twenty-eleven

2011 Biennial Report

The Applied Physics Laboratory
University of Washington

The Applied Physics Laboratory
University of Washington
1013 NE 40th Street
Seattle, WA 98105-6698

T: 206.543.1300
F: 206.543.6785
E: switchbd@apl.washington.edu
www.apl.washington.edu

Report Staff:
Brian Rasmussen, editor
Kim Reading, designer

Cover: Temperature profile from the sea surface to 200 m depth in the western Pacific Ocean, September 2010

twenty-eleven

2011 Biennial Report

The Applied Physics Laboratory
University of Washington

From the Director

Twenty-eleven and the close of the 2010 Federal Fiscal Year ended another impressive biennium for the Applied Physics Laboratory, marked by notable research accomplishments and an all-time high in grant and contract awards of $137M over FFYs 2009–2010. Research highlights for this most recent two-year period are presented in this report.

This biennium also marks the end of the first decade of the 21st century, one of considerable change and improvement for APL-UW. During this time the Laboratory has pursued new and exciting, major and interdisciplinary research programs; accelerated funding growth and diversity; enhanced infrastructure, including new space and improved research vessels; established a new higher report within the UW; increased and improved faculty appointments in UW academic units; recruited a customized and energized staff; fostered greater outreach and recognition; negotiated a new and superior Navy contract; and refreshed the Advisory Board. Productivity has increased in terms of discovery and invention, as well as collaborations with other institutions.

Over the last decade APL-UW has broadened its research interests beyond its traditional Navy focus, while maintaining very strong Navy-relevant expertise. APL-UW has developed new defense programs (e.g., in combat casualty care, countering improvised explosive devices, and cyber-security) and non-defense programs (e.g., in ocean observing systems, ultrasound therapy, marine ecosystems, applied optics, and energy). The Laboratory has also replenished and increased its world-class workforce, responsible for many notable scientific advances and transfers of technology, the latter including many 'fleet transitions' and an average of one spin-off company per year.

Improvements to the Laboratory's physical infrastructure include the acquisition of space in the Benjamin Hall Interdisciplinary Research Building and at 909 Boat Street; both have enabled overcrowding decompression and will provide for future growth. Investments in specialized laboratories and facilities have been made to provide unique capabilities, and a new research vessel, the R/V *Robertson*, was commissioned.

Over the last decade APL-UW researchers strengthened their integration within the UW. Joint faculty appointments, cross-campus research collaborations, and teaching and advising of students by APL-UW scientists and engineers have all contributed. And in 2009 the Laboratory began a new central management report to the UW Provost.

Today, the Laboratory is in excellent shape and well positioned for the future. APL-UW is a broader and more capable research institution than it was a decade ago, and it has stable funding and growth. The Laboratory's new strategic plan, *Our 2020 Vision*, will help to steer the way forward through the coming decade, and I look forward to working with the superb staff of this Laboratory and our supportive research sponsors as we embrace future opportunities and challenges.

Jeff Simmen

Honors & Awards

The American Meteorological Society awarded its Sverdrup Gold Medal to Principal Oceanographer **Eric D'Asaro**, and its Henry Stommel Research Award to Principal Oceanographer **Thomas Sanford**. Director Emeritus **Robert Spindel** received the Martell–Bushnell Undersea Warfare Award from the National Defense Industrial Organization. Principal Oceanographer **Neil Bogue** was presented a U.S. Naval Oceanographic Office Command Award for his support of the transition of Seaglider to operational status at NAVOCEANO.

Principal Physicist **Lawrence Crum** was elected a member of the Danish Academy of Natural Sciences and also President of the International Society for Therapeutic Ultrasound. The HSCB (Human Social Culture Behavior) Government Program Management Team recognized Senior Physicist **Michael Gabby** at their 2011 conference for his development of theory and computational simulations of insurgent rhetoric. (See "Words into Actions," on page 28.)

Principal Oceanographer **Jan Newton** was elected Chair of the Puget Sound Partnership Science Panel. **Brian Dushaw** won a Fulbright Scholarship from the U.S. State Department to conduct collaborative research on acoustical remote sensing in the Arctic at the Nansen Environmental and Remote Sensing Center (Norway). A Marie Curie International Incoming Fellowship was awarded to Principal Oceanographer **Jeffrey Nystuen** by the European Community Research Commission to collaborate with researchers at the Hellenic Centre for Marine Research (Greece) on projects to monitor oceanic rainfall acoustically.

EXECUTIVE DIRECTOR – Applied Physics Laboratory, UW

Jeffrey Simmen

ASSOCIATE DIRECTORS

William Bakamis – Business Operations and Finance
David Martin – Science and Technology Integration
Robert Miyamoto – Science and Technology Transition

ASSISTANT DIRECTOR

Robert Odom – Education and Outreach

DEPARTMENT LEADS

Eric D'Asaro, *Chair* – Ocean Physics
Gary Harkins, *Director* – Electronic and Photonic Systems
Andrew Jessup, *Chair* – Air-Sea Interaction and Remote Sensing
David Jones, *Director* – Environmental and Information Systems
Russell Light, *Head* – Ocean Engineering
Thomas Matula, *Director* – Center for Industrial and Medical Ultrasound
Axel Schweiger, *Chair* – Polar Science Center
Kevin Williams, *Chair* – Acoustics

Scan this QR code with a smart mobile device or visit www.apl.washington.edu/report/2011 for extended electronic media coverage of the twenty-eleven Biennial Report.

IMPROVED infrastructure

Fiscal growth has enabled APL-UW to expand activities into new research space and make infrastructure investments. Specialized laboratory and office space expanded by over one-third as new and some current staff relocated to three floors of the Benjamin Hall Interdisciplinary Research Building. Occupancy of the Benjamin Hall Building relieved crowding pressures in Henderson Hall for the first time since the 1980s. Henderson has been reconfigured to optimize research space and create collaborative synergy. The Laboratory has also secured a ten-year renewable lease of nearby 909 Boat Street, providing quality office space and freeing prime laboratory and office space in Henderson Hall for future expansion. Since 2000, APL-UW has doubled the space it occupies on the University of Washington campus.

909 Boat Street — the new home for the APL-UW Directorate and Business Operations and Finance offices

Record Revenues

The Applied Physics Laboratory has never been in a stronger financial position. For FFYs 2009–2010 APL-UW again set an all-time record for grant and contract awards received. During this period the Laboratory's total awards were $137.3M — an all-time one-year record of $76.3M in FFY 2010 broke the previous all-time record of $60.9M in FFY 2009. The $137.3M two-year total represents an $18.5M (15.6%) increase in grant and contract awards from the previous biennium. The record breaking revenues for the period FFYs 2007–2010 averaged $64.0M/year and grew by 48% over the previous four-year period of FFYs 2003–2006.

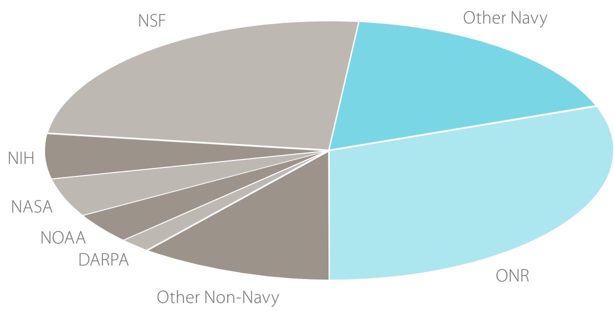
The Laboratory's primary partner remains the U.S. Navy, which provided about 46% of total funding. Annual grants from the National Science Foundation during the past biennium averaged $21M, placing the Laboratory in the upper echelon of University of Washington units receiving NSF funds. Other federal agency sponsors include NASA, NOAA, and NIH.

Much of the increase in FFYs 2009 and 2010 is attributed to the beginning of the National Science Foundation Ocean Observatories Initiative (see page 24), with all other research funding remaining at historically high levels.

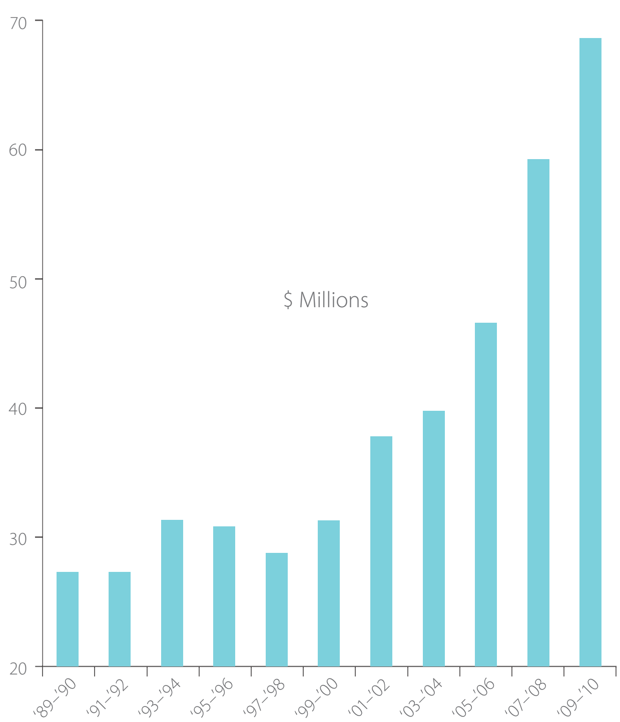
SPONSOR	FFY 2009	FFY 2010
Office of Naval Research	20,440,663	19,166,701
Naval Surface Warfare Center	2,841,101	7,879,962
Naval Sea Systems Command	3,186,120	1,325,034
Arctic Submarine Laboratory	978,000	2,500,397
Space and Naval Warfare Systems Command	340,000	768,725
Other Navy	267,990	2,967,884
U.S. Navy Subtotal	*$28,053,874*	*$34,608,703*
National Science Foundation	18,870,393	22,961,921
National Institutes of Health	3,873,142	3,380,577
National Aeronautics and Space Administration	2,830,940	3,402,371
National Oceanic and Atmospheric Administration	3,096,232	1,829,798
Defense Advanced Research Projects Agency	2,163,293	193,087
Department of Energy	406,500	373,236
Other	1,644,372	9,567,303
Subtotal	*$32,884,872*	*$41,708,293*
TOTAL	*$60,938,746*	*$76,316,996*

Financial Stability

FFYs 2009–2010 sponsorship



Biennial averages of annual revenues over two decades



The Laboratory's revenue base continues to diversify, with over 40 different sponsors in FFY 2010 and a bias toward basic research programs. About 20 years ago, the U.S. Navy provided over 90% of the Laboratory's funding, and the ratio between applied science and fundamental research was approximately 65% to 35%. The current percentage balance between applied and basic research has shifted in the opposite direction to reflect faster growth in fundamental research areas.

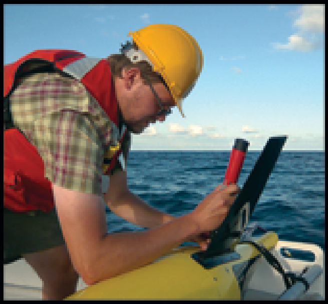
In 2010 APL-UW negotiated and obtained a new Navy (NAVSEA) 'omnibus' contract that is larger and longer than at any time in APL-UW history, moving from the prior seven-year $78M contract to a ten-year $256M contract. If fully funded the contract will be one of the largest research contracts in the University of Washington's history.

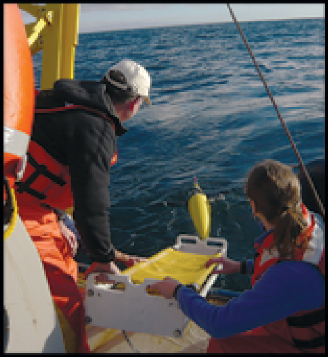
As APL-UW grant and contract revenues have increased, discretionary funds have increased and enabled the Laboratory to support new 'without tenure' faculty appointments, to help hire the next generation of scientists and engineers, and to seed new independent research and development programs that are vital to our success.

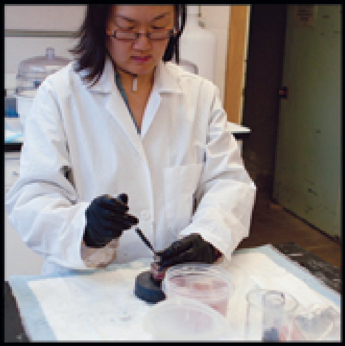
The Laboratory remains committed to ensuring that the long-term investments in it by the U.S. Navy and federal government are applied to national strategic and technical needs, and to preserving our ability to respond effectively and efficiently to present and future Navy, national defense, and government research and development needs.

