ORE since 1966
OCEAN AND RESOURCES ENGINEERING
IN THE SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY AT THE UNIVERSITY OF HAWAI'I AT MĀNOA

HANA O KE KAI "Work of the Ocean"

NEWSLETTER OF THE OCEAN AND RESOURCES ENGINEERING DEPARTMENT, Fall 2014, Volume 18, Issue 1

Chair's Message

Bruce M. Howe, Chair

We want to thank Prof. Oceana Francis and her colleagues and staff in Civil and Environmental Engineering for making the Hydraulics Lab available for ORE 601 Ocean Engineering Lab taught by Prof. Zhenhua Huang. The students were able to use the flume, learned how to generate waves and measure them downstream, and to measure forces on structures subjected to varying wave conditions.

In 2015, ORE will be one of six engineering programs here at the University of Hawaii coming up for ABET accreditation review. Alumni have already received questionnaires, and we will be contacting advisory committees for input as we write and compile the self-study report that is required. The review board will visit in late November. The review six years ago went well, and we anticipate the same again.

I'd like to encourage alumni and everyone who receives this newsletter to consider donating to our "ORE Enrichment Fund." This University of Hawaii Foundation account enables us to do a little more, primarily for students, such as food at seminars and social occasions, and travel to conferences. Having discretionary reserve funds is extremely important.

All the best wishes in the new year - Hau'oli Makahiki Hou!

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Editor's Corner

Jonathan Koons, TA

I hope everyone had a Merry Christmas and a Happy New Year. It's been another interesting semester here at ORE. I've enjoyed seeing the new students around Holmes Hall and keeping in contact with some of those that have recently graduated. Thanks to everyone that have contributed to the newsletter again.

Student and Faculty News

- **Kara Silver** defended her MS Plan B Presentation "A Passive Acoustic Automated Detector For Sei and Fin Whales" on November 12, 2014.
- **Kay Gemba** defended his Ph.D. Dissertation "Characterization of Underwater Acoustic Sources Recorded in Reverberant Environments with Application to Scuba Signatures" on November 14, 2014.
- **Betsy Seiffert** defended her Ph.D. Dissertation "Tsunami and Storm Wave Impacts on Coastal Bridges" on November 14, 2014.
- **Professor Kwok Fai Cheung** was awarded the Dr. Gaylord R. Miller Award for Excellence in Tsunami Preparedness by the Hawaii Emergency Management Agency in 2014.
- **Kay Gemba** took first place in the in the International Student Challenge Problem in Acoustical Signal Processing sponsored by the Acoustical Society of America.

Some Recent ORE Publications

Hayatdavoodi, M. and **Ertekin, R.C.** (2014), "Storm Wave Forces on Selected Prototype Coastal Bridges on the Island of Oahu," Dept. of Ocean and Resources Engineering, Univ. of Hawaii at Manoa, Report No. UH-MORE-14101, August, 109pp.

Zhao, B.B., **Ertekin, R.C.**, Duan, W.Y. and Hayatdavoodi, M. (2014). "On the steady solitary-wave solution of the Green-Naghdi equations of different levels," Wave Motion, Vol. 51, No. 8, December, pp. 1382-1395, Elsevier, DOI: 10.1016/j.wavemoti.2014.08.009 SOEST No. 9214.

Zhao, B.B., **Ertekin, R.C.** Duan, W.Y. and Kim, J.W. (2015) "Particle Trajectory Calculations under a Solitary Wave by High-level IGN Equations," J. Waterway, Port, Coastal and Ocean Engineering, DOI: 10.1061/(ASCE)WW.1943-5460.0000283

Hayatdavoodi, M. and **Ertekin, R.C**. (2015), "Nonlinear Wave Loads on a Submerged Deck by the Green-Naghdi Equations," J. Offshore Mechanics and Arctic Engineering, Vol. 137, Issue 1, February, pp. 011102-1 to 011102-9, DOI: 10.1115/1.4028997 SOEST No. 9244.

