the Northwest National Marine Renewable Energy Center Ocean Test Facility

Provided by:

Adam Schultz

Cooperative Institute for Marine Resources Studies

Oregon State University

Initial Report: November 30, 2012

Revised Report: May 7, 2013

Background

Monitoring electromagnetic fields (EMF) for marine renewable energy is a newly emerging application, and mission-specific instrumentation is needed. Horizontal and vertical electric fields are very different. The vertical electric field is really just oceanography. Ocean surface wave motions are translated into variable current outputs with a waveform that is a damped, phase-lagged version of those wave motions. The anticipated EMFs arising from a wave energy converter (WEC) would have a frequency content closely matching the ocean wave/swell spectrum rather than powerline frequencies and harmonics.

The Northwest National Marine Renewable Energy (NNMREC) at Oregon State University (OSU), in coordination with Science Applications International Corporation (SAIC) under an Oregon Wave Energy Trust (OWET) funded project, developed a prototype instrumentation system for measuring EMF associated with WEC devices. This 1st generation system uses a high definition wideband EM receiver, capable of detecting ocean wave/swell frequencies, as well as power line frequencies and harmonics (see Figure 14). The receiver has three electric field and three magnetic field channels, 32-bit resolution, and 1 kHz sampling. It also has separate compass, tilt sensors. ZongeANT2 induction coil magnetic field sensors are also included, which provide a frequency passband <0.1 Hz -> 1 kHz, noise ~ 50 ft./√Hz at 10 Hz, and flat response from 1 Hz -1 kHz within ±50 mdB. In addition, short-span electric field dipole receivers, silver-silver chloride electrodes, Polyamp PA3004 high gain differential preamps providing 66 or 86 dB gain, <1 nV/√Hzat1 Hz sensiϴvity, -180dB noise relative 1V at 1Hz are included.

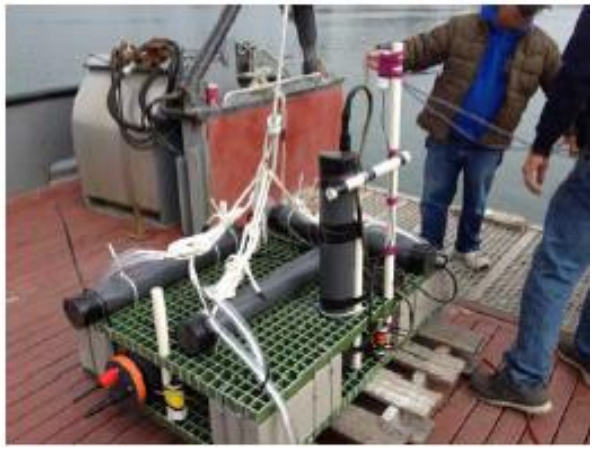


Figure 14: First Generation EMF measurement instrumentation.

NNMREC has also developed an advanced, 2nd generation monitoring system to characterize ambient EMF and measure EMF during an energized WEC test. While both EMF systems have nearly identical sensing capabilities, the 1st generation instrumentation is designed only to carry out "spot measurements" of EMFs on the seafloor for short periods of time to establish baseline field levels over a grid of survey locations on the seafloor. The 2nd generation system can also carry out sustained time series observations at fixed locations on the seafloor, while also accommodating higher sampling rates (4 kHz vs 1 kHz), due to the addition of a seismic sensor and a modest improvement in the magnetic field sensor noise ceiling.

Due to limitations in staff and equipment availability, however, the 2012 EMF survey at the NNMREC ocean test facility was performed with the 1st generation, rather than 2nd generation, instrumentation

system. There were unanticipated delays in completing the trawl resistant housing for the 1st generation EMF instrumentation, which involved fabrication by an outside company that encountered difficulties with integrating a cast syntactic foam buoyancy element in the composite trawl-resistant instrument shell. In addition, we encountered firmware issues that required sending the data acquisition boards back to the manufacturer for reprogramming. Another factor was the need to include SAIC personnel, given their substantial involvement in the integration of the various subsystems in the prototype EMF instrumentation.

Survey Design

A prototypical EMF survey would consist of an array center placed midway between WEC and power conditioning/transmission installation, as shown in Figure 15. Each point shown in this figure represents a seafloor measurement station. EMFs are monitored along four cardinal directions to evaluate anisotropic EMF propagation due to source and site characteristics (e.g., geology, water depth, orientation of EMF sources). Finer station spacing closer to the electric or magnetic field source is necessary because of stronger gradients in the near field. Moreover, it is important to take measurements in the water column at a number of control locations.