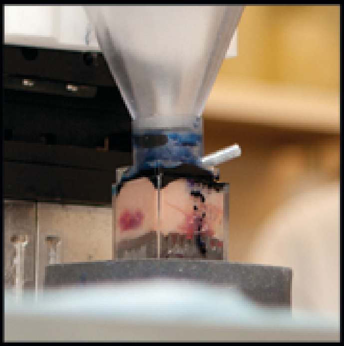

David Mora


David Mora

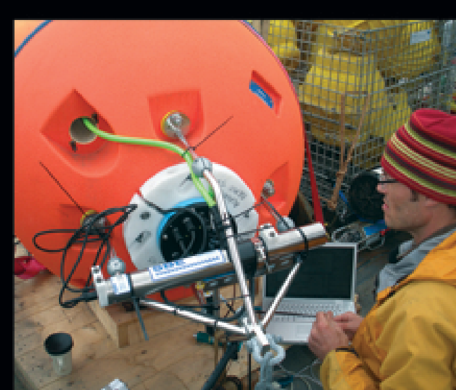


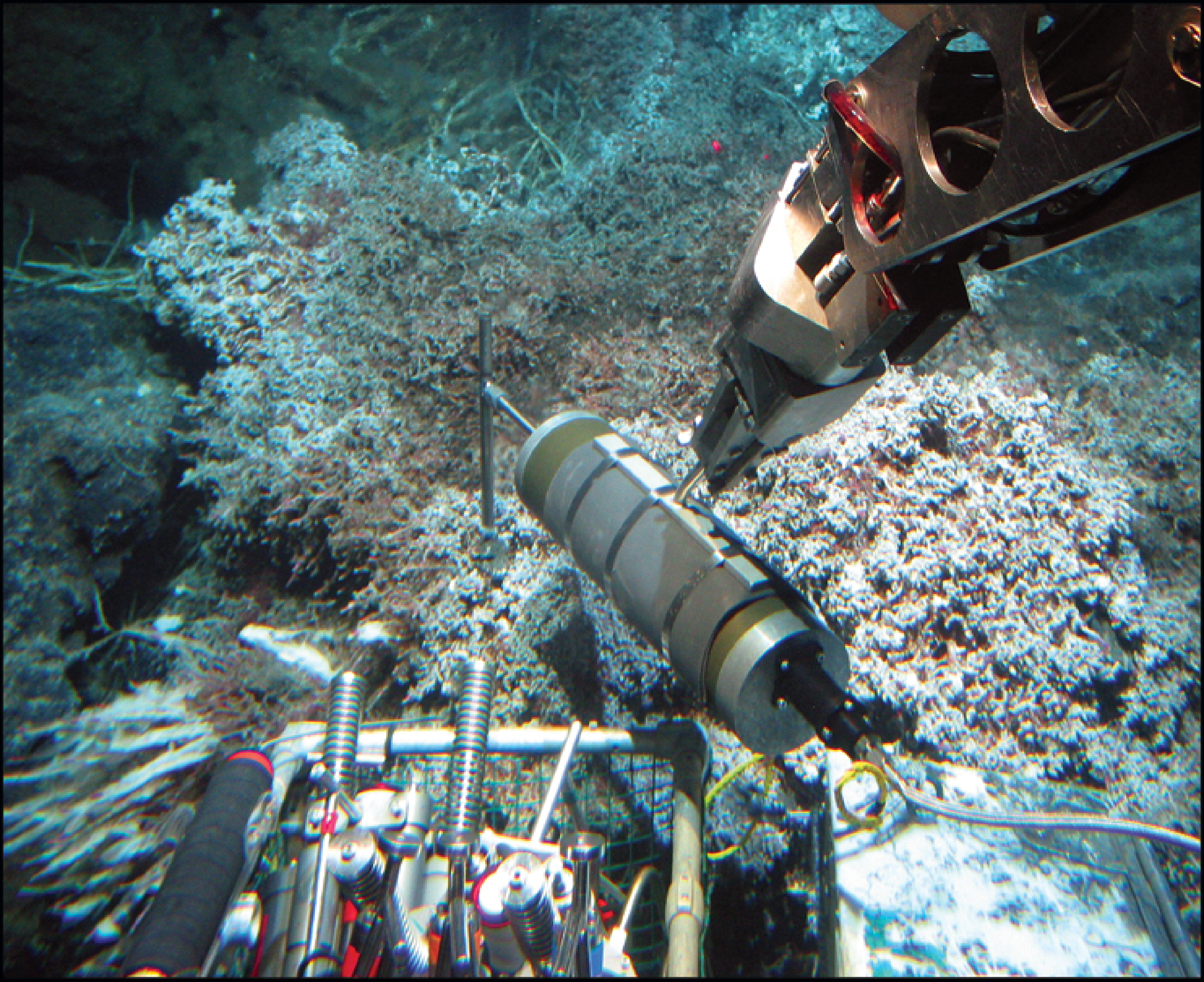







LeCroy
LeCroy





Applied Physics Laboratory Ice Station 2011 1
Polar Science Weekend at Pacific Science Center, Seattle 2
Environmental survey of tidal energy conversion sites 3
Autonomous undersea vehicle Seaglider 4
Flight test of LTAIRS, the Lighter-than-Air Remote Sensing system 5
Ultrasonic enhancement of drug uptake in tissue 6
Washington real-time coastal moorings 7
Raman spectroscopic sampling of a deep-sea hydrothermal vent 8


invention
DISCOVERY
advance scientific discovery and invention
highlights
9

Founded by the U.S. Navy in 1943 as one of four university laboratories to focus intellectual and technical resources on the war effort, the Applied Physics Laboratory of the University of Washington built a world-class reputation through service to the Navy and other federal agencies. Today APL-UW conducts a broad program of fundamental and applied research, development, engineering, and education for the national defense, federal government agencies, and industry.

Highlights

What is happening to sea ice in the Arctic Ocean from month-to-month? The Polar Science Center publishes the Arctic Sea Ice Volume Anomaly website to keep the world updated on this important climate variable. Sea ice volume is a more robust indicator of arctic climate change than sea ice extent because it is less susceptible to short-term weather variations. Sea ice volume is estimated on a continuing basis by assimilating the limited observations from satellites, U.S. Navy submarines, moorings, and other field measurements into the PIOMAS numerical model.

To pursue the lofty goal of transforming the way medicine is practiced, a collaborative team from the Center for Industrial and Medical Ultrasound and the UW departments of bioengineering and radiology established the ultrasound-based Washington Molecular Imaging and Therapy (uWAMIT) Center. The new center focuses on the discovery, development, translation, and commercialization of molecular imaging and therapy technologies. Because molecules are too small to be imaged directly, microbubbles or nanoparticles are used as beacons. Ultrasound enlivens these beacons to enable diagnosis and treatment at the molecular level.

Recent experiments in sonar detection and identification of anti-ship mines or unexploded ordnance in coastal waters have been pushed in complexity to include the acquisition of data with multiple targets and clutter in the sonar's field of view. In the Naval Coastal Systems Center test pond, acousticians were able to separate the acoustic scattering from targets from the scattering from clutter in many composed environments. Experiments are now moving to Gulf of Mexico sites with differing, and challenging, bottom and clutter conditions.

Through observations at a marine construction site in Puget Sound, researchers discovered the mechanism of underwater noise generation from high-impact pile driving — a supersonic bulge produced by the pile's compression. This structural wave produces a pressure field in the form of a Mach cone as it speeds down the pile. A patent application has been filed for a pile design that minimizes the noise of pile driving, lessening the potential for damaging noise impacts on marine organisms.

Several types of robotic autonomous underwater vehicles from different manufacturers are controlled by APL-UW's web-based Glider Monitoring, Piloting, and Communications (GLMPC) System. Leveling the software and communications differences among the AUVs, GLMPC provides a single control interface for all robots operating together in a mission space. GLMPC now supports the Liquid Robotics Wave Glider, which the U.S. Navy is evaluating in several applications.

Researchers are assessing the impact of regulated water flow in rivers on cold water refuge areas for migratory and resident fish. APL-UW's Airborne InfraRed Imaging System (AIRIS) was flown on the wing of a small plane over an 80-km stretch of the lower Klamath River during summer. Flights made over the course of an entire day measure the distribution of surface water temperatures and the effects of solar heating and shading along the river.

Some of the greatest dangers faced by combat soldiers are improvised explosive devices and the head injuries sustained by 40–60% of soldiers surviving attacks. These injuries require immediate brain imaging studies such as magnetic resonance imaging and computer tomography scans, but soldiers in the field are often far from these diagnostic tools. APL-UW research is developing a rugged, field-deployable ultrasound imaging device to diagnose traumatic brain injuries.

To detect trace levels of explosives adsorbed to surfaces, a system using two laser beams is being tested in typical urban environments, even in an airport screening scenario. The optical sensing technique — vibrational sum-frequency spectroscopy — detects molecules of explosives transferred to surfaces such as luggage. And because the sampling is nondestructive, fingerprints of suspected bomb makers are preserved.

Smart phone users can now access the NANOOS Visualization System on their devices. This evolution of the Northwest Association of Networked Ocean Observing Systems web portal aggregates, displays, and serves near real time meteorological and oceanographic data derived from buoys, gliders, tide gauges, radar, and satellites, as well as model forecast information. The 'app' is oriented toward general users and features intuitive, visual selection and discovery.

Seattle drew the Acoustical Society of America for its spring 2011 meeting and the MTS/IEEE Oceans'10 conference. Principal Physicist Thomas Matula chaired the ASA meeting and Principal Physicist Eric Thorsos served as chair of the technical program; 1500+ presentations were given over five days. Oceans'10 was chaired by Director Emeritus Robert Spindel; APL-UW scientists headed the technical committee and organized over 400 presentations to the 2,000+ attendees.

Management and administrative oversight for the Center for Process Analysis and Control moved to APL-UW in summer 2011. CPAC is a multi-disciplinary, multi-institutional academic–industry consortium that applies fundamental research toward solving process analysis challenges and develops tools for optimization, control, and quality improvements for industry. (See "Analytical Chemistry at the Speed of Light," on page 26.)

A significant part of the Laboratory's reputation is built on the capability to design, stage, and deploy ambitious research experiments around the globe — from the Philippine Sea to Davis Strait and from the Columbia River Plume to Antarctica. Over the past biennium more than 80 such expeditions spanning basic scientific research to operational programs were conducted.

Global Experimentation

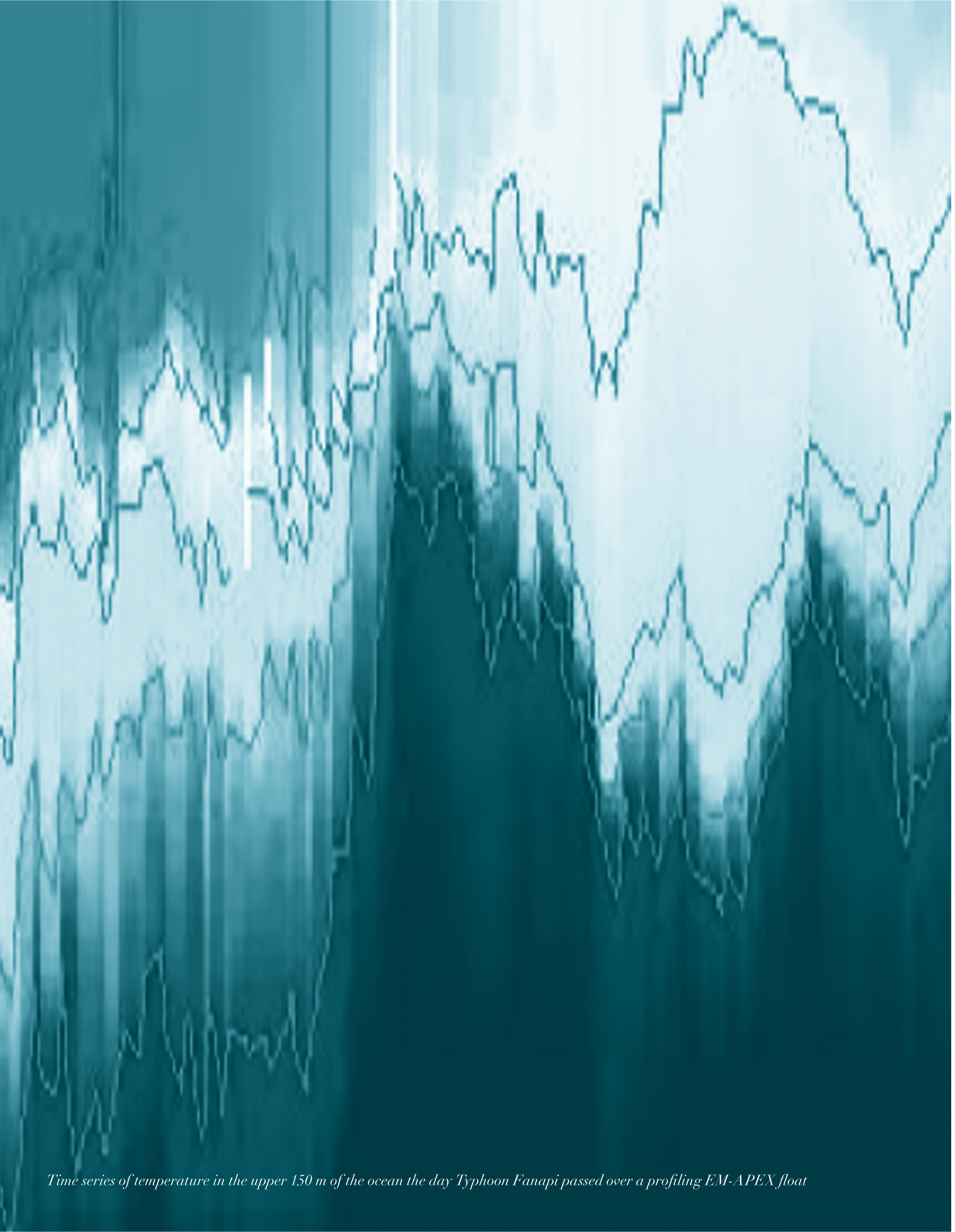
Principal investigators from APL-UW led four of the six legs of the Internal Waves in Straits Experiment (IWISE) during summer 2011 in the Philippine and South China seas. Moorings, robotic gliders, and shipboard instruments, including a 600-meter-long towed conductivity–temperature–depth sensor cable, were used to measure the generation of strong internal waves as tidal currents interact with two prominent ridges in Luzon Strait.