Hayatdavoodi, M., Seiffert, B. and **Ertekin, R.C**. (2015), "Experiments and Calculations of Cnoidal Wave Loads on a Flat Plate in Shallow Water," J. Ocean Engineering and Marine Energy, Vol. 1, No. 1, February, DOI 10.1007/s40722-014-0007-x

Zhao, B.B., **Ertekin, R.C**. and Duan, W.Y. (2015) "A Comparative Study of Diffraction of Shallow-water Waves by High-Level IGN and GN Equations," J. Computational Physics, DOI: 10.1016/j.jcp.2014.11.020.

Bai, Y., **Cheung, K.F**., Yamazaki, Y., Lay, T., and Ye, L. (2014). Surges around the Hawaiian Islands from the 1 April 2014 North Chile Mw 8.1 earthquake. *Geophysical Research Letters*, 41(23), DOI: 10.1002/2014GL061686.

Yue, H., Lay, T., Rivera, L.A., Bai, Y., Yamazaki, Y., **Cheung, K.F**., Hill, E.M., Sieh, K.E., Kongko, W., and Muhari, A. (2014). Rupture process of the 2010 Mw 7.8 Mentawai tsunami earthquake from joint inversion of near-field hr-GPS and teleseismic body wave recordings constrained by tsunami observations. *Journal of Geophysical Research*: *Solid Earth*, 119(7), 5574-5593.

Yim, S.C., Olsen, M.J., **Cheung, K.F**., and Azadbahkt, M. (2014). Tsunami modeling, structural load simulation, and validation using geospatial field data. *Journal of Structural Engineering*, 140(8), A4014012.

Foster, J., Li, N., and **Cheung, K.F**. (2014). Sea state determination from ship-based geodetic GPS. *Journal of Atmospheric and Oceanic Technology*, 31(11), 2556-2564.
Stopa, J.E. and Cheung, K.F. (2014). Periodicity and pattern of ocean wind and wave climate. *Journal of Geophysical Research*: *Oceans*, 119(8), 5563–5584.

Li, N., Roeber, V., Yamazaki, Y., Heitmann, T.W., Bai, Y., and **Cheung, K.F**. (2014). Integration of coastal inundation modeling from storm tides to individual waves. *Ocean Modelling*, 83, 26-42.

B. M. Howe, A Deep Cabled Observatory: Biology and Physics in the Abyss, *Eos, Trans. AGU*, 95(47), 429-430, 2014. DOI: 10.1002/2014EO470001

Events

Upcoming Meetings and Conferences

The Acoustical Society of America Spring Meeting will be held in Pittsburg, Pennsylvania from May 18-22, 2015. http://www.acousticalsociety.org/content/spring-2015-meeting

34th International Conference on Ocean, Offshore and Arctic Engineering (OMAE2014) in St. Johns, NL, Canada from May 31-June 5, 2015. http://asmeconferences.org/OMAE2015/

OCEANS'15 MTS/IEEE Conference in Genova, Italy from May 18-21, 2015. http://www.oceans15mtsieeegenova.org/

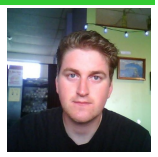
25th International Offshore (Ocean) and Polar Engineering Conference will be held in Kona, Hawaii from June 21-26, 2015. http://www.isope2015.org

2015 2nd International Conference on Coastal and Ocean Engineering will be held in Kyoto, Japan from April 6-7, 2015. http://www.iccoe.org/

The ORE 601 class on a field trip to a radar site run by Professor Pierre Flament of the Oceanography Department at UH, on Koko Head. From left to right: a mysterious pile of rocks, Conghao, Linyan, Matt, Ghizlane, Andreia, Jonathan, Professor Huang, Derek..

Inside ORE-Student Research

ORE Ph.D Student Kay Gemba Takes First Place in International Student Challenge Sponsored by Acoustical Society of America



The Technical Committee on Signal Processing of the Acoustical Society of America posed an International Student Challenge Problem in Signal Processing in the summer of 2014. The problem presented a real-world signal processing challenge encountered in the field of acoustics. This article provides an introduction to the problem followed by Kay's summary of his winning solution. Results provided by the committee as well as the submitted solution is available on the ORE website at http://www.ore.hawaii.edu/OE/ore_news2.htm.