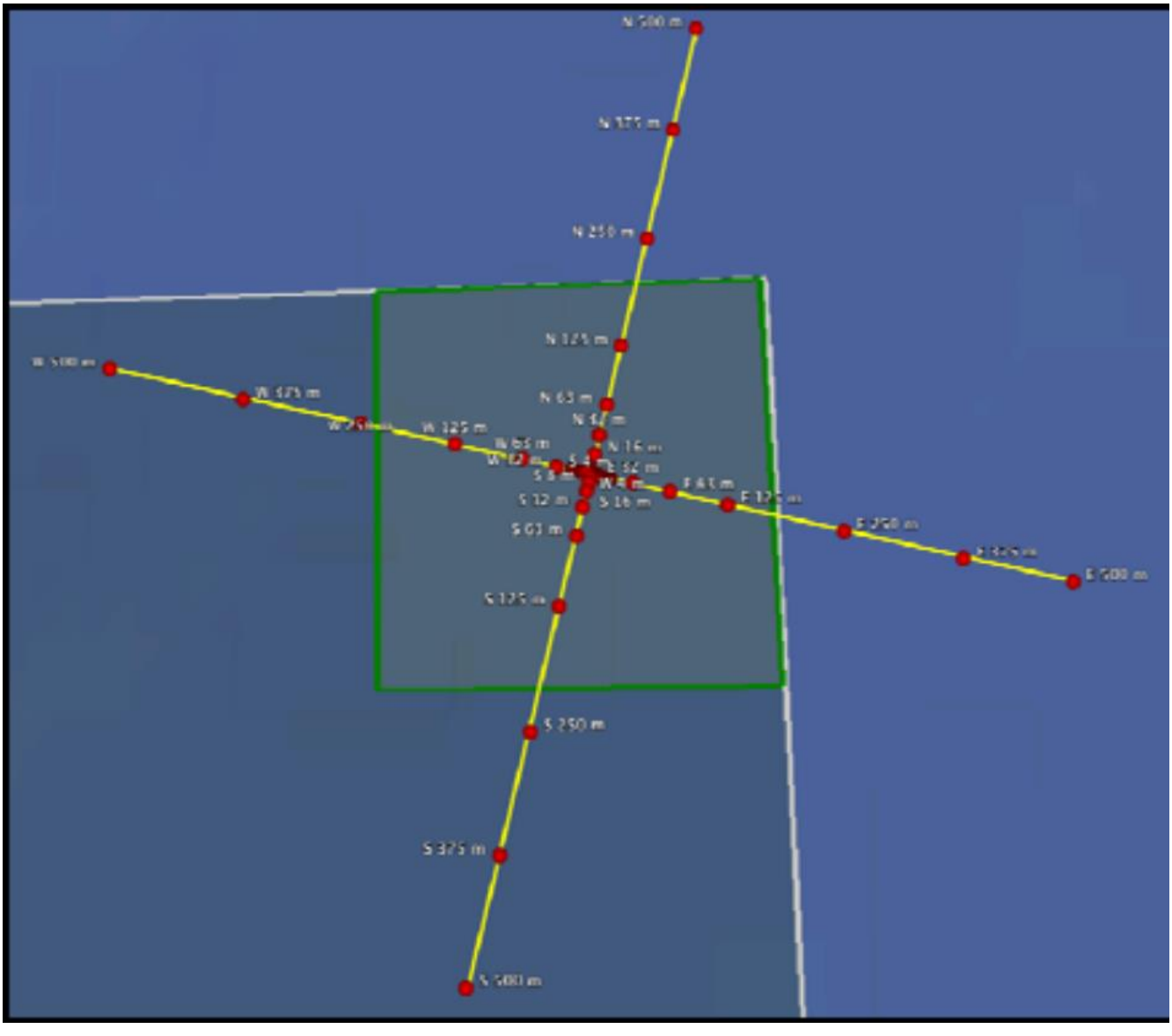


Figure 15: Prototypical EMF Survey Configuration

The survey performed during the 2012 WET-NZ/Ocean Sentinel test follows a slightly different configuration, however, which is shown in Figure 16. Due to the complexity of navigating around the project structures, the survey team used somewhat greater standoff distances from both the WET-NZ and the Ocean Sentinel than originally planned.

Figure 16: 2012 EMF Survey Configuration

Methods

A typical EMF survey would involve the following:

1. Survey design based on 3D models of Electric and Magnetic Field diffusion for designated site. Knowledge of bathymetry and subsea floor electrical conductivity is a requisite.
2. In absence of pre-existing conductivity model, survey footprint should be based on most pessimistic scenario, with embedded, resistive sub-seafloor formation that would extend propagation distances to perhaps 1 km or greater.
3. Pre-installation baseline EMF measurements over an array of locations spanning distances of maximum likely detectible EMF signature.
4. Repeat survey(s) with installed, energized system, over same survey grid, while also recording source wave forms at the WEC and signal conditioning/transmission equipment.

Ideally, one would characterize the project site prior to devices installation and then measure EMF during deployment. Due to time constraints related to instrument and staff availability, however, we planned to reverse the sequence of events by carrying out the “operational” (i.e., during deployment of

energized WEC device) survey in September 2012, with the "baseline" (i.e., WEC not present or not energized) survey to follow in 2013. The EMF survey was performed over a two-day period from September 20 – 21, 2012. The sea state was so low, however, that the peak power output of the WET-NZ on Day 1 of the survey was 40 watts, with zero watts being more characteristic. Day 2 was an even lower sea state day than day 1. Because the WET-NZ was barely energized, we consider the September 2012 survey data to be representative of ambient conditions rather than operational WEC test monitoring.

The survey was executed as planned, with the exception of modifying the survey configuration to omit a small number of survey points closest to the midpoint in the umbilical cable connecting the Ocean Sentinel to the WET-NZ (as shown in Figure 16). Ocean surface currents were carrying the survey vessel too close to the cable, and at times to the WET-NZ, to safely deploy the sensor when distances were closer than approximately 45 m from the indicated midpoint. Despite the fact that we expended considerable time carefully maneuvering the survey vessel around the delicate cables and mooring lines near that point, it was considerably difficult to avoid fouling the lines or impacting the Ocean Sentinel and WET-NZ. This experience caused us to find a safer standoff distance for deploying the EMF instrumentation system, based on actual ocean surface currents present at the time of the survey. The only possible negative impact of this larger standoff distance is that it may have diminished our ability to sense very low EMF emission levels that might be associated with the barely energized WET-NZ and/or the Ocean Sentinel.

Results

Although technologically successful, the September 2012 survey was complicated by logistical challenges associated with maneuvering around the project devices, as well as fishing activities occurring both around and within the test boundary markers. Low energy sea states may also have limited the quality of the data available. Functionally, however, the EMF monitoring goals were met with the 1st generation EMF system and the survey was very successful from a technical standpoint. Further, the survey achieved the study goals of 1) evaluating the ability to detect EMF generated from the project and 2) measuring the levels produced at various distances from project devices. Approximately 22 minutes of data was obtained from the time the EMF instrumentation landed on the seafloor to the time it was retrieved. Analysis of that data shows that the intensity of spectral levels is persistent, for the 38 Hz modulation in particular. The 10–11 Hz modulation in magnetic field is stable over the measurement period as well. The results and analyses are described further in Figures 17 – 26.