APL-UW scientists, students, and their international colleagues involved in the Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES) are using chemical tracers, acoustically-tracked floats, EM-APEX profiling floats (see page 16), and shipboard surveys to quantify oceanic mixing in the Southeast Pacific Ocean, Drake Passage, and the Scotia Sea. Together they seek to take direct measurements, where few have been made before, in the regions where mixing processes exert influence on the overturning circulation of the ocean — a critical regulator of the Earth's climate.

An engineering crew established the 2011 Applied Physics Laboratory Ice Station (APLIS) 150 nautical miles north of Prudhoe Bay, Alaska, on the Beaufort Sea for the month of March. Two of the U.S. Navy's newest submarines, the USS *Connecticut* and *New Hampshire*, were at the station to test and develop under-ice operations and procedures. APL-UW provided science, infrastructure, and technical support for the station, and debuted a digital system to perform all underwater acoustic tracking operations.

To conduct surveys of the physical and biological characteristics of a proposed tidal energy conversion site in Puget Sound, the APL-UW R/V *Robertson* has made many expeditions from its home port of Seattle. On the bottom of Admiralty Inlet, in some of the strongest tides in the country, a Sea Spider tripod (see image gallery in this volume) has been deployed in several-month increments over nearly three years to measure the currents as well as ambient noise, water quality, fish passage, and marine mammal activity.

Examples of global experimentation given 'in depth' treatment in this report are: "Atmosphere–Ocean Interactions in the Extreme," "Seagliders Listening for Beaked Whales," "Engineering for Ocean Observatories," and "Blue Water Acoustics."



Time series of temperature in the upper 150 m of the ocean the day Typhoon Fanapi passed over a profiling EM-APEX float

Atmosphere–Ocean Interactions in the Extreme

Perils posed to human life and property by tropical cyclones can be mitigated by accurate forecasts of track and intensity. A tropical cyclone's energy is supplied by the relatively thin layer of warm water on top of a deep, cold ocean. The strong winds and large waves mix these two layers and leave a trail of colder water — a 'cold wake'— as the storm advances. As the wake forms the sea surface temperature decreases under the storm and may reduce the energy available and limit its intensity. Many current forecasting tools couple atmospheric and oceanic processes, but only measurements of the atmosphere are made during storms, and the formation of a cold wake and its impact on storm intensity has never been measured directly.

ITOP

The western Pacific Ocean has the highest frequency and concentration of tropical cyclones, called typhoons in this region. The U.S. Office of Naval Research and the Taiwan National Science Council fielded research programs here to study the interactions between typhoons and the ocean. Experiments were designed to take in situ oceanic observations on the paths of typhoons across a range of oceanic and atmospheric conditions. These programs, called ITOP (Impact of Typhoons on the Ocean in the Pacific), culminated in an intensive observation period in August–October 2010 and resulted in the largest set of oceanographic and atmospheric data ever taken within and immediately following tropical cyclones.

Observation Strategy

An array of four deep moorings (5000–6000 m) was emplaced in the region of maximum typhoon frequency in 2008 and enhanced with three more in 2010. Data from their atmospheric sensors and oceanographic instruments to a depth of 500 m were transmitted by Iridium satellite communications every six hours. The moorings provided continuous sampling of the atmospheric forcing of the ocean and the ocean's response as typhoons passed.

During the intensive observation period C130 aircraft of the 53rd Air Force Reserve "Hurricane Hunter" Squadron were based in Guam. Their mission on 16 September 2010 included the air-launch of seven EM-APEX floats, four Lagrangian floats (see page 9), and 16 drifters in front of Typhoon Fanapi. This oceanographic instrument array was deployed about one day ahead of the storm's passage and in a line long enough to sample the ocean on both sides of the storm. After Typhoon Fanapi's passage, the "Hurricane Hunters" air-deployed additional floats and drifters into the typhoon's wake and the R/V *Revelle*, recalled from a cruise nearby, was deployed rapidly to the region to survey wake properties using shipboard instruments and an array of nine Seagliders.

APL-UW engineers designed and built the Self-contained Iridium Transmitter (SIT) that was part of each mooring instrument package.

SIT is capable of receiving measurements of temperature, conductivity, pressure, and velocity from the subsurface sensors and transmitting them over the satellite communications network. The lightweight device contains a battery pack capable of year-long operation, a data logger, and GPS.

EM-APEX, an APL-UW-engineered electromagnetic subsystem applied to Webb Research Company APEX profiling floats, measures temperature, salinity, and velocity—the three crucial variables to understand the response of the ocean on the scale of the storm. The Lagrangian floats, designed and built by APL-UW, measure turbulence, waves, and wave breaking, which are key to understanding the rates of mixing in the upper layers of the ocean.

Through September and October 2010, operations were coordinated and directed from a control center at the Naval Postgraduate School in Monterey, CA. From here, Chief Scientist **Eric D'Asaro** and his graduate student **Rosalinda Mrvaljevic** worked with a small team to coordinate ship and aircraft operations.

Satellite remote sensing data and measurements from the field were assimilated into all available typhoon prediction models. Because floats and drifters had to be deployed about one day ahead of the storm and the aircraft crews and the oceanographic packages had to be prepared an additional day before that, accurate forecasts of the storm track and intensity were critical. Typhoon Fanapi's complex S-shaped track was forecast with remarkable accuracy. The floats and drifters were deployed while the storm was tracking northeastward. Due to the skill of the forecast team, the anticipated turn to the west occurred as predicted and the storm traveled through the middle of the deployed array.

Wake Persistence

As Typhoon Fanapi passed the instrument array with 105-knot winds, the upper layer of the ocean was mixed to a depth of more than 80 m and a wake 3°C colder than the surrounding ocean was generated. In the days following the storm's passage, satellite sea surface temperature images showed the cold wake fading. The floats, drifters, gliders, and R/V *Revelle*, however, continued to observe a subsurface cold wake for at least 20 days.

Because of the generally warm and sunny conditions, the sea surface quickly warmed and formed a cap that isolated the cold wake from the atmosphere and shielded it from satellite sensors. Mrvaljevic's Master's thesis in physical oceanography analyzes the persistence of Typhoon Fanapi's cold wake. The wealth of in situ wake measurements reveal a water mass with a distinct temperature signature that was peeled in half by subsurface topography, stretched by an eddy, and eroded from the bottom by mixing.

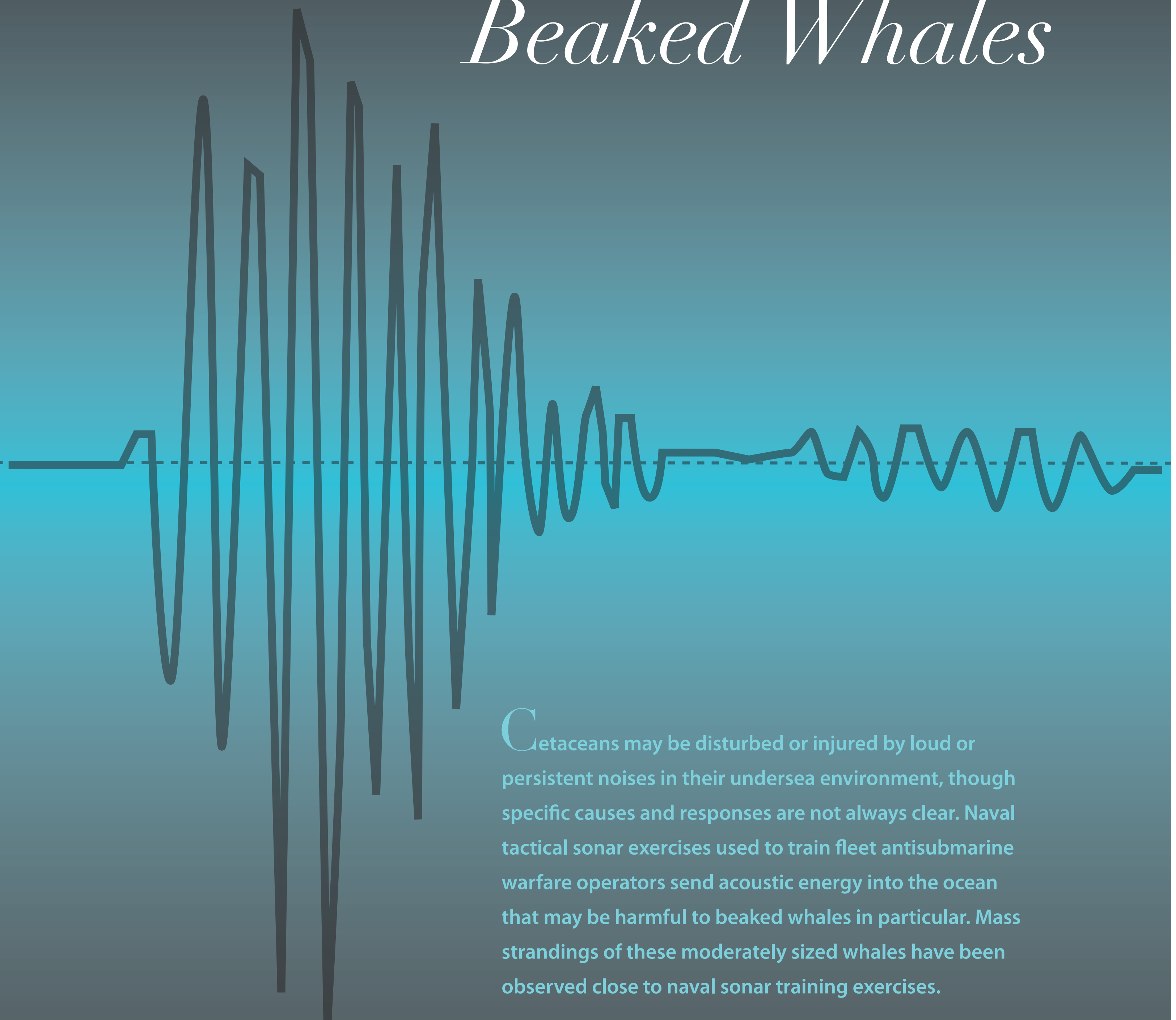
A persistent subsurface cold wake such as this could affect the energy available to a subsequent typhoon passing through the region. Yet, because it is hidden from remote sensing observations, the wake would not be accounted for in current forecasting models.

APL-UW TEAM MEMBERS: Eric D'Asaro, Craig Lee, Ren-Chieh Lien, Rosalinda Mrvaljevic, Luc Rainville, and Thomas Sanford

SPONSOR: Office of Naval Research

www.apl.washington.edu/report/2011

Seagliders Listening for Beaked Whales



Cetaceans may be disturbed or injured by loud or persistent noises in their undersea environment, though specific causes and responses are not always clear. Naval tactical sonar exercises used to train fleet antisubmarine warfare operators send acoustic energy into the ocean that may be harmful to beaked whales in particular. Mass strandings of these moderately sized whales have been observed close to naval sonar training exercises.

Echolocation click recording of a Cuvier's beaked whale (Ziphius cavirostris) *with duration of 203 microseconds*

The Office of Naval Research and APL-UW are working on a passive acoustics system on Seaglider to listen for beaked whales. The goal is to provide near real time detection notification to shore-based commanders during exercises, as well as to monitor beaked whale presence and behavior before, during, and after a sonar exercise.

Seaglider, the buoyancy-driven robotic glider developed by APL-UW and the University of Washington, has proven to be an adaptable instrument for long-duration scientific missions and naval operations. For this application APL-UW engineers designed a custom acoustic data acquisition and recording electronics board and integrated it with high-frequency omni-directional hydrophones mounted at various external locations on Seaglider. The board carries enough computational power for on-the-fly processing of detection and classification algorithms developed by colleagues at Oregon State and San Diego State universities.

Sonar training exercises are usually conducted over the span of weeks with several vessels operating in a defined geographic area — an acoustic test range. Two relatively common types of beaked whales, Blainville's (*Mesoplodon densirostris*) and Cuvier's (*Ziphius cavirostris*), are often present at U.S. Navy ranges in the Atlantic and Pacific oceans.

Though difficult to observe on the surface, beaked whales are monitored with greater ease by listening under water for their distinctive echolocation clicks during deep foraging dives. These clicks are at relatively high frequencies (30–80 kHz) and are generally only produced below several hundred meters depth. These attributes are a good fit for a Seaglider-based passive acoustic system — the vehicle's and whale's dive depths and durations are similar.

Detection algorithms are based on analysis of the energy contained in each click in various frequency bands and the inter-click interval. Likely beaked whale clicks are passed to the classifier, which uses other spectral attributes to attempt a species-level classification.

At-sea tests of Seagliders equipped with the new passive acoustic system began off the Kona, Hawai'i, coast. The Seaglider operated close to the 1500-m isobath, the approximate midpoint of the offshore habitats favored by Blainville's and Cuvier's beaked whales. The Seaglider was directed to execute repeated dives to 1000 m along a course roughly parallel to the coast. Several successful detections of beaked whales were made during the transects. The Seaglider was also operated in a station-keeping mode while the passive acoustic system was operated under fully autonomous control through the vehicle's Iridium telemetry. Further tests were done on instrumented U.S. Navy ranges at AUTEC in the Bahamas and SCORE off San Clemente Island, California. Here the detections made by Seaglider were compared with those made using the Navy's own bottom-mounted hydrophones.

One of Seaglider's main attributes is persistence. Sensor systems, however, must be small, lightweight, and use power economically. This is especially challenging for computationally intensive applications like real time detection, classification, and localization of marine mammals. The at-sea tests have shown that it is feasible to deploy Seagliders to monitor beaked whale presence and behavior for up to three months under typical operating conditions.