Problem formulation

A truck with a 4-stroke diesel engine travels along a straight road with constant speed. Near the road is a microphone that senses the radiated acoustic noise from the truck during its passage past the microphone. The output of the microphone is sampled at the rate of 12,000 samples/second and 30 seconds of data are recorded during the trucks transit. During the recording of the data, the speed of sound propagation in air was a constant 347 m/s.

Problem

Assuming that the truck is a point source, and given that the strongest spectral line is the engine firing rate, calculate the trucks engine firing rate (EFR, in Hz), cylinder firing rate (CFR, in Hz), number of cylinders, tachometer reading (in revolutions/minute), speedometer reading (in km/hour), distance (in meters) of the closest point of approach of the truck to the sensor, time (in seconds) at which the closest point of approach occurs.

Introduction

Discrete Fast-Fourier Transforms (FFT) can be used to estimate the frequency content of discrete, finite time signals. The frequency content for stationary signals is constant in time and the FFT is an appropriate analysis tool. However, the FFT is not localized in time which is a limitation when estimating the frequency content of nonstationary signals. A solution is to segment the original signal into smaller parts, compute the FFT for each part (usually with some overlap to smooth transitions between segments) and assemble the output in temporal order. This time-frequency (TF) representation is called a spectrogram and is an intuitive way to display a signal's frequency content in time. Time and frequency resolution are related by the uncertainty principle, an increase in frequency resolution reduces the time resolution and vice versa, e.g., estimating the instantaneous frequency (IF) of a source (such as a passing airplane, vessel or a truck) is a tradeoff between time and frequency resolution. Alternatively, IF estimates can be computed using the Pseudo-Wigner-Ville distribution (PVWD). The PWVD is a is a high-resolution TF method, allowing a more precise estimate of the IF than using STFT. The following discussion will address how to estimate the IF of a passing truck, which is subsequently compared to the output of a parametric model used to compute four of the seven parameters in the problem statement. The remaining three parameters can be estimated directly from the recording.

Parameter estimation

Four parameters are estimated using a parametric model. Here, this model approximates the IF of a constant tone emitted by the passing truck of constant speed along a straight road. Model parameters (EFR, speed of the vehicle, distance from the microphone and time of closest approach) are varied and results are compared to the IF extracted from a TF plot using the acoustic recording (referred to as data). Optimum parameters are found by minimizing the squared difference between model output and data.

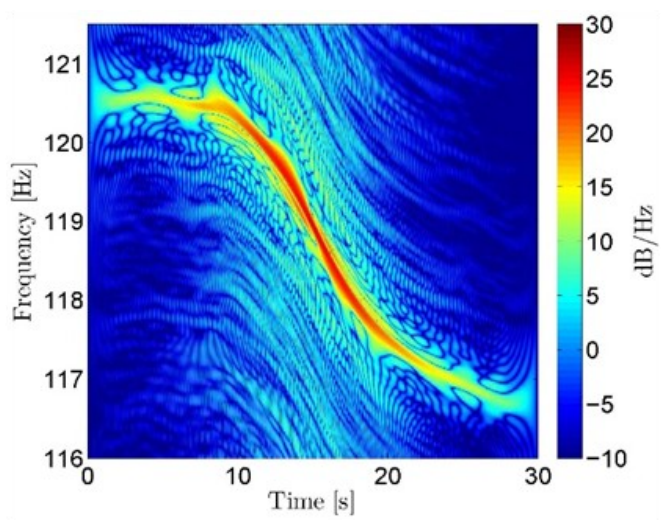


Figure 1: Spectrogram showing Doppler shift of the EFR using PWVD (Kaiser window with beta=4.5).