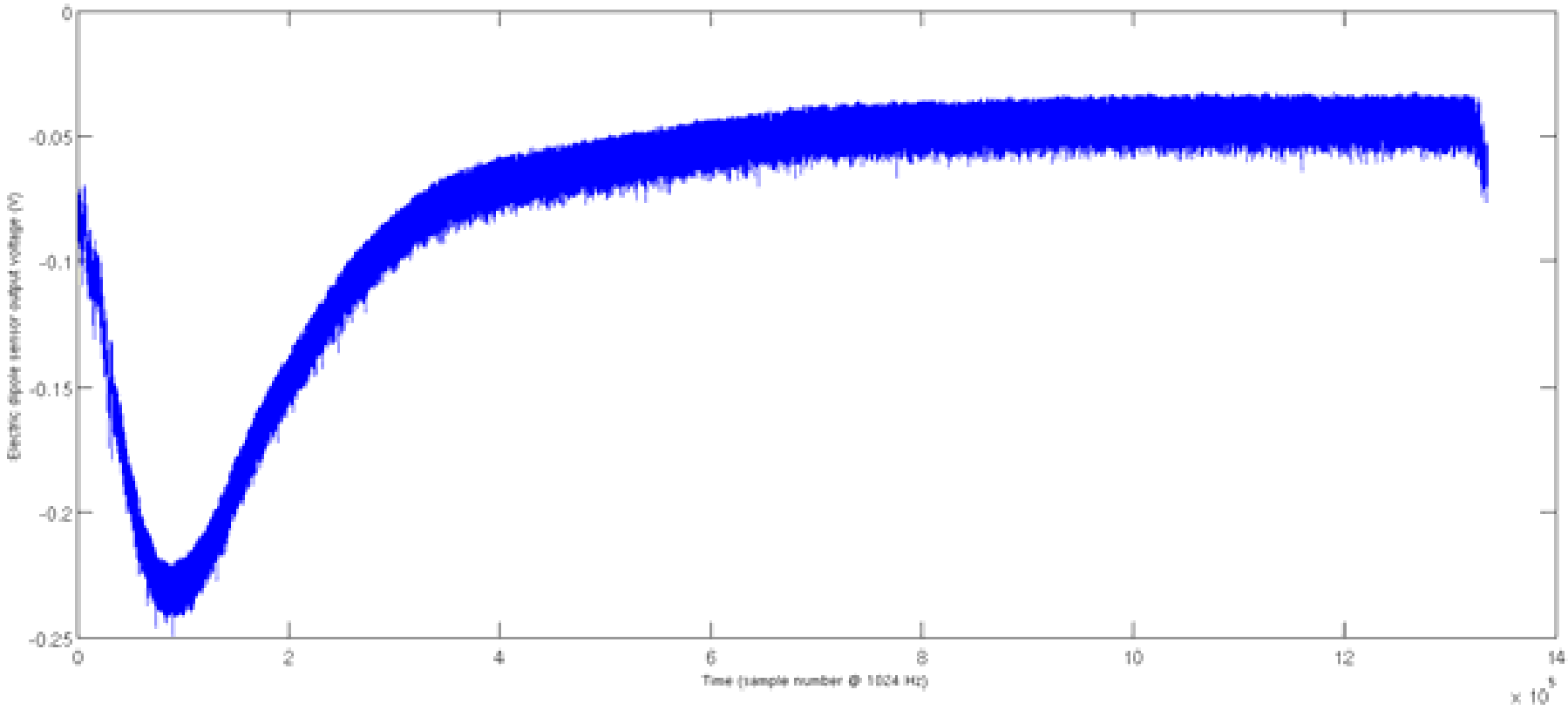


Figure 17: Electric dipole sensor output voltage, horizontal orientation.

In Figure 18, the electric dipole sensor output voltage of the vertical electric field time series is shown; this component is sensitive to water column motions.

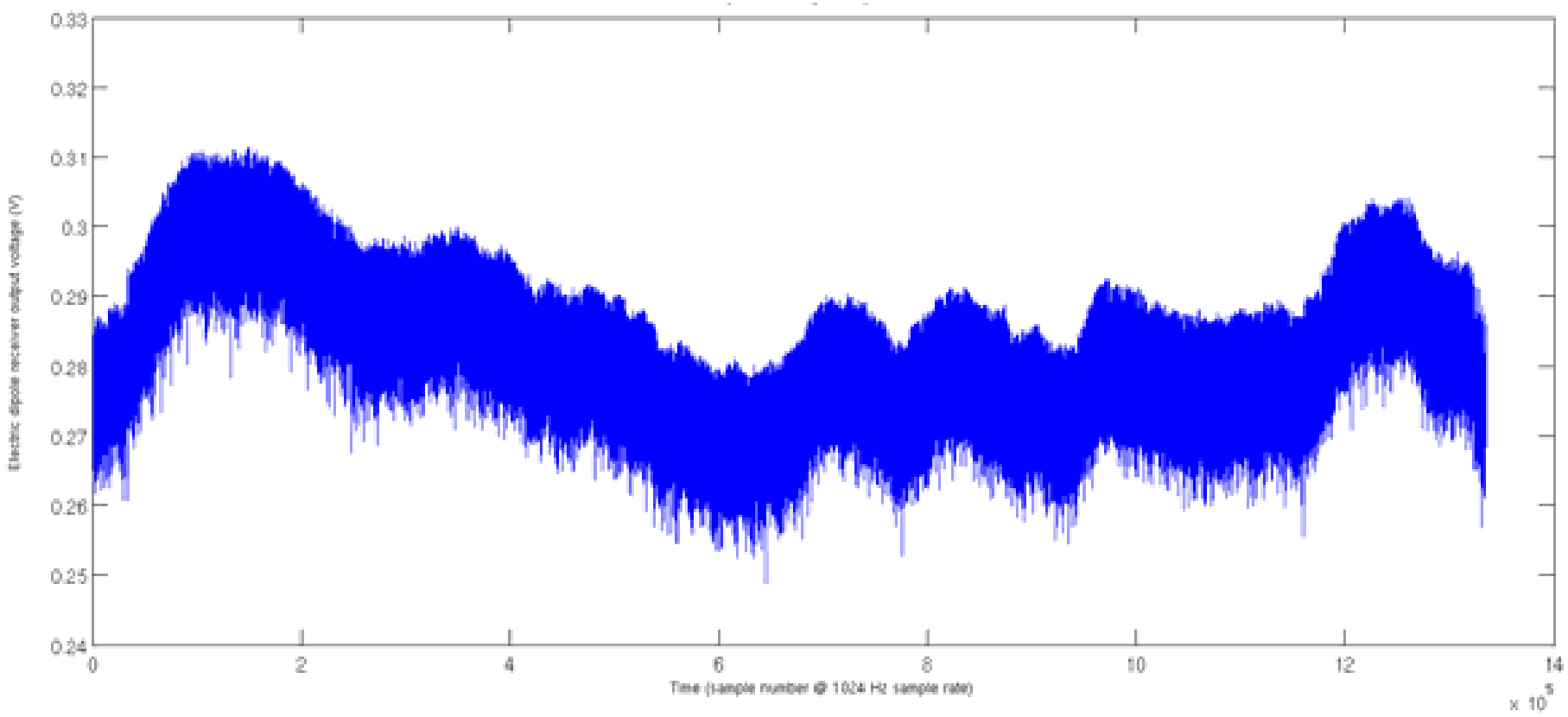


Figure 18: Electric dipole sensor output voltage, vertical component.

Figures 19 and 20 show the induction coil sensor output voltages for the east-west and vertical magnetic field time series, respectively.