APL-UW TEAM MEMBERS: Neil Bogue, William Jump, Trina Litchendorf, James Luby, Geoffrey Shilling, and Angela Wood
SPONSOR: Office of Naval Research

If stones and fragments of stones from lithotripsy are in the lower portion of the kidney — below the exit — they are very unlikely to overcome gravity and rise to the exit. Our system moves stones easily and safely to the point where they'll pass naturally.

– Michael Bailey

Treatment with a Push

Even though passing a kidney stone is painful for a patient, APL-UW researchers are hoping to put technology in urology clinics to assist patients do exactly that. An ultrasound-based system may provide an office procedure to speed the natural passage of stones, doing so without exposing patients to X-ray diagnoses and lowering the incidence of potential injury from extracorporeal shockwave lithotripsy and other surgeries.

Ultrasonic Propulsion

A diverse team of scientists, engineers, and students at the Center for Industrial and Medical Ultrasound has developed a system that uses commercial ultrasound components to locate stones in kidneys. It creates clear pictures of them and then applies an acoustic radiative force, repositioning stones in the kidney so they are likely to pass naturally. Ultrasonic propulsion may be used to remove small stone fragments after lithotripsy surgery or to diagnose and speed the removal of small stones before they become symptomatic.

Combined, team members have decades of research experience in lithotripsy — breaking kidney stones with shock waves — as well as high intensity focused ultrasound (HIFU) — "cooking" diseased tissue such as prostate cancer. During a laboratory experiment to break simulated kidney stones with HIFU, researchers observed stones shooting across the water bath in which they were placed. It was clear that pushing, not breaking, stones was an idea worth pursuing.

Making Clearer Pictures

Before a stone can be moved it must be seen. Two conventional ultrasound imaging modes used in urology practice are brightness (B-mode) and color flow Doppler. B-mode shows a bright reflection from kidney stones, which, compared to the surrounding tissue and fluid, are hard and reflect the acoustic energy. Doppler mode detects objects that are moving away from or toward the probe; applying color in image processing makes it especially useful to detect blood flow. When imaging kidney stones, however, something in the ultrasound reflection from the stone confuses the Doppler image processing and causes the stone to display as a flickering mosaic of color.

Bioengineering doctoral student **Wei Lu** has conducted extensive research on the colorful 'twinkling' artifact returned in Doppler mode images of kidney stones. The flickering is caused by the noisy signals echoing from the stones. It is likely that the high reflectivity of the stones and their roughness, curvature, and reverberant nature make them sensitive to even slight changes in the angle of the incident wave from the ultrasound probe. Lu and the team, knowing that Doppler processing aims to eliminate noisy signals to more effectively image blood flow, set to re-engineer the image processing to accentuate such signals. Processing algorithms were created to specifically image the reflective and reverberant stones, but not motion (blood flow).

Repositioning Stones

In practice, the urologist scans the kidney with the ultrasound probe, zooms to a location of interest using the touch screen display, and with several ultrasound imaging techniques available including the Doppler 'twinkle' mode, locates the stone(s). Because the radiation force is applied in the direction normal to the transducer face, the urologist manipulates the probe's angle to direct the stone toward the kidney exit. Then a mouse-click on the screen image of the stone flashes a test pulse to reveal the location of the push-pulse beam to confirm alignment. When the urologist mouse-clicks a second time, the radiative force is applied and the stone is pushed. The display tracks the stone moving within the kidney. The system then returns to the stone detection and localization mode so that more pushes may be made if needed.

commercialization

The National Space Biomedical Research Institute knew of the team's research in lithotripsy and funded work to develop a portable system to protect astronauts on long missions from the effects of kidney stone disease. NSBRI came to Seattle to meet with the research team and the University of Washington Center for Commercialization. C4C identified several foundations interested in promoting transition of this technology into the clinical sphere and the commercial realm. Patent applications have been filed and the current plan is to conduct a clinical trial and achieve device approval before starting up a company or licensing the technology.

Next Steps

The detection and repositioning system operates at levels above regulated limits for diagnostic ultrasound. **Julianna Simon**, also a doctoral bioengineering student, and the team performed safety studies where they exposed porcine model kidney tissue to a series of increasing ultrasound intensities and duty cycles. Exposed tissue samples were examined microscopically to look for evidence of mechanical or thermal damage. They determined that the system propels stones effectively within safe thresholds and at no risk to kidney tissue.

Confident that their system is effective and safe, the team is conducting clinical simulations and submitting device approval applications with the Food and Drug Administration.

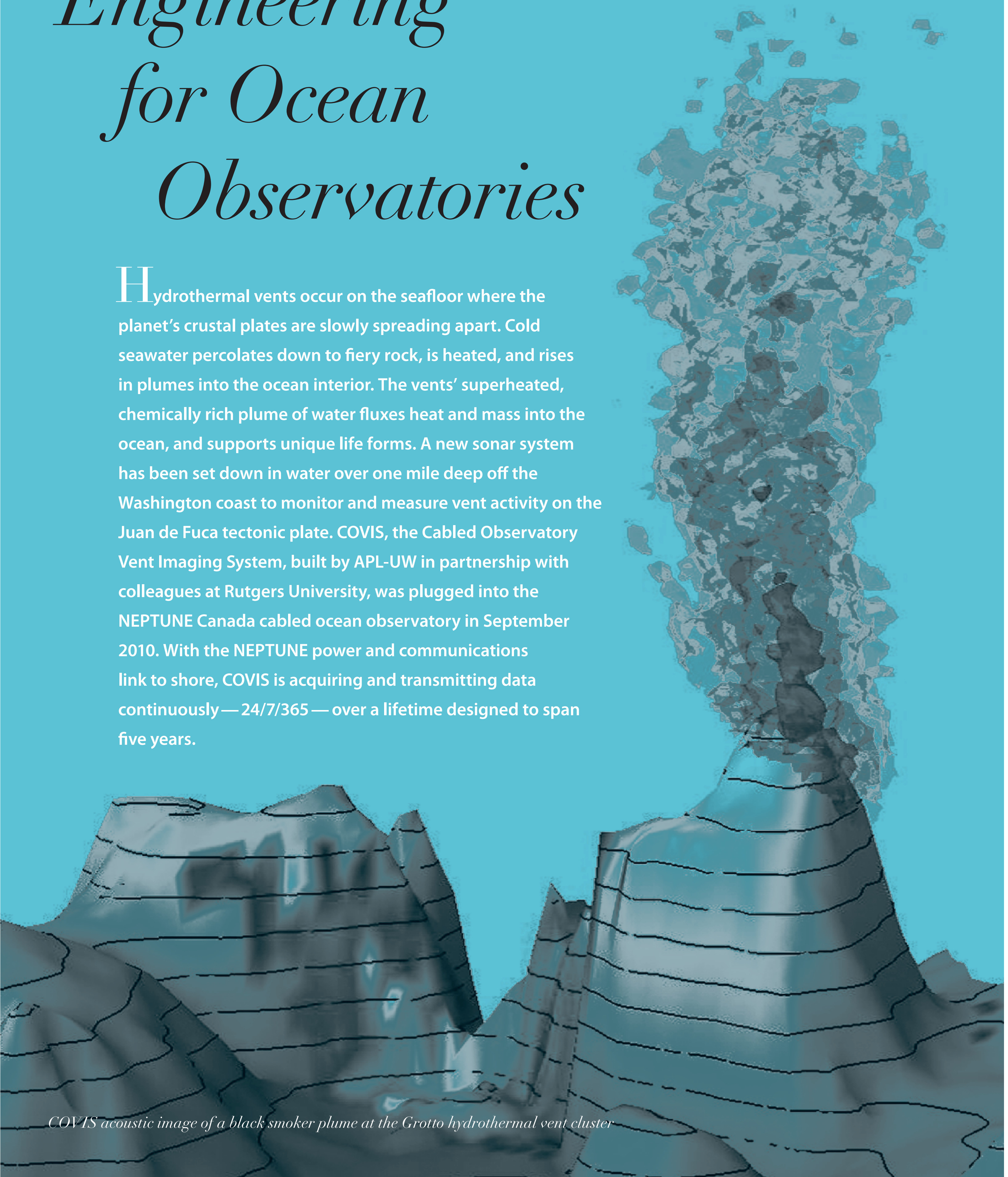
APL-UW TEAM MEMBERS: *Michael Bailey, Lawrence Crum, Bryan Cunitz, Barbrina Dunmire, Ray Illian, Peter Kaczkowski, Tatiana Khokhlova, Vera Khokhlova, Wayne Kreider, John Kucewicz, Wei Lu, Brian MacConaghy, Marla Paun, Oleg Sapozhnikov, Julianna Simon, Frank Starr, and Yak-Nam Wang*

SPONSORS: *National Institutes of Health, National Space Biomedical Research Institute, UW Center for Commercialization, Washington Research Foundation, Institute of Translational Health Sciences, and W.H. Coulter Foundation*

www.apl.washington.edu/report/2011

Engineering for Ocean Observatories

Hydrothermal vents occur on the seafloor where the planet's crustal plates are slowly spreading apart. Cold seawater percolates down to fiery rock, is heated, and rises in plumes into the ocean interior. The vents' superheated, chemically rich plume of water fluxes heat and mass into the ocean, and supports unique life forms. A new sonar system has been set down in water over one mile deep off the Washington coast to monitor and measure vent activity on the Juan de Fuca tectonic plate. COVIS, the Cabled Observatory Vent Imaging System, built by APL-UW in partnership with colleagues at Rutgers University, was plugged into the NEPTUNE Canada cabled ocean observatory in September 2010. With the NEPTUNE power and communications link to shore, COVIS is acquiring and transmitting data continuously — 24/7/365 — over a lifetime designed to span five years.



COVIS acoustic image of a black smoker plume at the Grotto hydrothermal vent cluster

Deep Sea Eyes

The COVIS transducer has freedom to move precisely up, down, and from side to side, much like a camera tripod, providing a large area of coverage from its fixed position on the seafloor. Here, where no sunlight penetrates, COVIS uses acoustics to measure the geometry and discharge rates of hydrothermal plumes. High-bandwidth data (25 GB every 3 hours) are transmitted to shore and used to render three-dimensional views of plume dynamics. On time scales of hours and days, COVIS data show the response of the buoyant plume to the tides, while on week-month-year scales, they give a never-before-seen understanding of hydrothermal responses to volcanic and tectonic events.

Visionary Engineering

The installation of COVIS on the NEPTUNE Canada observatory is one example of the engineering expertise required to support the University of Washington's implementation of the Regional Scale Nodes (RSN) — the cabled ocean observatory being installed off the Pacific Northwest coast that is one component of the National Science Foundation's Ocean Observatories Initiative. The RSN network of instruments and sensors will be used to study climate variability, ocean circulation and ecosystem dynamics, air–sea exchange, seafloor processes, and plate-scale geodynamics over a 25–30-year lifetime.

APL-UW engineers and their collaborators in the UW School of Oceanography comprise a 54-member team that achieved significant milestones over the past biennium. Extensive surveys were completed in April 2010 for the routes cables will take to link all the observatory's assets. Over the summer of 2011, the primary power and communication cables were laid to the two primary study sites: Hydrate Ridge, about 75 miles southwest of Pacific City, Oregon, and Axial Seamount on the Juan de Fuca Ridge 310 miles west. In July 2011, these "backbone" cables were brought ashore at Pacific City, and were connected to the land-based power and Internet station.

During the VISIONS'11 research expedition on the R/V *Thomas G. Thompson* in August 2011, two test frames designed to hold junction boxes on the network's secondary infrastructure were recovered. These frames, which had been deployed one year earlier, are being analyzed for corrosion and biofouling. The VISIONS'11 cruise also transmitted live, high-definition video from the recent eruptions at Axial Seamount using a camera mounted on the remotely operated vehicle *ROPOS*.

In summer 2012 the team will work with the prime contractor, L3 MariPro, to deploy and install the primary nodes on the cabled network. Like giant electrical outlets on the seafloor, the primary nodes will serve to distribute power and handle two-way communications with the secondary infrastructure — low-power nodes, junction boxes, vertical moorings, instrument platforms, and sensors — the ongoing design challenge for the RSN engineering and science team.

APL-UW TEAM MEMBERS: (COVIS) Darrell Jackson, Christopher Jones, Michael Kenney, Russell Light, Keith Magness, Vernon Miller, and Peter Sabin; (RSN) Les Anderson, Craig Bathgate, Derrick Coté, Geoff Cram, Skip Denny, Grayson Dietrich, Jesse Dosher, Evan Gander, Wes Gustafson, Gary Harkins, Michael Harrington, Eric Hultman, Robert Johnson, Christopher Jones, Frederick Karig, Jacob Maltby, Dana Manalang, Timothy McGinnis, Charles McGuire, Eric McRae, Matthew Milcic, Larry Nielson, Colin Sandwith, Eric Strenge, Marvin Strenge, James Tilley, and Michael Welch

SPONSOR: National Science Foundation

Analytical Chemistry at the Speed of Light

Raman spectroscopy is a well-established vibrational spectroscopy technique. A spectrum is obtained by exciting a sample with laser light and recording the spectrum of scattered photons. This spectrum reveals the sample's fingerprint—its chemical bonds and molecular symmetry. APL-UW's Applied Optical Sensing Laboratory, headed by Senior Engineer Brian Marquardt, has expertise spanning analytical chemistry, optics, spectroscopy, data processing, and engineering. The team has advanced Raman spectroscopy in new directions—engineering novel instruments and developing new methods to apply this optical sensing technique to science and industry.