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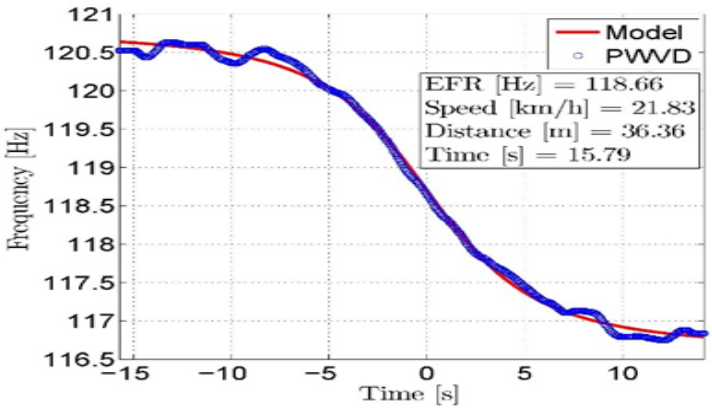


Figure 2: Parameter estimation results computed by comparing IF estimates from Fig. 1 to the output of a parametric model.

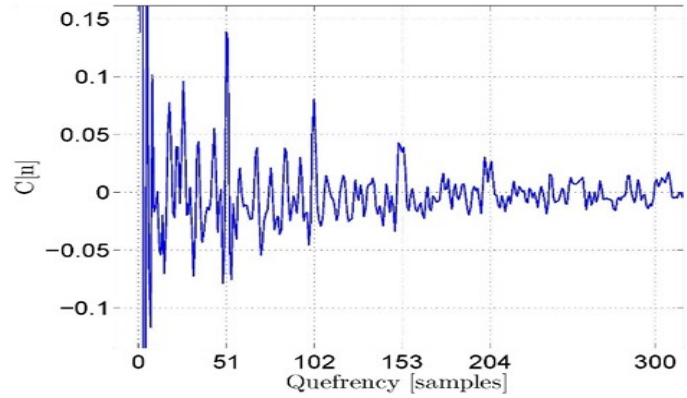


Figure 3: Zoomed in real cepstrum of the recording. The first rahmonic peak at nominally 51 samples corresponds to a CFR of 19.6 Hz.

To estimate the IF of the passing truck from data, TF representations are computed using the
Short Time Fourier Transform and PWVD. An example of a TF representation using PWVD is shown in Fig. 1, zoomed in on the strongest spectral line. As given in the problem statement, this line corresponds to the EFR of the vehicle. However, its frequency content changes in time (this phenomenon is called the Doppler effect) and the IF at the closest point of approach cannot be directly identified. One approach is to extract the IF estimates using a peak-detection algorithm and compare the data to the output of a parametric model. Here, the peak-detection algorithm operates over the range of the Doppler shift (115 - 122 Hz) at each time step and selects the maximum frequency value. Figure 2 shows the output of the peak-detection algorithm (blue trace).

Estimating the model parameters is an optimization problem, e.g. the goal is to minimize the cost function which corresponds to the difference between the output of the peak detection algorithm and model output. In short, a nonlinear least-squares optimization problem for vector-valued functions can be solved using a trust region reflective algorithm (Levenberg-Marquardt Algorithm). Model output corresponding to the minimum error is plotted in Fig. 2 (red trace) along with estimated parameters. In comparison, parameter solutions provided by the organizers of the student challenge are 118.64 Hz, 21.29 km/hr, 34.75 m, and 15.64 s (EFR, speed of vehicle, distance at closest point of approach, and time at which the closest point of approach occurs, respectively).

To estimate the three remaining parameters, real cepstra of the data are computed (see for an introduction to concepts and cepstral glossary; see for a discussion using cepstral analysis and autocorrelation to find the CFR). The spectrum of the log of the spectrum of a ttime waveform is referred to as the cepstrum, the independent variable is called quefrency and harmonics are called rahmonics. The motivation for cepstral analysis is to separate periodic components in the time signal, such as constant cylinders firing.