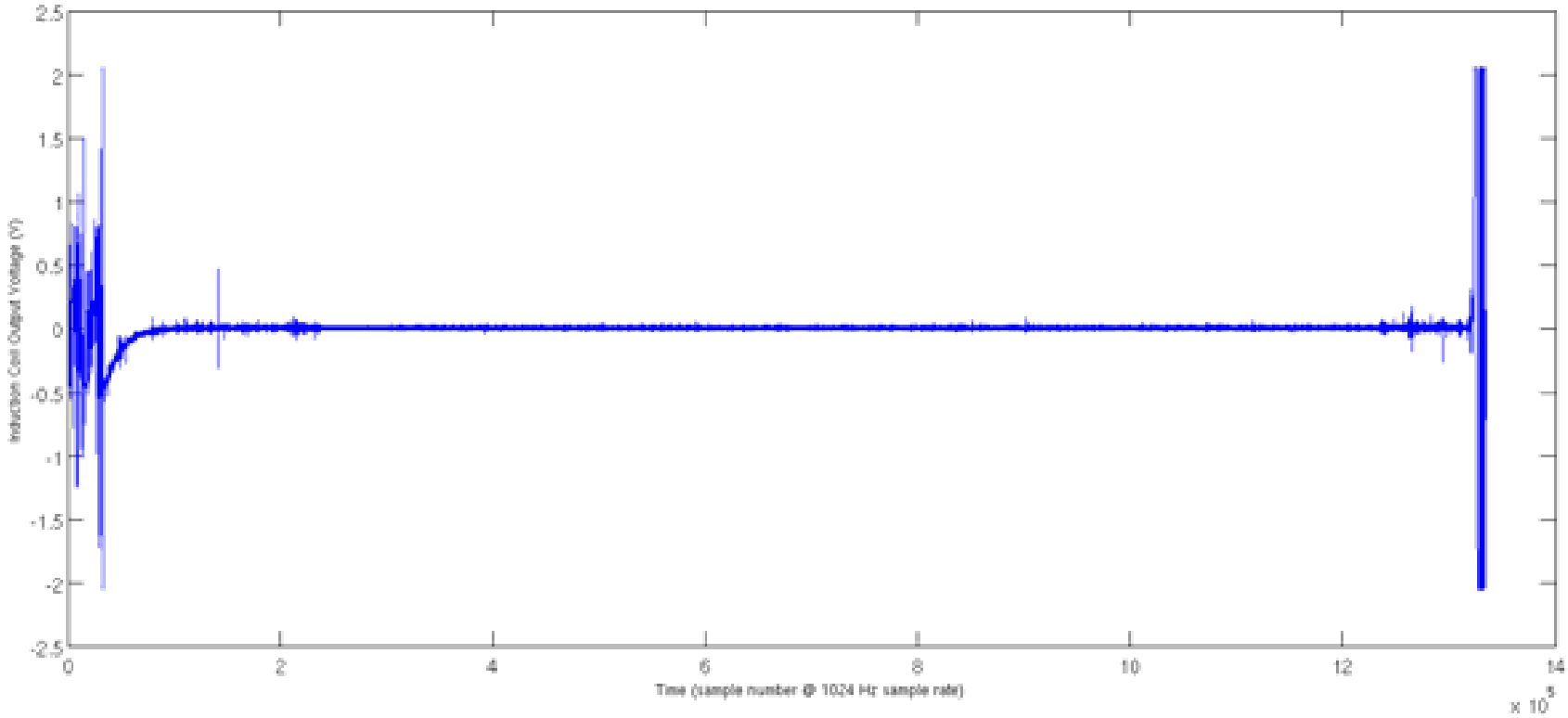


Figure 19: Induction coil sensor output voltage for east-west magnetic field time series.

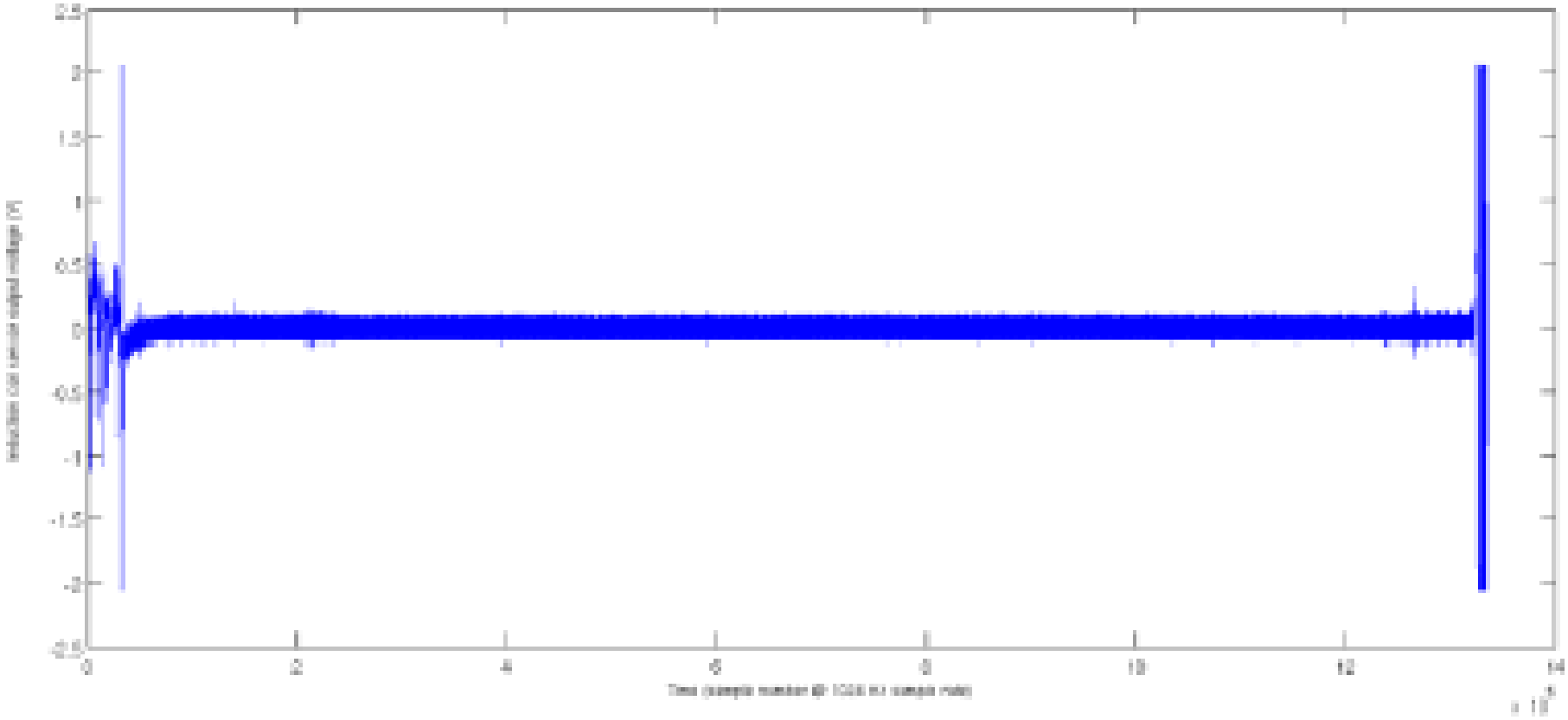


Figure 20: Induction coil sensor output voltage for vertical magnetic field time series.

Considering a four second window of the electric field data in Figure 17, a square wave at 1 Hz frequency becomes visible, as shown in Figure 21 below.

