

# Sensor Systems for National Security, Energy, and Environmental Applications



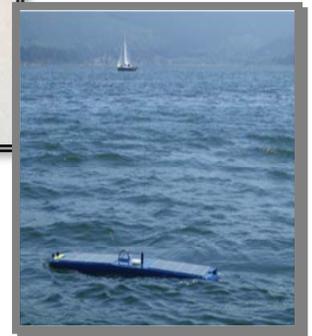
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*To address the applications of operational hardware in a challenging maritime environment, the Electronic and Measurement Systems Team (E&MS) at PNNL's Marine Science Lab is developing resource constrained devices with integrated sensors and/or wireless communications for long term sensing in remote locations.*

- New signal discovery and sampling methodologies within the littoral environment
- Cutting edge sensor development - biological, optical, and electrical
- Systems implementation utilizing persistent, low power, *in-situ* platforms within coastal areas
- Low-power, data acquisition, and power management experience
- Low-noise, custom electronic design for harsh marine environments
- Efficient data processing schemes for remote sensing, acoustical analysis

The United States has 95,000 miles of coastline, and the nearshore regions are home to about two-thirds of the nation's population, as well as major industries, ecologically and economically important natural resources and some of the world's busiest maritime traffic. Our ability to maintain resilient commercial and recreational activities relies on our persistent capability to detect and track threats and to establish the methods to rapidly transmit data so appropriate responses can occur in a time effective manner. In addition to a national security mission, we are developing a strong technology interface with energy and climate change issues.

Energy derived from the coastal environment (waves, tides, currents, thermal gradients, offshore wind, and marine biomass) could significantly reduce the nation's dependence on fossil fuels for electricity and fuels. However, our ability to produce significant power from offshore sources is constrained by a limited knowledge/measurement of the resource, thereby complicating environmental permitting.



Commercial fishing and industry is under threat from climate change. The coupling of climate change and large offshore energy systems may result in other water quality problems, such as reduced oxygen, growth of toxic algae blooms, and death of marine organisms. Our ability to measure these parameters is key to maintaining a healthy, viable ecosystem.

## EXAMPLES:

- Determine the characteristics of small vessels and construct sensors to exploit signatures that will discriminate illicit activities from background.
- Develop a system using COTS sensors to track marine mammal movement so that warning signals can be sent to nearby tidal power generation hardware.
- Measure ocean acidification using novel unmanned platforms integrated to COTS sensors and determine effects on marine environments.
- Construct a photonic energy harvester and biological sensor using living marine systems (diatoms). Metabolic changes are being harnessed to exploit bio-inspired, nanostructured processes.

*Each project involves developing solutions that contribute to autonomous sensing systems that must address stringent power constraints, data exfiltration and ruggedized packaging.*

## PROJECTS:

The E&MS Team follows a rigorous process that applies the systems engineering approach to every project and involves: creating custom algorithms/computation models; customizing micro-electronics design; designing low ( $\mu$ W) energy computational processes; ruggedizing mechanical packaging; simplifying user interaction to systems with enhanced graphical user interfaces; characterizing, verifying and validating hardware through testing and Quality Assurance; and executing successful technology transfer.

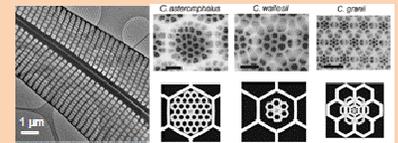
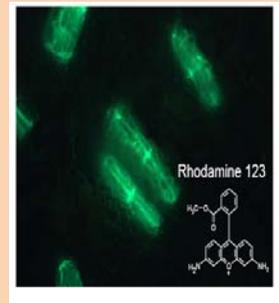
PNNL has developed a multi-sensor suite and integrated it onto a mobile trailer for the purpose of recording, identifying, and characterizing maritime threats from small vessels. The mobile trailer incorporates X-band radar, EO and IR cameras, hydrophones (tethered and stand-alone), on-board processing with specific triggering algorithms, and select cellular data exfiltration. The system is rapidly deployable and can be used as a forward-placed system to characterize locations for possible illicit activities.



PNNL has developed a rapidly deployable imaging system that is triggered in the presence of motion. The system is based on COTS game camera technology, integrated with a passive infrared trigger, infrared illuminator, cellular modem and custom built electronics for signal conditioning (e.g. data compression) and data management. The device is designed to be readily deployable and to operate close to a selected target. Data can be securely exfiltrated within minutes to a Microsoft Exchange server.



Diatoms are unicellular algae containing porous silica. These biostructures have known photoluminescent sensitivity to a variety of vapor phase chemical targets. Diatoms derivatized with biological receptors have also shown modulation in photoluminescent strength when binding a target. PNNL is seeking to enhance sensor efficiency by metabolically inserting optical materials into the silica and is developing hardware to measure the signal and convert into actionable data.



## About Pacific Northwest National Laboratory

The Pacific Northwest National Laboratory, located in southeastern Washington State, is a U.S. Department of Energy Office of Science laboratory that solves complex problems in energy, national security and the environment, and advances scientific frontiers in the chemical, biological, materials, environmental and computational sciences. PNNL currently has approximately 4,900 staff members and a business volume of more than \$1.1 billion. The Laboratory has been managed by Ohio-based Battelle since 1965.

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