Figure 3 shows a filtered and downsampled (1000 samples/sec) real cepstrum. The signal is filtered for illustration purposes to eliminate tire and other noise sources at higher frequencies. The first rahmonic at a delay of 51 samples corresponds to a CFR of 19.6 Hz (sampling rate / delay). To increase the sample resolution, a real cepstrum is computed with the original sampling rate. Erratic peaks due to the increased resolution are smoothed by applying a window. Results are similar to Fig. 3, a distinct peak at 607 samples corresponds to a CFR of 19.77 Hz.
The number of cylinders is found to be 6 (EFR / CFR). Values for 4,8,10, and 12 cylinders correspond to theoretical delays of 33, 66, 83, and 100, respectively. Examining Fig. 3, the closest peak to a delay of 33 samples is found at 26 samples (no match). There are no peaks close to 66 and 83 samples and the peak at 100 samples (possible match) is likely a rahmonic of 51 samples (a V12 should be a multiple of a V6). In addition, the lowest deterministic
tone (in the spectrum) is called the cylinder fire rate and is found to be nominally 20 Hz by visual inspection. This result is close to the above 19.77 Hz, which suggests that the vehicle has 6 cylinders. In a 4 cycle engine, every piston has to go up and down twice to fire once and the tachometer reading in rpm can be estimated using CFR x 60 x 2= 2372 rpm. In comparison, parameter solutions provided by the organizers of the student challenge are 19.8 Hz, 6, and 2370 rpm (CFR, number of cylinders, and tachometer reading, respectively).

i. Ferguson, B. G. and Culver, R. L. (2014). Acoustics Today. International Student Challenge Problem in Acoustic Signal Processing, 10(2):26-29.
ii. Boashash, B., editor (2003). Time Frequency Signal Analysis and Processing. Elsevier Science, Oxford, UK, First Edition.
iii. Oppenheim, A. and Schafer, R. (2004). Dsp history - From frequency to quefrency: a history of the cepstrum. IEEE Signal Processing Magazine, 21(5):95-106.
iv. Thomas, D. and Wilkins, B. (1970). Determination of engine firing rate from the acoustic waveform. Electronics Letters, 6(7):193-194.
v. Cevher, V., Chellappa, R., and McClellan, J. (2009). Vehicle Speed Estimation Using Acoustic Wave Patterns. IEEE Transactions on Signal Processing, 57(1):30-47.

New Students

We have a few new students at ORE, and what better way is there to get to know them than ask them a couple questions they may or may not want to answer?

Questions

1. What degree are you seeking?
2. What is your academic background?
3. Any particular research goals?
4. Where did you grow up?
5. On a scale of vegetables to ice cream, what food would you pick to describe your time at ORE and in Hawaii so far?
6. Favorite hobbies?

Vincent Varamo

1. MS, Coastal
2. BS in Physics with a concentration of Physical Oceanography. UNC Wilmington
3. Haha, survive
4. Charlotte, North Carolina
5. Poke bowls for life
6. Surfing

Kyle Ryan

1. MS (ORE and/or NREM)
2. Naval Architecture and Marine Engineering, US Coast Guard Academy, MBA Maritime Transportation, Old Dominion University
3. AUV for DOD application, human/cetacean interaction
4. Washington State
5. Mystery meat, Pumpkin Pie
6. Gardening

Andreia Queima

1. MS, Coastal
2. BS in Civil Engineering
3. Wave modeling for structural design
4. Rio de Janeiro, Brazil
5. At Hawaii, ice cream, at ORE, a nice eggplant!
6. Surfing and outdoors activities

Inside ORE-Recent Ph.D Dissertation Abstracts

Tsunami and Storm Wave Impacts on Coastal Bridges

Betsy Seiffert

Wave loads on coastal bridges due to tsunami and storm waves are studied through a set of laboratory experiments and numerical calculations. Effects of wave nonlinearity and entrapped air on wave loading under conditions where the bridge may be partially or fully inundated are of particular interest. In addition, effects of compressibility and scaling are investigated through numerical calculations. With the destruction of bridges during recent events such as the 2011 Tohoku tsunami and hurricanes Katrina in 2005 and Ivan in 2004, this highlights the importance of this research in understanding the mechanisms of failure during such events to prevent future coastal bridge failures. Destruction of these bridges is not only financially costly, but can prevent emergency services from reaching coastal communities, thus potentially contributing to loss of life. Along with the bridges, this research is applicable to other coastal and offshore structures, such as piers, submerged breakwaters and offshore platforms, in which wave loading or entrapped air is of concern.