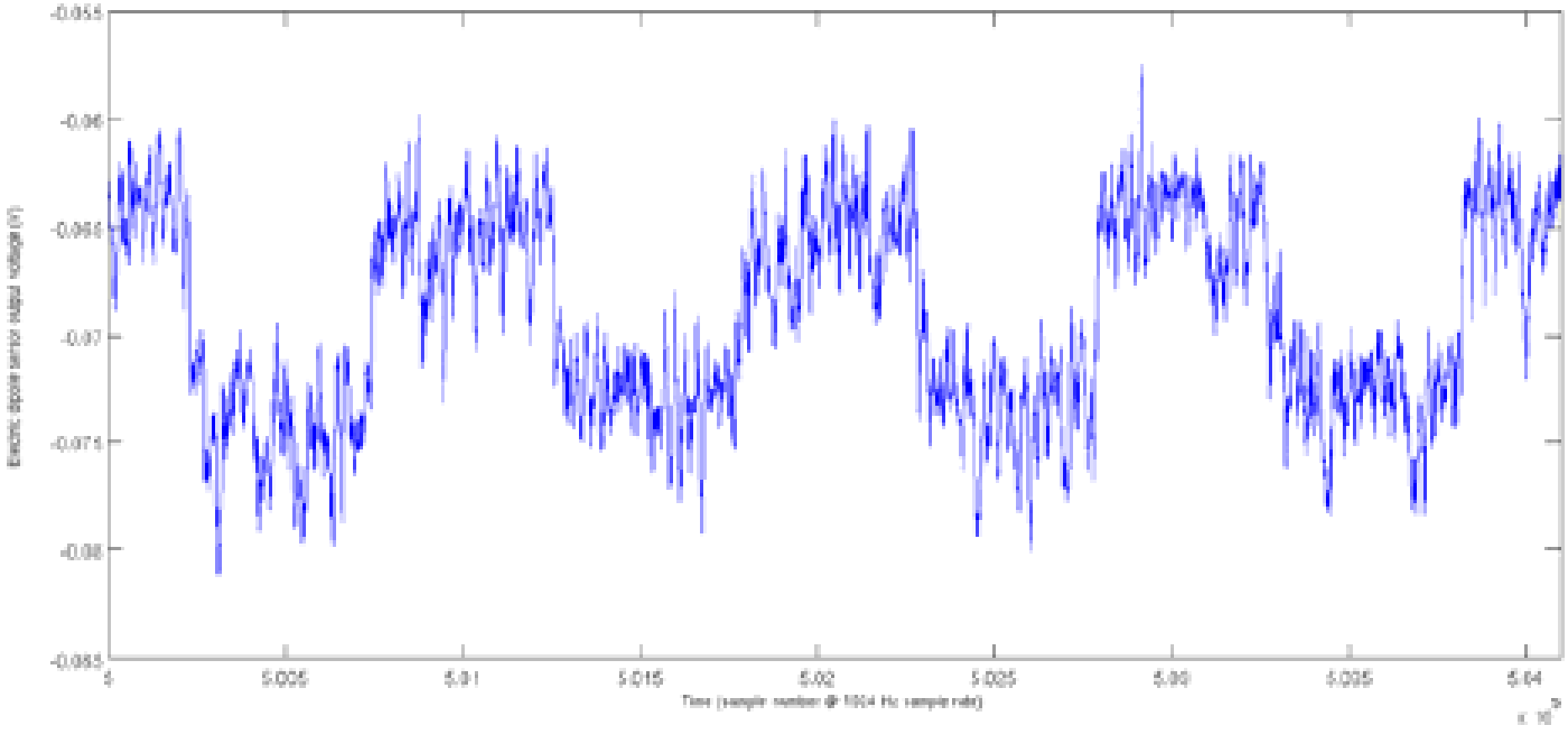


Figure 21: Four second long window view of electric field time series data (N-S).

In a two second window of the same data, 38 Hz periodicity is visible at approximately 5.009 seconds, as shown in shown in Figure 22 below.

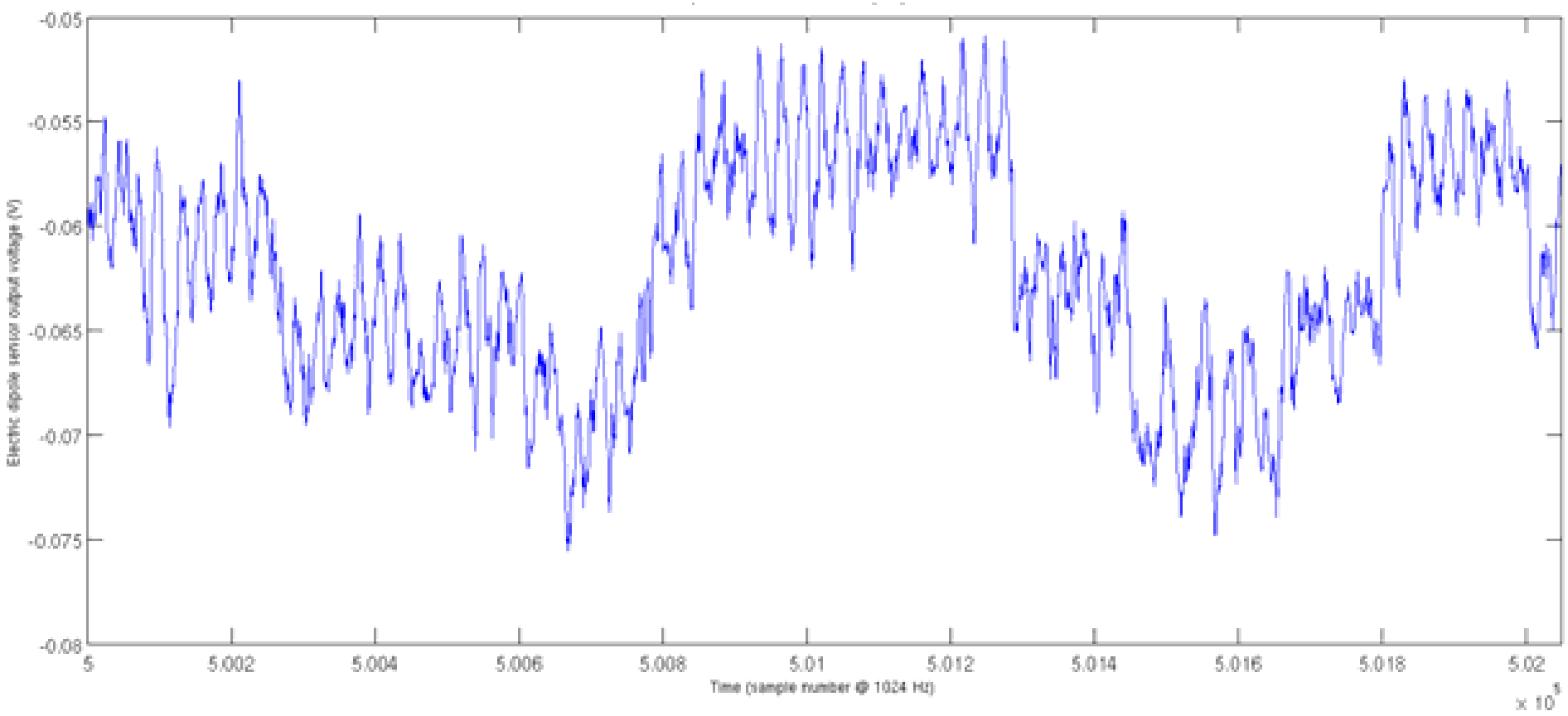


Figure 22: Two second window view of electric field time series data (N-S).

In a two second window of both the east-west and vertical components of the magnetic field time series, a 10 or 11 Hz saw tooth pattern is seen, as shown in Figures 23 and 24.