Raman spectra of a crude oil distillation fraction

Invention

Raman spectroscopy determines qualitative and quantitative molecular information from solids, liquids, and gases. APL-UW researchers designed a Raman instrument and immersion probe that can be simply placed onto or into a sample that is either static or flowing. The probe's novelty is a spherical lens that is used as both the light focusing element and the optical interface with the sample. This design provides a constant and precisely positioned focal volume, located directly on the proximal face of the spherical optic, which leads to greatly increased measurement precision.

Applications

The Raman instrument has been deployed to monitor chemical activity in deep-sea hydrothermal vents (see image gallery in this volume). Here, at depths greater than 2000 meters, high pressures, and centimeter-scale temperature gradients of 2°– 400°C, materials and engineering are put to the test.

Raman spectroscopy is adaptable to this environment because it has high chemical sensitivity, requires no sample preparation, and can be conducted in the presence of water with minimal interference. The team's instrument was first deployed by the deep sea vehicle *Alvin* on the Main Endeavor vent field off the Washington coast to conduct chemical analysis of multiple vent sites with temperatures of 2°–380°C. (See "Engineering for Ocean Observatories," on page 24, for more about research at the Main Endeavor vent field.) As cabled ocean observatories come online, the instrument could provide months-to-years time series of chemical data and be used by scientists to detect and understand subtle changes in hydrothermal vent and deep-sea chemistry.

The technology may also provide benefit to the energy industry: research is being conducted to deploy a similar instrument with the novel spherical immersion probe to make several simultaneous measurements of crude oil products during the refining process. Two key factors that determine the market value of refined oil products are their specific gravity and hydrogen–carbon ratios. These quantities are measured at many points throughout the refining process as a means of quality assessment and assurance. Fast, accurate, and online measurements inform quicker and better decisions, which lower costs and increase refining efficiency and product quality compared with traditional offline approaches.

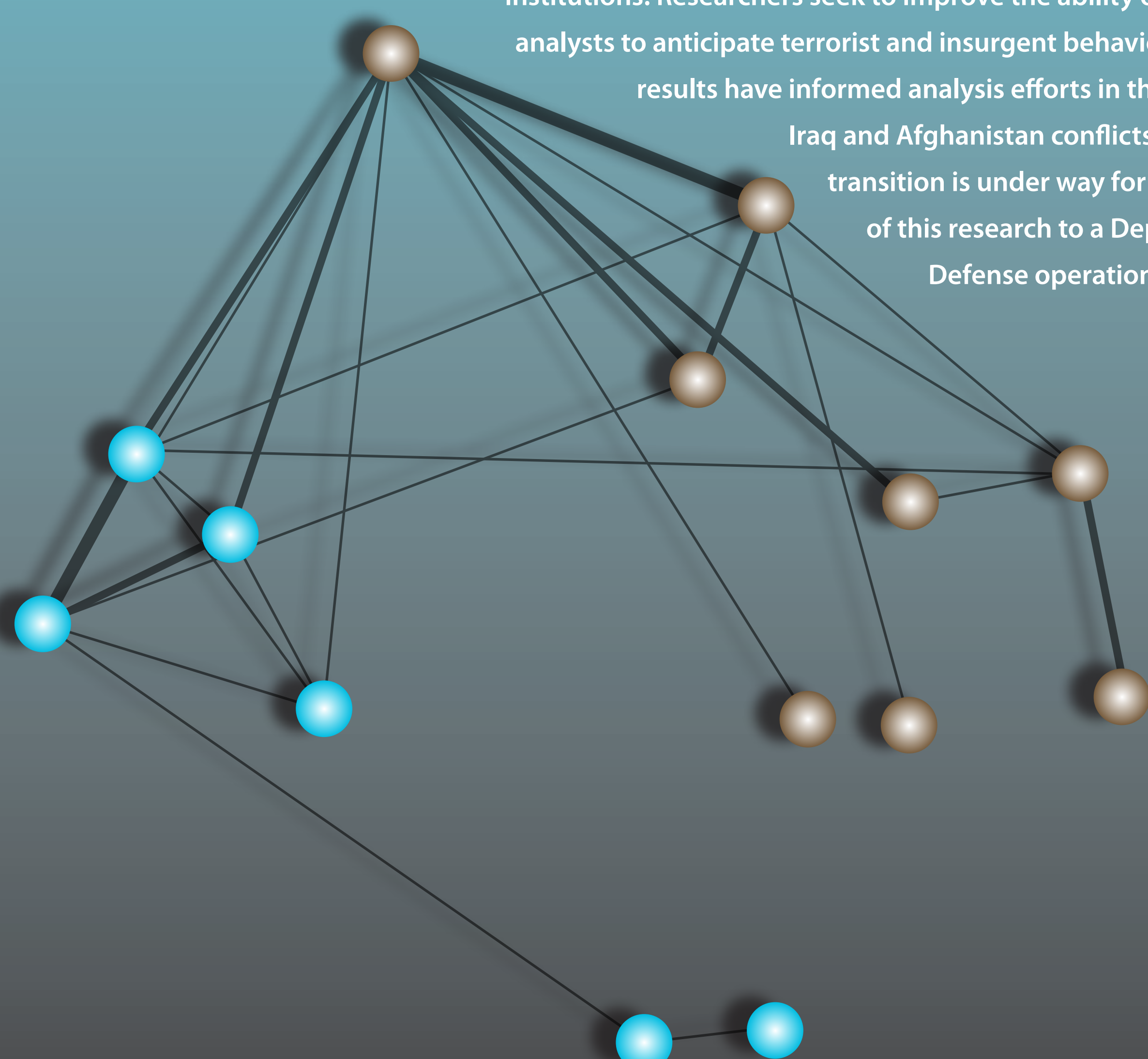
The research and development team's overall goal is to design and implement novel optical instrumentation and sensors for online monitoring of chemical and biological processes. These systems are based on many optical sensing techniques, including Raman spectroscopy. Several analytical techniques applied online create an integrated system for continuous, real time chemical process analysis and control.

APL-UW TEAM MEMBERS: Charles Branham, Thomas Dearing, Lauren Hughs, Brian Marquardt, Sergey Mozharov, Michael Roberto, and Wesley Thompson

SPONSORS: National Science Foundation, Center for Process Analysis and Control, Chevron Energy Technology Company, Food and Drug Administration, and Pfizer

Words into Actions

Terrorist and insurgent groups are among the most pressing current national security concerns for the United States. APL-UW scientists are using the groups' observable behavior—their public speech—to understand their structure and dynamics. This approach integrates recent advances in network science research, developed primarily by physicists and mathematicians, with social science theory and methods; it involves APL-UW research collaborations with faculty in political science and communications at the University of Washington and other institutions. Researchers seek to improve the ability of intelligence analysts to anticipate terrorist and insurgent behavior and the results have informed analysis efforts in the ongoing Iraq and Afghanistan conflicts. A pilot transition is under way for elements of this research to a Department of Defense operational command.



Observed network of declared joint operations among insurgent groups in Iraq 2005–2007

Models of Terrorist Network Dynamics

Insurgent and terrorist groups are fundamentally political entities. Political systems are difficult to quantify, a problem exacerbated by the covert nature of insurgent and terrorist operations. But these groups are notable for their use of the Internet, satellite television channels, and other public media to convey their messages. One APL-UW research program exploits insurgent groups' rhetoric—public speech and political declarations—to develop computational models of the groups' decision making and behavior. Three components of rhetoric were identified as key to insurgent strategic decision making. 1) How do they frame the conflict? Who are the good guys and who are the bad guys? 2) What are their targeting claims? Who do they take credit for attacking? 3) What are their declared relationships? With whom do they cooperate publically?

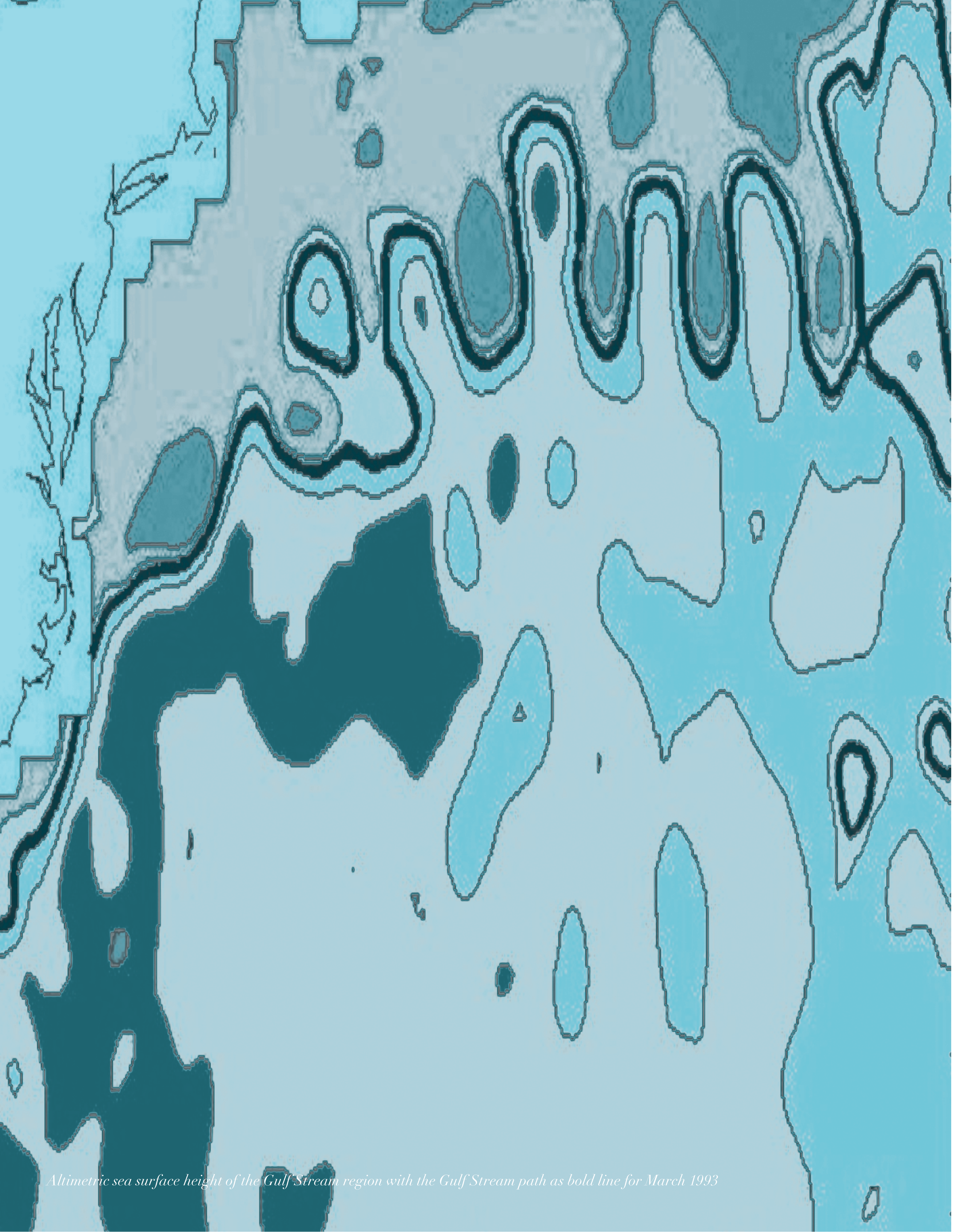
There are two distinct but related outputs of this research that can be used to analyze insurgent behavior. The first are data maps drawn from rhetorical components that provide a quantitative and visual representation of insurgency factional structure. For example, the method shows which insurgent groups in Iraq during the period 2003–2009 were most important, their ideological and strategic relationships, and their level of political cooperation. Conventional analysis had divided Iraqi insurgents into two groups—jihadists like Al Qaida in Iraq and nationalists like the Islamic Army in Iraq. The factional maps generated by this research, however, showed that this binary division was too coarse and that certain groups like the Islamic Army in Iraq—the largest of the insurgent groups—were best considered as hybrid nationalist-jihadists with crucial implications for their strategic decision making.

Model simulations based on these rhetorical components also reveal the evolution of insurgent network structure, which could alert analysts to impending shifts in insurgent dynamics. For example, a computational model of publicly claimed tactical cooperation between insurgent groups was tested against data from Iraq on joint operations between insurgent groups. The simulation agrees with the observed joint operations networks, reproducing particularly well the separation between the jihadist and nationalist wings of the insurgency. This structure is not reproduced, however, by a social network model that accounts only for insurgent group sizes and not policy differences or leadership inputs.

Because the model simulations are driven with empirical data, the method is more amenable to real-time updates than if analyst judgments were used as input. As groups release statements and claims of attacks, the quantitative variables can be re-estimated and used to refine model predictions. The ultimate application would be to forecast the evolution of the insurgent or terrorist groups' operational network, assessing how, for instance, efforts to sow discord among insurgent groups may affect tactical cooperation across the insurgency, allegiance shifts, and operational efficacy.

APL-UW TEAM MEMBERS: Luca Cazzanti, Arindam Das, Charissa Ford, and Michael Gabbay

SPONSOR: Office of Naval Research



Altimetric sea surface height of the Gulf Stream region with the Gulf Stream path as bold line for March 1993

Oceanography from Space

North Atlantic Eighteen Degree Water

The strong storms and intense cold air outbreaks of winter in the North Atlantic cause heat to flux from the ocean to the atmosphere, the sea surface temperature to decrease, and the oceanic mixed layer to deepen. This ocean ventilation process creates subtropical mode water—a deep layer extending down from the surface that is of nearly homogeneous temperature. Here in the North Atlantic the water's temperature, 18°C, provides its common name.