Characterization of Underwater Acoustic Sources Recorded in Reverberant Environments with Application to Scuba Signatures

Kay Gemba

The ability to accurately characterize an underwater sound source is an important prerequisite for many applications including detection, classification, monitoring and mitigation. Unfortunately, anechoic underwater recording environments, required to make ideal recordings, are generally not available. Current methods adjust source recordings with spatially averaged estimates of reverberant levels. However, adjustments can introduce significant errors due to a high degree of energy variability in reverberant enclosures and solutions are inherently limited to incoherent approximations. This dissertation introduced an approach towards a practical, improved procedure to obtin an anechoic estimate of an unknown source recorded in a reverberant environment.

An anechoic estimate of the source is obtained by equalizing the recording with the inverse of the channel's impulse response (IR). The IR is deconvolved using a broadband logarithmic excitation signal. The length of the IR is estimated using methods borrowed from room acoustics and inversion of non-minimum phase IR is accomplished in the least squares sense. The proposed procedure is validated by several experiments conducted in a reverberant pool environment. Results indicate that the energy of control sources can be recovered coherently and incoherently with root-mean square error (RMSE) of approximately –70 dB (10-70 kHz band).

The proposed method is subsequently applied to four recorded SCUBA configurations. Results indicated that reverberation added as much as 6.8 dB of energy. Mean unadjusted sound pressure levels (0.3-80 kHz band) were 130 ± 5.9 dB re 1 μPa at 1 m. While the dereverberation method is applied here to SCUBA signals, it is generally applicable to other sources if the impulse response of the recording channel can be obtained separately.

This dissertation also presented an approach to separate all coloration from the deconvolved IR. This method can be used to estimate the channel's IR or the magnitude spectrum of the combined electrical equipment. The procedure is validated using synthetic results of an image-source model and the channel's IR is recovered over the full band with a RMSE of –31 dB.

Aloha from Galveston to Hawaii

Masoud Hayatdavoodi

Masoud fishing in Galveston Bay. Where's those 7 fish Masoud?

My period in the ORE department started on October 2006, when I joined as a visiting scholar. On August 2014, I left the department after finishing my Post-Doctoral study with Professor R. Cengiz Ertekin. I truly enjoyed my life the entire time I lived in Hawaii and worked in the department. In September 2014, I became a member of Texas A&M University at Galveston (TAMUG). The transition time between UH and TAMUG was short as I had to teach classes about a week after my arrival to Galveston.

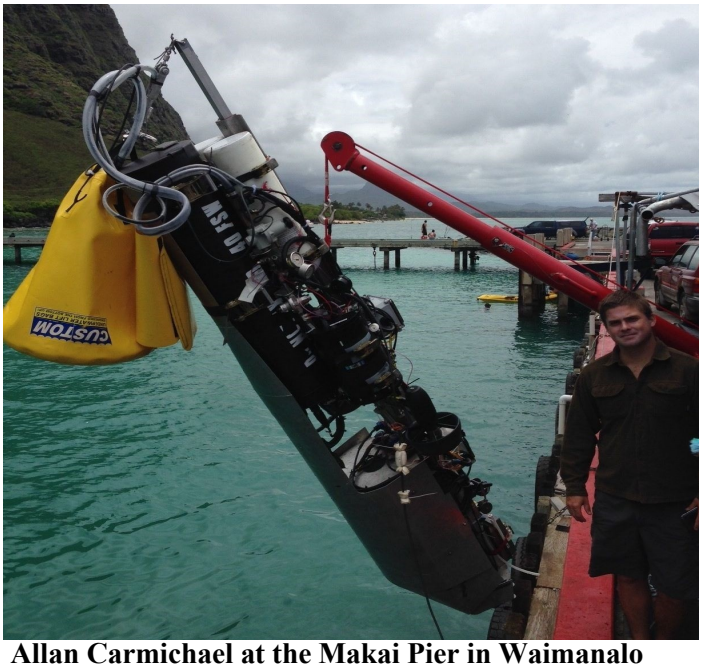
Now it is the end of the first semester, and I think I have survived. My office at TAMUG is just a few steps away from the beach, and I value all aspects of work in the academic environment; particularly, teaching and advising students is rewarding. Although not like Hawaii, Galveston is a nice place. Fishing is one of the most popular activities here. In my life, I have gone fishing about 4-5 times and I have caught 7 fish, all of which have occurred in Galveston.