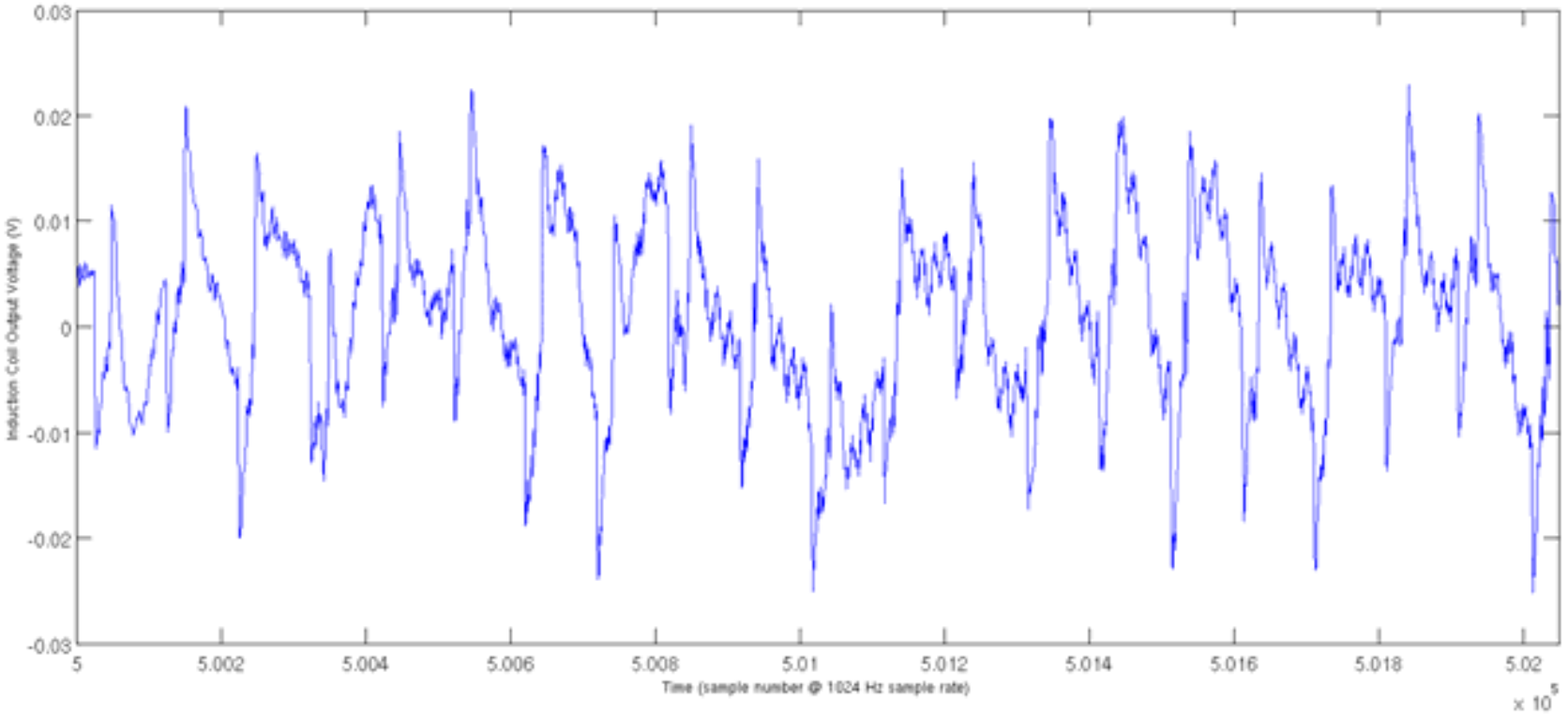


Figure 23: Two second window view of magnetic field time series data (E-W).

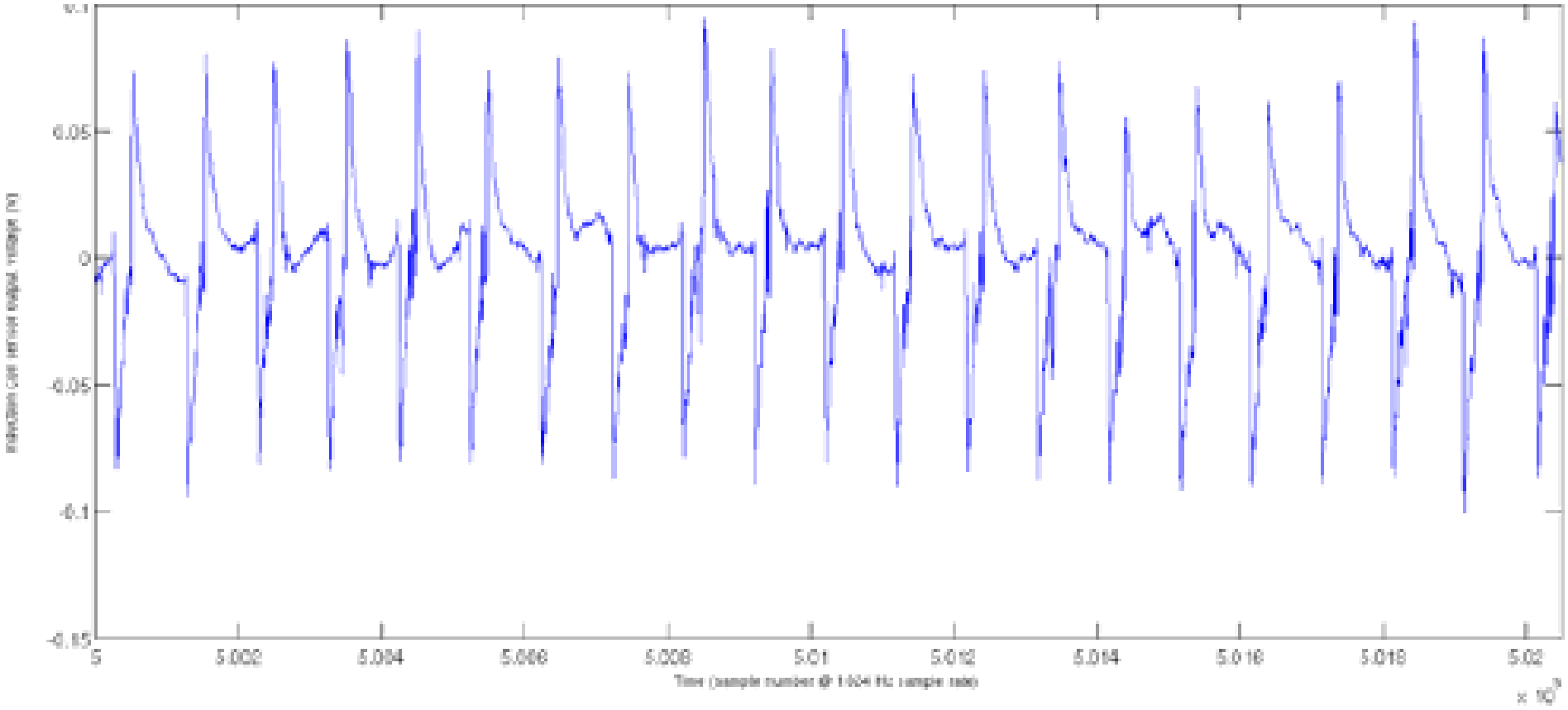


Figure 24: Two second window view of magnetic field time series data (vertical).