Eighteen Degree Water (EDW) is formed in a region just south of the Gulf Stream between 75° and 50°W. Its formation and subsequent mixing, movement out of the region (advection), and subduction under a warming surface layer in spring are of great interest to oceanographers and the climate modeling community.

U.S. members of the international Climate Variability and Predictability (CLIVAR) group organized the CLIVAR Mode Water Dynamics Experiment (CLIMODE) to study EDW processes—formation, mixing, advection, and subduction. Researchers from APL-UW's AIRS Department (Air–Sea Interaction and Remote Sensing) with colleagues from the University of Miami, are using a 20-year time series of satellite observations to complement the extensive CLIMODE field measurements taken during the winters of 2006 and 2007. The in situ measurements will improve the physics describing EDW processes for numerical models of climate, while the long time series of satellite observations are being used to determine which processes have the greatest impact on the interannual variability of EDW volume.

The volume of EDW formed in late winter is calculated from sea surface temperature maps and from air–sea heat fluxes, both derived primarily from satellite infrared and microwave sensors. The long, wide lens of the satellite data record is also used to determine how mixing and advection contribute to interannual EDW volume variations, but only indirectly.

APL-UW researchers are using measures of sea surface height by satellite altimeters to create proxies for the mixing of EDW in the formation region and advection out of the region. These were measured during the CLIMODE at-sea campaigns, but there is no long data record of field measurements. The proxy for mixing derived from satellite data is the length of the Gulf Stream path as it passes through the EDW formation region. A strong, stable Gulf Stream with a straight, short path from 75° to 50°W contributes little mixing; an unstable, meandering Gulf Stream mixes the EDW along its length, which diminishes EDW volume.

Eighteen Degree Water contributes to the climate memory for the North Atlantic. The water mass carries the coupled atmosphere–ocean signal around the subtropical gyre from year to year.

The proxy for EDW advection is the ocean's surface velocity in the formation region, also derived from the altimeter. The stronger the southward flow, the more EDW is transferred out of the formation region, where it is subducted beneath warmer waters and isolated from contact with the atmosphere, thus preserving the memory of the atmosphere–ocean interaction from the preceding season.

EDW is cold relative to surrounding waters: a large EDW volume corresponds to low ocean heat content. When the EDW layer is again exposed to the atmosphere during fall and winter surface cooling and deep mixing in the North Atlantic, it has enormous thermal inertia; its heat deficit is so large that it cannot be depleted in a single warm year. EDW volume also exerts its memory of North Atlantic climate with a feedback of opposite sign. Increased heat advection from the Gulf Stream over several years causes an accumulation of heat in the gyre, a decrease in EDW volume, and larger discharges of heat to the atmosphere.

Fresh Water in the Arctic

Researchers at the Polar Science Center, in collaboration with the Jet Propulsion Laboratory, have combined data products from two NASA satellite systems to yield first-ever maps of changes in freshwater content and circulation over the whole Arctic Ocean.

The Arctic Ocean is a repository for a tremendous amount of river runoff, especially from several huge Russian rivers. As fresh water exits the Arctic Ocean through Framm Strait it increases stratification in the Nordic Seas and North Atlantic Ocean. Here, a thick freshwater 'cap' may limit wintertime overturning convection with implications for global thermohaline circulation.

Beginning in the 1990s, scientists began to recognize major changes in the Arctic, which spurred measurement programs designed to track these changes on decadal time scales. Researchers at the Polar Science Center have long led observation programs of the ocean–ice–atmosphere system in the Arctic. Programs include repeat and long time series oceanographic measurements at the North Pole and extensive aerial hydrographic surveys from bases in Canada and Alaska. During the spring 2008 survey, oceanographers detected major shifts in the amount and distribution of fresh water. The Canada basin had freshened; had the entire Arctic Ocean?

Despite the extensive observational programs, large portions of the Arctic remain poorly sampled. Combining the data products from two satellite systems with complete Arctic Ocean coverage—ICESat to measure sea surface height and GRACE to measure bottom pressure—new insight was achieved. The difference between the weight of the water measured by GRACE and the height of the water column measured by ICESAT yields an estimate of density, which can be related to freshwater content.

Analysis of satellite records over the period 2005–2009 shows that salinity increased on the Russian side of the Arctic and decreased in the Beaufort Sea on the Canadian side. Chemical samples in the Beaufort Sea confirmed that the freshwater source was the Russian rivers on the opposite side of the basin.

One dominant feature of Arctic Ocean circulation is the transpolar drift that moves ice and water from the Russian side, across the North Pole, and out through Framm Strait. Another is the Beaufort Gyre — a clockwise circulation of the atmosphere and ice in the Canada Basin.

With an Arctic-wide view of circulation from ICESat, researchers were able to determine that atmospheric forcing had shifted the transpolar drift counterclockwise and driven Russian runoff east to the Canada Basin. Thus, Russian river water, instead of being flushed from the Arctic by the transpolar drift, was taken on a more complex path that included residence in the Beaufort Gyre.

The atmospheric regime that forced these circulation changes in the last decade reversed in 2010. Will the fresh water stored in the Canada Basin bleed out through Framm Strait and will the Russian rivers again discharge through the strait, producing a flushing event of fresh water into the Nordic Seas and North Atlantic Ocean? It gives urgency to the science community to observe and understand this rapidly changing ocean–ice–atmosphere system as it evolves. A current challenge is to construct numerical model simulations of these processes to predict how and when the changes in the Arctic will interact with the rest of the world ocean.

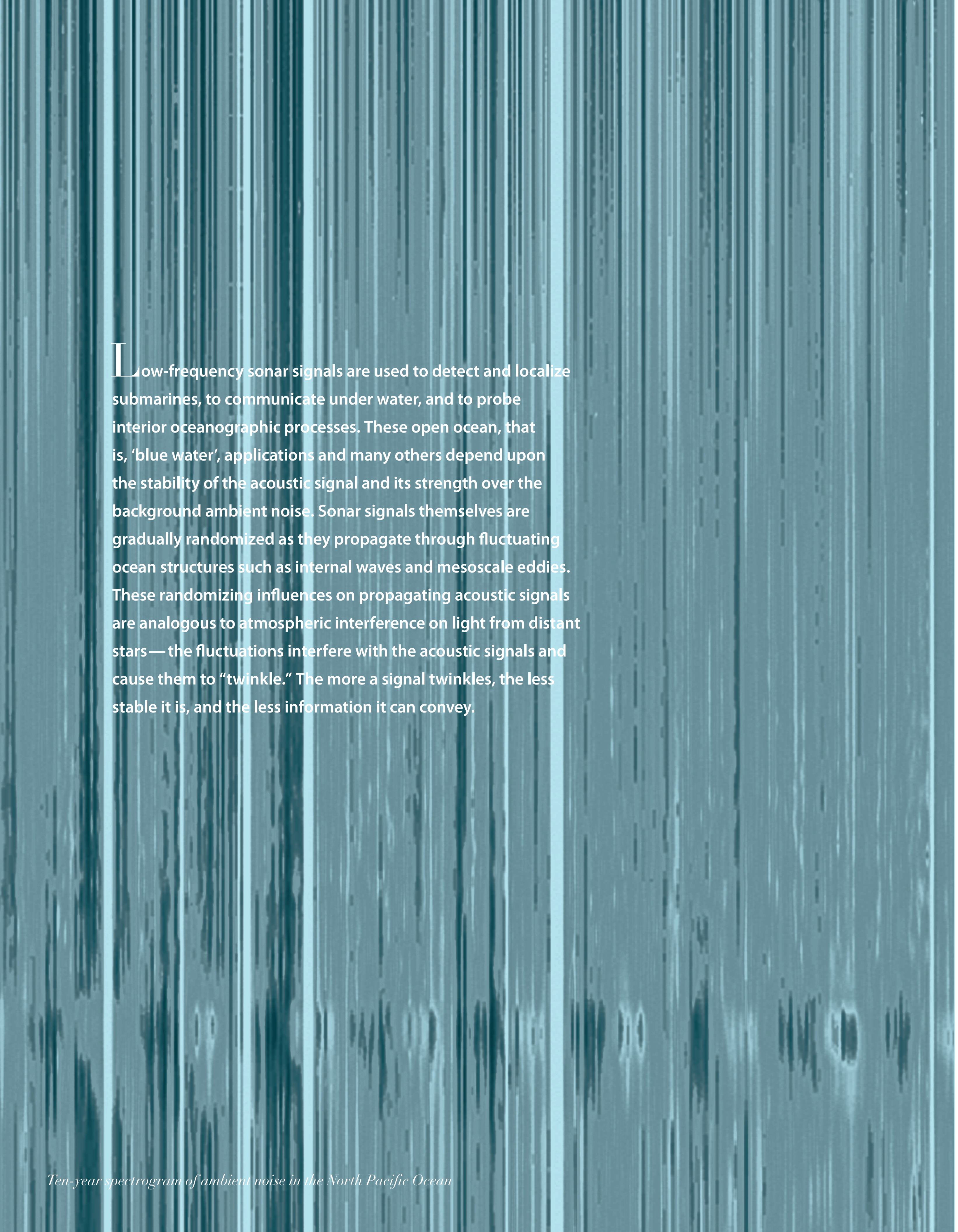
GRACE is the Gravity Recovery and Climate Experiment launched in 2002. The instrument is actually twin satellites that measure the distance separating them while in orbit to make detailed measurements of Earth's gravity field.

ICESat, the Ice, Cloud, and land Elevation Satellite launched in 2003, is the benchmark mission for measuring ice sheet mass balance, cloud and aerosol heights, as well as land topography and vegetation characteristics over polar regions.

APL-UW TEAM MEMBERS: *(Arctic) Matthew Alkire, James Morison, Cecilia Peralta-Ferriz, Ignatius Rigor, and Michael Steele; (North Atlantic) Suzanne Dickinson and Kathryn Kelly*

SPONSORS: *National Science Foundation and National Aeronautics and Space Administration*

www.apl.washington.edu/report/2011



Ten-year spectrogram of ambient noise in the North Pacific Ocean

Low-frequency sonar signals are used to detect and localize submarines, to communicate under water, and to probe interior oceanographic processes. These open ocean, that is, 'blue water', applications and many others depend upon the stability of the acoustic signal and its strength over the background ambient noise. Sonar signals themselves are gradually randomized as they propagate through fluctuating ocean structures such as internal waves and mesoscale eddies. These randomizing influences on propagating acoustic signals are analogous to atmospheric interference on light from distant stars—the fluctuations interfere with the acoustic signals and cause them to "twinkle." The more a signal twinkles, the less stable it is, and the less information it can convey.

Blue Water Acoustics

North Pacific Acoustic Laboratory

For more than two decades an APL-UW team of ocean acousticians, in collaboration with researchers from the Scripps Institution of Oceanography, Woods Hole Oceanographic Institution, the Massachusetts Institute of Technology, and the Naval Postgraduate School, have instrumented a region of the North and East Pacific Ocean, known as the North Pacific Acoustic Laboratory, to quantify the characteristics of sonar fluctuations and oceanic ambient noise over long ranges at low frequencies from 20 Hz to 500 Hz.

The results have been intriguing. It had been thought that sonar signal randomization would be so severe at very long ranges—Hawaii to Oregon or to the Aleutian Islands, for example—that the signal content would be lost completely. Surprisingly, the pattern of signal crescendos and fades—the "twinkle rate"—remains predictable for 5 to 15 minutes. The signal, although very faint with range, is useful over these time spans. Sonar signals were also unusually audible to hydrophones placed at deep regions where numerical models predicted only quiet ambient noise to be heard. It is now thought that both of these characteristics are related to internal ocean waves that fluctuate on timescales of minutes to hours.

The results have also been unexpected. Oceanic ambient noise levels had not been measured in the region since sparse observations were first reported in the 1960s. Profiting from more than one decade of support from the Office of Naval Research, the NPAL long-term ambient noise measurement program shows that the average ambient noise has risen as much as ten-fold in the past 40 years. This seems to follow the growth of the world's merchant shipping fleet over the last half-century. However, looking month-by-month inside the multi-year data records shows that noise levels are actually decreasing with time along the Pacific Northwest coast. More research is needed to determine why these noise levels are not following the growth of the world merchant fleet at these locations.

long-range low-frequency

New Waters

While understanding of long-range, low-frequency propagation in the northeastern Pacific is somewhat mature, APL-UW acousticians recognize that this region is a relatively benign mid-ocean gyre. The natural extension to these experiments is to examine the extent to which theoretical understanding remains valid in other ocean basins.

To this end, comparative experiments were conducted in the Philippine Sea. This region, more than 5000 m deep at its deepest point, is bounded to the south by the North Equatorial Current and to the west by the strong Kuroshio Current. Mesoscale structures propagate westward into the basin and collide with eddies spun off the Kuroshio, creating a much more energetic and complicated oceanography than is typical in the northeastern Pacific. These processes, however, evolve over time scales of weeks, so it is possible that the twinkle rate and the degree to which acoustic signals are refracted into acoustically quiet deep regions — both of which are mediated by processes with time scales of minutes to hours — may not be different than observed in the North Pacific Acoustic Laboratory.

Over the past two years, experiments in the Philippine Sea addressed the vertical structure of sonar signals over the entire water column with a 5000-m deep hydrophone array, and the temporal nature of the twinkle rate with high-resolution sampling for several periods of 50–60 hours. The hydrophone data were recovered in mid-2011. Early results are again intriguing and unexpected. The long-range signals that propagate predominantly in the middle ocean interior show typical twinkle rates and strength, but those signals passing near the surface experience occasional multi-hour drops in overall intensity, that is, "hushed" periods. Ambient noise levels also appear to be quieter than expected near the surface.