All the best to all of you, and I hope to see you very soon.

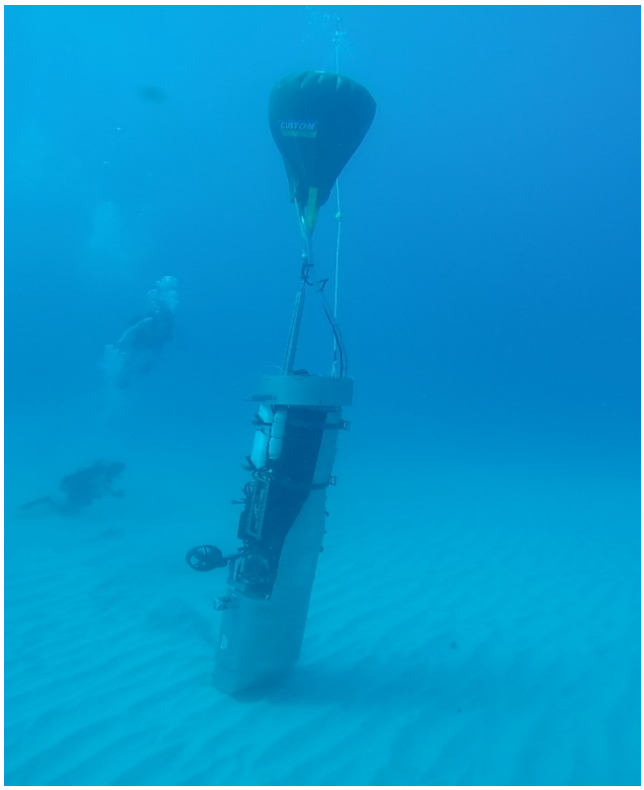
Alumni

Allan Carmichael

Makai Ocean Engineering and the University of Hawaii have jointly developed a novel autonomous underwater vehicle (AUV) that combines features of a conventional AUV with that of a bottom crawling vehicle. This 'bottom skimming' hybrid AUV is called the Shallow Water Oceanographic Profiler or SWOP. The SWOP navigates autonomously to a predefined location, skims along or hovers above the seafloor using variable buoyancy, and installs oceanographic sensors in the seafloor for environmental monitoring. Recent ORE alumnus Allan Carmichael (MS ORE Spring 2014) is a key engineer on the project, and has been performing mechanical design, fabrication, testing, and evaluation on the vehicle, as well as diving support for the at-sea testing of the vehicle.



Allan Carmichael at the Makai Pier in Waimanalo



Allan performing dive support for the SWOP

Deploying the SWOP at sea

Final Page

Your Gift to the ORE Enrichment Fund

THE ORE ENRICHMENT FUND (The University of Hawaii Foundation Account # 123-7310-4)

Yes, I'll support

My gift* is:

□ $10,000 □ $5,000 □ $3,000

□ $1,000 □ $500 □ $300

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□ My check is enclosed payable to:

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Please mail your check and this form to: c/o ORE Enrichment Fund Administrator, Department of Ocean and Resources Engineering, University of Hawaii at Manoa, 2540 Dole Street, Holmes Hall 402, Honolulu, HI 96822, USA
Eml: *adminore@hawaii.edu*, ***Tel:*** *+1 (808) 956-7572*, ***Fax:*** *+1 (808) 956-3498*

The ORE 601 class checking out the two deep-sea submersibles at the Hawaii Underwater Research lab at Makai Pier in Waimanalo with Professors Wiltshire and Huang.

Hana O Ke Kai
Newsletter of the
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