Analysis of linear frequency spectra for the electric field time series (N-S) shows the 38 Hz periodicity and harmonics. In addition, this plot verifies the 1 Hz square wave modulation of the electric field measurements; see Figure 25.

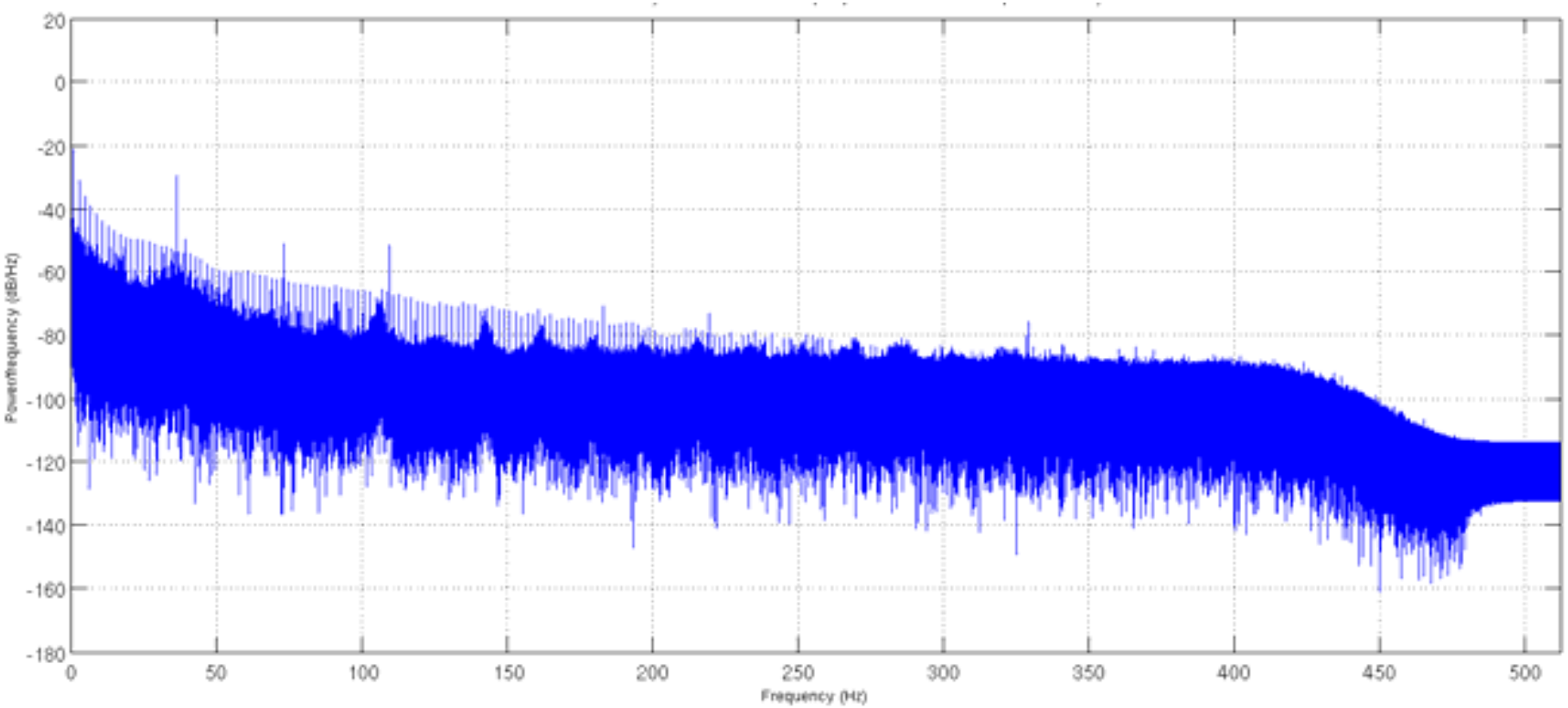


Figure 25: Linear frequency spectra for electric field time series (N-S)

Analysis of linear frequency spectra for the magnetic field time series (vertical) shows the 38 Hz periodicity and harmonics. In addition, this plot verifies the 10 -11 Hz saw tooth modulation of the magnetic field measurements; see Figure 26 below.

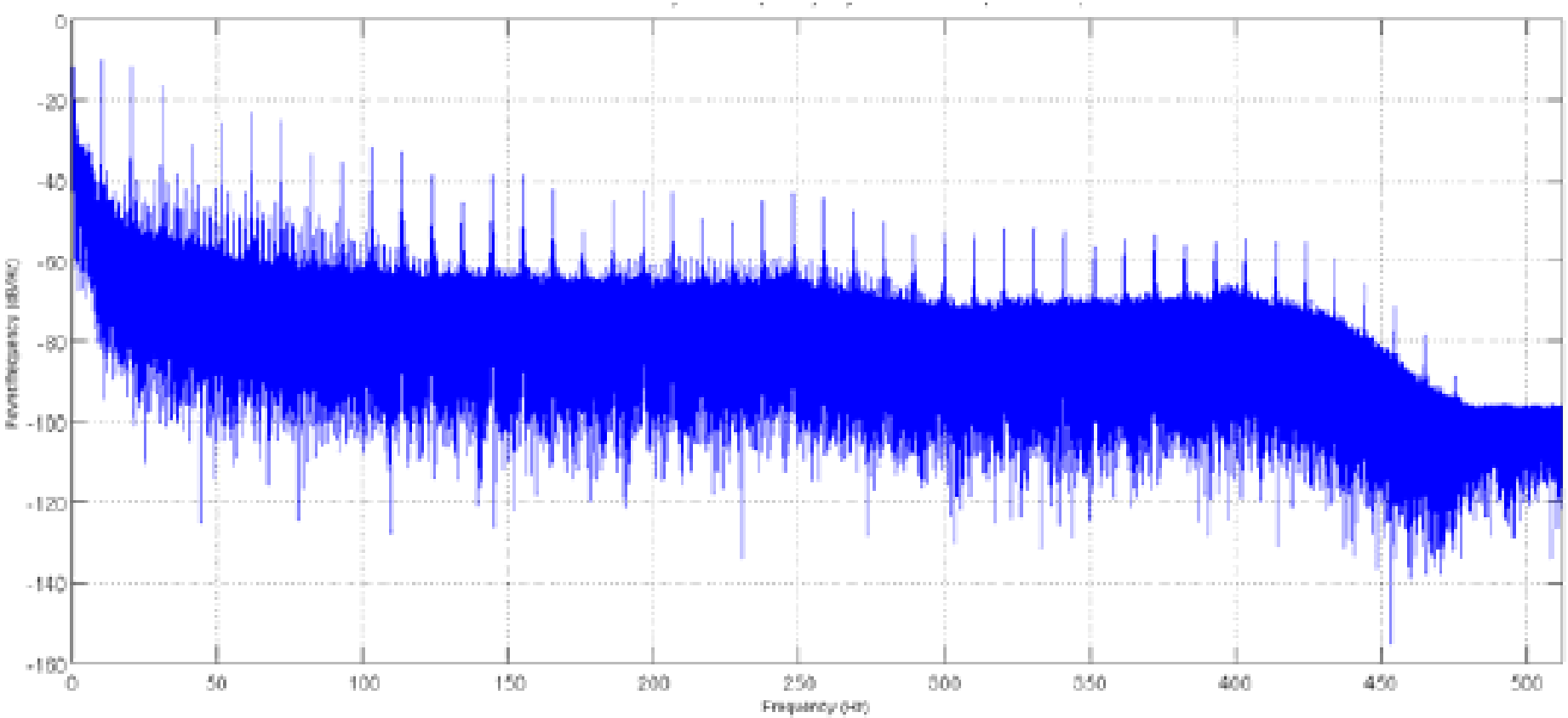


Figure 26: Linear frequency spectra for magnetic field time series (vertical).