Whether these two phenomena are related remains to be determined. There are no known models for mechanisms that would induce this effect. Such a model would be valuable to predict when, for example, surface-to-depth underwater communications might be stronger or weaker, or object detection probabilities better or worse.

APL-UW TEAM MEMBERS: Rex Andrew, Bradley Bell, Eric Boget, Robert Bolstad, Linda Buck, Andrew Ganse, Ray Glennon, Lyle Gullings, Frederick Karig, Timothy McGinnis, Sean McPeak, James Mercer, Nicolas Michel-Hart, Christopher Siani, Timothy Wen, Andrew White, and Joseph Wigton

SPONSOR: Office of Naval Research

Teach, Advise, Collaborate

Over the past biennium the Laboratory has strengthened its commitment to the education mission of the University of Washington by supporting a vibrant cadre of joint faculty appointments in UW departments. APL-UW scientists and engineers holding academic appointments work collaboratively with the faculty; teach, sponsor, and mentor graduate and undergraduate students (see pages 44–46); and advise graduates in thesis and dissertation research (see page 43).

APL-UW researchers hold fifty-six faculty appointments across thirteen University of Washington departments and five colleges. The greatest numbers of these ties are with the College of Engineering and the College of the Environment. The Laboratory has continued its successful program to increase the number of researchers holding 'without tenure' appointments, which require teaching. Recently **Matthew Alford**, **Kathryn Kelly**, **Craig Lee**, and **Rebecca Woodgate** were appointed to the School of Oceanography, **Andrew Jessup** to Civil and Environmental Engineering, and **Kristin Laidre** to the School of Aquatic and Fishery Sciences, bringing the number of APL-UW 'without tenure' faculty to 18.

The topics of university courses taught by APL-UW faculty mirror their interests and expertise, and often focus on imparting essential skills to developing researchers. **Kathryn Kelly** teaches *Oceanographic Data Analysis* for student oceanographers who learn field data collection techniques in **Matthew Alford's** and **Craig Lee's** *Methods and Measurements in Physical Oceanography.* **Gordon Farquharson's** *Probability and Random Processes* and **Jim Thomson's** *Fluid Mechanics* are essential foundations for respective electrical and mechanical engineering students.

The integration of APL-UW researchers with UW units is apparent in the research collaborations across the campus, which recently totaled over 80 such interactions spread over more than 30 departments. These research collaborations often entrain top graduate students who seek the expertise of APL-UW scientists and engineers to support their pursuit of advanced degrees.

Doctoral student **Christopher Bassett** is advised by APL-UW's **Jim Thomson** and **Brian Polagye** from the Department of Mechanical Engineering. Bassett is working on problems related to marine renewable energy, measuring and modeling the ambient noise of the highly energetic coastal waters that are suitable for tidal in-stream energy conversion. His demonstrated talent and ambitious research topic garnered a prestigious Graduate Research Fellowship from the National Science Foundation.

Support & Mentor

The Hardisty Undergraduate Scholarship, established in 1997, provides funds for students to work with an APL-UW staff mentor on a funded research project in addition to a one-time book award. The Boeing/APL-UW Undergraduate Scholarship for Women, Under-represented Minorities, and Economically Disadvantaged Students is an exact parallel to the Hardisty program. Since 2004 this scholarship has been funded by generous grants from The Boeing Company.

2009 & 2010

HARDISTY SCHOLAR	ADVISOR
Benjamin Brand	Russell Light
Robert Burns	Peter Dahl
Brian Henderson	Jim Thomson
Kang Yu	Pierre Mourad

BOEING SCHOLAR	ADVISOR
Lily Blair	Robert Odom
Tamisha Downing	Pierre Mourad
Charles Harris-White	Timothy Elam & Dale Winebrenner
Trevor Martin	Yanling Yu
Vi Nguyen	Yanling Yu
Elizabeth Wicks	Timothy Elam & Dale Winebrenner

Two undergraduate scholarship programs expose students to real research environments where they work with APL-UW scientists on sponsored projects. **Elizabeth Wicks** analyzed topographic data from the largest known gypsum deposit on Mars. Under the direction of **Timothy Elam** and **Dale Winebrenner**, she focused on the area of proposed meltwater channels, which she studied by exaggerating the color scale in data from the Mars Orbiter laser altimeter.

Lily Blair, working with **Robert Odom**, co-authored "*Traveling Wave Modal Attenuation in Layered Media,*" which was presented at the American Geophysical Union meeting. Her work is relevant to geophysicists as well as to the non-destructive testing of composite materials. And **Trevor Martin** worked with polar scientist **Yanling Yu** to understand the impacts of arctic storms on variations in landfast ice. He learned to use interpolation techniques to handle data gaps and outliers, a technique he had not been exposed to in undergraduate course work.

Sharing Science

Principal Oceanographer Jan Newton engages historically under-represented communities in ocean science at UW's premier marine field laboratory, Friday Harbor Laboratories on San Juan Island. Students from the Northwest Indian College in nearby Bellingham receive peer-to-peer instruction from UW students. On research cruises apprentices learn ocean observing techniques, work as a team conducting time-series sampling, and design projects on river plumes, ocean forcing, climate variation, and biological interactions. Sponsored by the National Science Foundation and the UW College of the Environment, the program fosters development of a work force of tribal members trained in coastal marine sciences who can aid wise management of marine resources.

Students from the Northwest Indian College on a research cruise out of the UW Friday Harbor Laboratories on San Juan Island

photo: Jude Apple

Polar Science Weekend is four days of hands-on activities, live demonstrations, and exhibits about the polar regions and current polar research, presented by scientists from APL-UW and held at Seattle's Pacific Science Center, which is Washington State's most well-attended museum. The goal is to inspire an interest in science through one-on-one, face-to-face interactions between visitors and scientists. Guided by their "polar passports," over 6000 visitors in 2011 learned about the Greenland ice sheet, the diving behavior of narwhals, the difference between sea ice and freshwater ice, how Seagliders work, and much more as they visited dozens of stations and talked to scientists.

Organized by Senior Mathematician **Harry Stern**, Polar Science Weekend is a partnership between APL-UW and Pacific Science Center with funding from NASA. Scientists and volunteers are trained on how to design engaging exhibits and present them to the public. An annual event since 2006, Polar Science Weekend has become a model for other science weekends hosted by Pacific Science Center.

Engineer **Wesley Thompson** co-coordinated the Pacific Northwest Regional ROV Challenge for the Marine Advanced Technology Education Center, and then went on to serve as an engineering judge at the International MATE ROV competition, which was held at NASA's Neutral Buoyancy Laboratory in Houston. Students competed with their ROVs in simulations of the same conditions and challenges faced by ROV operators during the 2010 Deepwater Horizon oil spill. Besides helping students learn critical science, technology, engineering and math (STEM) skills, the competition helps them learn about team building, creative thinking, and problem solving.

APL-UW staff members are frequent mentors and judges at student science and technology fairs and competitions in the Seattle area. At a local middle-school science fair, over one-half of the student body was inspired to participate. "The experiments dreamed up by these kids are interesting, inspiring, and fun. It's like watching the next generation of APL-UW researchers being formed. Now we need to hold a proposal writing fair to complete their training," said fair judge and APL-UW Senior Engineer **Peter Brodsky**.

Oceanographer **Kate Stafford** blogged for *New York Times* readers for six weeks in spring 2011. Her research took her to a perch atop a mound of sea ice rubble off the coast of Barrow, Alaska, to conduct a census of bowhead whales. While informing readers of the scientific value of counting bowhead whales, she captured the springtime awakening of the Arctic through compelling entries on many facets of the physical and biological environment.

High-school student winners of the Orca Bowl competition at the University of Washington gained at-sea experience aboard APL-UW's R/V *Robertson*. As a prize, the winning team participated in a one-day science cruise on Lake Washington where they deployed a Seaglider equipped with new instruments — an acoustic Doppler current profiler and a pumped conductivity–temperature–depth sensor. Students assisted APL-UW researchers with the glider launch and recovery and with four CTD casts from the *Robertson*. They then compared the CTD data with the data collected during the glider's flight. The annual Orca Bowl competition is part of the National Ocean Sciences Bowl, which attracts about 2,000 students from 400 high schools across the nation; student teams tackle questions in all areas of marine studies, including ocean physics, chemistry, biology, and technology.

Oceanographer **Kristin Laidre** was the first speaker in the 2011 "Sound Conversations" series held at the Seattle Aquarium, where she described the challenges and rewards of working in the high Arctic. The audience was introduced to her research on narwhals and polar bears, how they handle the dynamic Arctic ecosystem, and how they might be affected by a changing climate.

For over two decades, APL-UW has presented a seminar series to the University of Washington and area community during the academic year. Scientists from the Laboratory, the UW, and other institutions, as well as frequent international experts cover a wide range of topics in these weekly talks. Some titles from the past year were: *General Time-Frequency Framework for the Characterization of Underwater Signals*, *Bowhead Whale Foraging Ecology in West Greenland*, *Thick or Thin? Antarctic Sea Ice Thickness and Its Snow Cover*, and *The Antikythera Mechanism: An Astronomical Calculating Machine from Ancient Greece*.

The Laboratory's doors are always open to educators, students, and interested members of the public. Tours and hands-on learning activities are provided by Assistant Director **Robert Odom** and other APL-UW staff members for UW initiatives such as Math Day, that draws high school mathematics and science students from all over the Pacific Northwest, and the federally funded GEAR-UP (Gaining Early Awareness and Readiness for University Programs), that exposes economically disadvantaged learners to the opportunities of pursuing science, technology, engineering, and mathematics.

Student Achievements

Graduate Degrees Awarded

Student	Degree/Topic	Advisor(s)
Marilee Andrew	Bioengineering, Ph.D., 2009 *Quantifying pharmacokinetics in altered physiological states*	Bryers & Vicini
Christopher Basset	Mechanical Engineering, M.S., 2010 *Ambient noise at a tidal energy site*	Thomson & Polagye
Charles Branham	Chemistry, Ph.D., 2010 *Design, characterization, and optimization of vapochromic sensors for oxygen analysis*	Marquardt
Michael Canney	Bioengineering, Ph.D., 2009 *Nonlinear enhancement of heating due to shock formation in high-intensity focused ultrasound fields*	Bailey & Crum
David Dall'Osto	Mechanical Engineering, M.S., 2009 *A study of the spectral and directional properties of ambient noise in Puget Sound*	Dahl
Jeff Epler	Mechanical Engineering, M.S., 2010 *Tidal resource characterization from acoustic Doppler current profilers*	Thomson & Polagye
Samuel Gooch	Mechanical Engineering, M.S., 2009 *Siting methodologies for tidal in-stream energy conversion systems*	Thomson & Polagye
Kim Martini	Oceanography, Ph.D., 2010 *Internal tides and mixing over the Oregon continental slope*	Alford
Anna Pyayt	Electrical Engineering, Ph.D., 2009 *Field-induced guiding optical devices made from electro-optic polymers*	Chen
Gavriel Speyer	Electrical Engineering, Ph.D., 2010 *Rytov modeling for backscatter monitoring of high-intensity focused ultrasound therapy*	Crum, Kaczkowski & Brayman
Haishan Sun	Electrical Engineering, Ph.D., 2009 *Efficient fiber coupler for vertical silicon slot waveguides*	Chen
Dejie Zhou	Mechanical Engineering, M.S., 2009 *Investigation of the performance of a method to reduce structurally generated underwater noise*	Dahl & Reinhall

Graduate Student Research

Student	Topic	Advisor(s)
Marilee Andrew	*Quantifying pharmacokinetics in altered physiological states*	Bryers & Vicini
Christopher Bassett	*Underwater noise at a tidal energy site*	Thomson & Polagye
Charles Branham	*Design, characterization, and optimization of vapochromic sensors for oxygen analysis*	Marquardt
Michael Canney	*Nonlinear enhancement of heating due to shock formation in high-intensity focused ultrasound fields*	Bailey & Crum
Hong Chen	*Ultra-high speed optical imaging of ultrasound-activated microbubbles*	Matula
Brian Chinn	*Mechanism and variability of diapycnal mixing in the Southern Ocean*	Girton & Alford
M. Beth Curry	*Volume, heat, and freshwater transport across Davis Strait*	Lee
David Dall'Osto	*A study of the spectral and directional properties of ambient noise in Puget Sound*	Dahl
Jeff Daniels	*Vector sensor development*	Dahl & Reinhall
Hayley Dosser	*Arctic mixing*	Rainville & Woodgate
Charles Elliot	*Photothermal deflection detection of trace chemical vapors*	Chen
Jeff Epler	*Tidal resource characterization from acoustic Doppler current profiles*	Thomson & Polagye
Navid Farr	*High-intensity focused ultrasound and drug synergy*	Hwang
Dara Farrell	*Shallow water acoustic propagation with emphasis on Puget Sound transmission loss modeling*	Dahl
Ana Cecilia Peralta Ferriz	*Analysis of Arctic Ocean pressure gauge and GRACE satellite gravity data describing ocean bottom pressure and circulation*	Morison
Christopher Fisk	*Development of miniaturized interferometric synthetic aperture radar techniques for nearshore ocean characterization*	Farquharson & Ritcey
Andrew Ganse	*Theoretical aspects of nonlinear inversion*	Odom
Marc Geilhufe	*Use of wavelets to classify images of skin lesions*	Percival
Samuel Gooch	*Siting methodologies for tidal in-stream energy conversion systems*	Thomson & Polagye
Joseph Graber	*Land-based infrared imagery for marine mammal detection*	Thomson & Polagye
John Guthrie	*Analysis of field data for internal waves and mixing in the Arctic Ocean*	Morison
Evan Hanusa	*Feature aided tracking*	Krout & Gupta
Tyler Hennon	*Internal wave analysis from drifting ARGO floats*	Riser & Alford
Simon Henricksen	*Turbulence at wind energy sites*	Thomson
Kevin Jamieson	*Multiple target tracking algorithms*	Krout
Byron Kilbourne	*The Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES)*	Girton
Nathan Lauffenburger	*Quantifying submesoscale lateral dispersion and turbulent mixing near the Gulf Stream*	Sanford
Tong Li	*Image guided therapy for high-intensity focused ultrasound*	Crum & Curra
Wei Lu	*Better ultrasound for detecting kidney stones*	Bailey & Crum
Kim Martini	*Internal tides and mixing over the Oregon continental slope*	Alford
Brooke Medley	*Accumulation in the Amundsen Sea region*	Joughin
Twila Moon	*Greenland ice sheet mass balance and ice dynamics*	Joughin
Will Mortensen	*Improving an environmentally adaptive tracker through knowledge of target aspect*	Miyamoto
Rosalinda Mrvaljevic	*Evolution of the wakes of typhoons*	D'Asaro