Conclusions

Data analysis reveals that the predominant electrical and magnetic frequencies observed at 1Hz are due to the EMF data gathering instrument itself; frequencies observed at 38 Hz are likely due to the boat used to deploy the EMF measurement device; frequencies observed at 10 – 11 Hz are unidentified as yet, but are possibly from the Ocean Sentinel or WET-NZ.

Ability to Detect EMF

The heavy infrastructure associated with ocean energy facilities imposes a certain degree of complexity on marine EMF survey design. In particular, it is operationally difficult to approach moored devices like the WET-NZ and Ocean Sentinel. In addition, each device component (WEC or other electro kinetic generator), loads, power conversion and distribution systems and/or cables, may act as a complex AC/DC electric and or magnetic field source. The Ocean Sentinel acts as a quasi-grid simulator, providing a resistive load for the attached WEC (in this case the WET-NZ), and many internal subsystems within the Ocean Sentinel act as potential EMF sources. Additionally, the umbilical cable between the Ocean Sentinel and the WET-NZ has the potential to serve as a dipole magnetic and, under some circumstances, an electric field source. Further, once data is obtained, it is difficult to deconvolve the contributions of each of these elements. In order to deconvolve the contributions of each component of the installed infrastructure, it is necessary to capture source current waveforms for each subsystem at frequencies appropriate to the source (e.g. wave swell for WECs, power line and harmonics for converters/transmission lines, etc.).

Level of EMF from Project Devices

In attempting to identify signal sources, the survey team has concluded that the 1 Hz peak is ubiquitous for all electric field measurements taken in coastal Oregon offshore surveys. This was true not only for the September 2012 survey at the NNMREC ocean test site off the coast of Newport, but also for a baseline survey performed off the coast of Reedsport, OR. This implies that the 1 Hz peak is independent of the WET-NZ and the Ocean Sentinel. This is also true for the 38 Hz peak in electric and magnetic fields. It was eventually discovered that the 1 Hz peak comes from the EMF measurement instrument itself; specifically, the system battery power loading caused by LEDs flashing at 1Hz with 50% duty cycle.

The 38 Hz modulation in both electric and magnetic fields is undetermined. During the baseline EMF survey in Reedsport, however, the ship was determined, at times, to be resonating mechanically at 38 Hz based on on-board accelerometer measurements. The same vessel, the Miss Linda, was used in both Newport and Reedsport surveys, so it is possible that this resonance is coupled into the measurement system, moving the sensors enough to yield this signal. The result is ambiguous, however, since the 38 Hz EMF spectral peak persisted in our seafloor measurements- even for those times when the survey vessel stood off a full nautical mile and powered down all systems, which ended the mechanical resonance. It may be that other vessels operating in the area produced a similar mechanical resonance effect, with similar potential for coupling to the seafloor through seismo-acoustic energy propagation, but this is speculative absent additional information (although there is evidence for an intensification of

the 38 Hz spectral EMF peak when the survey vessel was powered up and in closer proximity to the EMF survey sites). Consequently, the 38 Hz modulation remains of indeterminate cause.

The 10 or 11 Hz magnetic field modulation was found at every survey location around the NNMREC ocean test site, but the field intensity did depend on location with respect to the project devices. Determining the source is work-in-progress, but there seem to be variations in the intensity of the 10-11 Hz spectral peak with offset from the WET-NZ and/or Ocean Sentinel. Future surveys should aid in determining the source of the signal, and whether it is associated with the WEC or the Ocean Sentinel.

Determination of Whether There is a Meaningful Source of EMF from the Project

The EMF frequencies observed at the NNMREC ocean test site in September 2012 suggest that the 10 - 11 Hz spectral peak in EMF field intensity that was potentially associated with the project does rise above the background spectral energy levels associated with surrounding frequencies, as does the 38 Hz spectral peak of indeterminate origin. There is currently a lack of information in the scientific literature on the sensitivity of marine species to EMF levels associated with these spectral peaks (and their harmonics, which also rise above background levels). Further work on both localization of these spectral peaks to installed infrastructure (including WECs, Ocean Sentinel and other support systems), and on the behavioral and toxicological response of indicated marine species to EMFs associated with these frequencies and their spectral harmonics, is indicated.

EMF Propagation Model Effectiveness

Given the low sea states and barely energized state of the WET-NZ during the September 2012 survey, the results are not useful in characterizing the EMFs from an energized WEC. As such, it is recommended that this survey be considered an ambient baseline survey rather than an operational WEC survey. Following device removal, the survey team concluded that there was no technical advantage to returning to the project site to repeat the survey to characterize baseline levels of EMF at the project site. Therefore, we do not plan to repeat the EMF survey in 2013 to obtain a set of de-energized background measurements, as these would prove redundant. However, we believe a follow-on survey would be warranted during a future WEC test to characterize the WEC in its energized state.

Efficacy in Measuring EMF for Future Tests & Survey Modifications

For future surveys, we would deploy the 2nd generation EMF system since it can operate for sustained periods of time autonomously on the seafloor. The survey design would also change to reflect the experience gained in 2012. That is, we have determined that there is an operational inconsistency between the need to study how EMF's propagate with distance and azimuth from the WEC, and the need to obtain temporally sustained (rather than brief spot) measurements of seafloor EMFs that reflect a full range of WEC power output conditions. The fair weather conditions that make it possible to execute the spot measurement grid survey are, by their nature, not conducive to high power outputs from the WEC. It will also be important to maintain at least 1 kHz continuous sampling of voltages and currents inboard the Ocean Sentinel to provide source waveforms that we can then correlate against for our sea floor measurements. This is particularly important since the Ocean Sentinel deployed with a WEC cannot be guaranteed to produce standard power line harmonics, which means we cannot rely simply on detecting power line and wave energy frequencies in spectrograms; instead, we will need to

calculate transfer functions between the actual waveforms logged inboard the Ocean Sentinel and the signals we observe at the seafloor survey stations. Additional considerations are discussed in Section 2.5.1 of the 2012 Annual Operations and Monitoring Report.