Student	Topic	Advisor(s)
Michael Palodichuk	*Current survey methods for tidal energy*	Thomson & Polagye
Nathan Parrish	*Underwater communications*	Arabshahi
Camilo Perez	*Synthesis, characterization, and bio-effects in the use of ultrasound contrast agents*	Crum & Matula
Andrew Pickering	*Internal waves and mixing in Luzon Strait*	Alford
Kristin Poinar	*Ice sheet modeling*	Joughin
Anna Pyayt	*Field-induced guiding optical devices made from electro-optic polymers*	Chen
Roopesh Ranjan	*Analysis of sea ice using wavelets*	Percival
Justin Reedy	*Experimental and mathematical investigation of opinion dynamics in small groups*	Gabbay & Gastil
Eric Rehm	*Bio-optical study of the North Atlantic bloom*	D'Asaro
J. Paul Rinehimer	*Hydrodynamics and thermodynamics of tidal flats*	Thomson
Michael Roberto	*Optimization and control of a continuous flow reactor using online analyzers*	Marquardt
Marcela Sarmiento	*Extracellular polymeric substances from arctic sea ice bacteria*	Deming & Woodgate
Michael Schwendeman	*Turbulent dissipation by whitecaps*	Thomson
Andrew Shao	*Tracer modeling in the North Pacific using a global climate model*	Mecking
Julianna Simon	*Mechanisms of tissue injury by ultrasound*	Bailey & Crum
Gavriel Speyer	*Rytov modeling for backscatter monitoring of high-intensity focused ultrasound therapy*	Crum, Kaczkowski & Brayman
Christopher Strickland	*Inversion with multiple data types*	Odom
Mark Stockham	*Spectral analysis of pile driving noise*	Dahl & Reinhall
Haishan Sun	*Efficient fiber coupler for vertical silicon slot waveguides*	Chen
Weiwei Sun	*Electro-optic materials characterization*	Chen
Kevin Taylor	*Post typhoon structure and evolution of the Kuroshio Current near Taiwan*	Sanford
Samantha Terker	*Sources, propagation and dissipation of internal tides in Monterey Canyon*	Sanford
Cynthia Travers	*Bering Strait throughflow*	Rigor & Woodgate
Danling Wang	*Trace chemical sensors*	Chen
Ranran Wang	*Statistical post-processing of weather forecasts generated from numerical weather prediction (NWP)*	Marzban
Melinda Webster	*Arctic sea ice–ocean interaction*	Rigor & Morison
Andrew White	*Analysis of acoustic signal in long-range propagation*	Mercer
Menglu Xia	*Single-carrier frequency-domain equalization for underwater acoustic communications*	Rouseff & Ritcey
Kai-Chieh Yang	*Observation of internal tides and Kuroshio variability near the Luzon Strait using Seagliders*	Lee
Steve Zech	*Relationship between network properties and terrorist group functions*	Gabbay
Jinting Zhang	*Meridional transports in the North Atlantic Ocean*	Kelly & Thompson
Shuang Zhang	*Washington coastal oceanography*	Alford & Newton
Dejie Zhou	*Investigation of the performance of a method to reduce structurally generated underwater noise*	Dahl & Reinhall

Undergraduate Student Research

Student	Topic	Advisor(s)
Adrienne Antonsen	*Obtain and analyze in situ sea ice algae data and output from a global climate model*	Steele & Zhang
Taryn Black	*Cryolab simulations of the ocean surface on 'Snowball Earth'*	B. Light
Lily Blair	*Algorithm coding for elastic wave propagation in a strongly attenuating medium*	Odom
Benjamin Brand	*Ocean engineering; GulfEx11– sediment effects on acoustic propagation*	R. Light
Robert Burns	*Analysis of ambient sound measurements taken during the Pacific Science Center's Around the Americas cruise; design and build circuit for underwater accelerometer*	Dahl
Anna Cleveland	*Using intense focused ultrasound to localize peripheral pain generating tissue*	Mourad
Alex de Klerk	*Instrumentation for thermal sensing of intertidal sediments*	Thomson
Trevor Dickey	*Use of intense focused ultrasound to localize peripheral pain generating tissue*	Mourad
Tamisha Downing	*Use of intense focused ultrasound to localize peripheral pain generating tissue*	Mourad
Leslie Elston	*Deep Bleeder Acoustic Coagulation (DBAC) test bed*	Crum
Chris Fuller	*Sensor research; detection of concealed bank notes*	Chen
Josephine Garcia	*Use of intense focused ultrasound to localize peripheral pain generating tissue*	Mourad
Mariah Gentry	*Beaked whale detection and Seaglider R&D*	Bogue
John Grigg	*Northwest Association of Networked Ocean Observing Systems (NANOOS)*	Martin
Xiaohan Gu	*Detect elevated intracranial pressure; stroke imaging with sonoelasticity*	Mourad
Charles Harris-White	*X-ray spectrophotometer for elementary analysis of planetary surfaces*	Elam & Winebrenner
Sarah Huffer	*Northwest Association of Networked Ocean Observing Systems (NANOOS)*	Martin
Karsten James	*Algorithm coding for elastic wave reflection from a gradient layer*	Odom
Brice Johnson	*JAVA 3D application modeling underwater vehicles in a simulated ocean*	Kirby
Benjamin King	*Radar sounding of Martian polar ice caps*	Winebrenner
Kristopher Knigge	*Mooring fabrication*	Alford
Chris Knopf	*Test reproducibility of hydrophone design*	Bailey
Christopher Knott	*Martian polar topography and radar sounding*	Winebrenner
Dea Kolukcija	*Sensor research*	Chen
Hoon Kwon	*Apply a wavelet method to study the spatial and temporal variations of arctic sea ice thickness*	Yu
Sarah Mangiameli	*Obtain and analyze satellite and in situ observations and output from a coupled sea ice–ocean model*	Woodgate & Zhang
Trevor Martin	*Examine long-term changes in arctic land-fast ice and its response to cyclone variability; analysis of arctic climate data*	Yu
Abigail McClintic	*Use of focused ultrasound to localize peripheral pain generating tissue*	Mourad
Jennifer Mileli	*Coastal Margin Observation and Prediction (CMOP)*	Martin
Connie Ozimek	*Employ numerical ice–ocean model output to determine long-term changes in the timing of summer Arctic Ocean warming and ice retreat*	Steele
Zoë Parsons	*Instrument preparation for study of internal waves*	Alford
Steve Postlewait	*Ultrasound optimization*	Curra
Caitlin Shannon	*Deep Bleeder Acoustic Coagulation (DBAC) test bed*	Crum
Lien Thi Huynh	*Northwest Association of Networked Ocean Observing Systems (NANOOS)*	Martin
Sophorn Ven	*Northwest Association of Networked Ocean Observing Systems (NANOOS)*	Martin
Melinda Webster	*Reanalysis of sea ice concentrations from satellite passive microwave data*	Morison & Rigor
Elizabeth Wicks	*Ice penetrator development and Martian polar topography*	Elam & Winebrenner
Dickson Widjaja	*Miniaturized river monitoring radar and COHSTREX setup*	Farquharson & Plant
Alan Wright	*Support development of new technique for the measurement of albedo of laboratory grown sea ice in extreme conditions*	B. Light
Anning Yao	*Stroke imaging with sonoelasticity*	Mourad
Kang Yu	*Detect elevated intracranial pressure*	Mourad

publications 47

APL-UW scientists share their discoveries by publishing results of their research in books and journal articles as well as by participating in conferences and workshops. Since 2000, over one thousand papers authored by Laboratory researchers have appeared in the peer-reviewed literature.

Technical Reports and Memoranda, Issued in 2010

Andrew, R.K., J.A. Mercer, B.M. Bell, A.A. Ganse, L. Buck, T. Wen, and T.M. McGinnis, *PhilSea10 APL-UW Cruise Report: 5–29 May 2010*, APL-UW TR 1001, October 2010.

Articles in Journals, Books, and Book Chapters, 2010

Alford, M.H., Sustained, full-water-column observations of internal waves and mixing near Mendocino escarpment, *J. Phys. Oceanogr.*, 40, 2643–2660, doi:10.1175/2010JPO4502.1, 2010.

Alford, M.H., R.-C. Lien, H. Simmons, J. Klymak, S. Ramp, Y J. Yang, D. Tang, and M.-H. Chang, Speed and evolution of nonlinear internal waves transiting the South China Sea, *J. Phys. Oceanogr.*, 40, 1338–1355, 2010.

Alkire, M.B., K.K. Falkner, J. Morison, R.W. Collier, C.K. Guay, R.A. Desiderio, I.G. Rigor, and M. McPhee, Sensor-based profiles of the NO parameter in the central Arctic and southern Canada Basin: New insights regarding the cold halocline, *Deep-Sea Res. I*, 57, 1432–1443, doi:10.1016/j.dsr.2010.07.011, 2010.

Andreev, V.G., T.B. Krit, and O.A. Sapozhnikov, Standing waves in an elastic layer loaded with a finite mass, *Phys. Acoust.*, 56, 168–173, doi:10.1134/S1063771010020077, 2010.

Andrew, R.K., M.R. Zarnetske, B.M. Howe, and J.A. Mercer, Ship-suspended acoustical transmitter position estimation and motion compensation, *IEEE J. Ocean. Eng.*, 35, 797–810, 2010.

Arbab, M.H., D.P. Winebrenner, E.I. Thorsos, and A. Chen, Retrieval of terahertz spectroscopic signatures in the presence of rough surface scattering using wavelet methods, *Appl. Phys. Lett.*, 97, doi:10.1063/1.3507384, 2010.

Au, W.W.L., J.K. Horne, and C. Jones, Basis of acoustic discrimination of chinook salmon from other salmons by echolocating *Orcinus orca*, *J. Acoust. Soc. Am.*, 128, 2225–2232, doi:10.1121/1.3473697, 2010.

Azetsu-Scott, K., A. Clarke, K. Falkner, J. Hamilton, E.P. Jones, C. Lee, B. Petrie, S. Prinsenberg, M. Starr, and P. Yeats, Calcium carbonate saturation states in the waters of the Canadian Arctic Archipelago and the Labrador Sea, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005917, 2010.

Baehr-Jones, T., A. Spott, R. Ilic, A. Spott, B. Penkov, W. Asher, and M. Hochberg, Silicon-on-sapphire integrated waveguides for the mid-infrared, *Opt. Express*, 18, 12127–12135, 2010.

Bagniewski, W., K. Fennel, M.J. Perry, and E.A. D'Asaro, Optimizing models of the North Atlantic spring bloom using physical, chemical and bio-optical observations from a Lagrangian float, *Biogeosciences Discuss.*, 7, 8477–8520, doi:10.5194/bgd-7-8477-2010, 2010.

Bessonova, O.V., V.A. Khokhlova, M.S. Canney, M.R. Bailey, and L.A. Crum, A derating method for therapeutic applications of high intensity focused ultrasound, *Acoust. Phys.*, 56, 354–363, 2010.

Bobkova, S., L. Gavrilov, V. Khokhlova, A. Shaw, and J. Hand, Focusing of high intensity ultrasound through the rib cage using a therapeutic random phased array, *Ultrasound Med. Biol.*, 36, 888–906, doi:10.1016/j.ultrasmedbio.2010.03.007, 2010.

Booth, J.F., L.A. Thompson, J. Patoux, K.A. Kelly, and S. Dickinson, The signature of the midlatitude tropospheric storm tracks in the surface winds, *J. Climate*, 23, 1160–1174, 2010.

Born, E.W., A. Heilmann, L. Kielsen Holm, and K.L. Laidre, Polar Bears in Northwest Greenland: An Interview Survey about the Catch and the Climate (*Monographs on Greenland, vol. 351*) (Copenhagen: Museum Tusculanum Press, 2010, 250 pp).

Bouchoux, G., N.R. Owen, F. Chavrier, R. Berriet, G. Fleury, J.-Y. Chapelon, and C. Lafon, Interstitial thermal ablation with a fast rotating dual-mode transducer, *IEEE Trans. Ultrason. Ferroelec. Freq. Control*, 57, 1086–1095, 2010.

Briggs, K.B., A.H. Reed, D.R. Jackson, and D. Tang, Fine-scale volume heterogeneity in a mixed sand/mud sediment off Fort Walton Beach, FL, *IEEE J. Ocean. Eng.*, 35, 471–487, 2010.

Byrne, R.H., S. Mecking, R.A. Feely, and X. Liu, Direct observations of basin-wide acidification of the North Pacific Ocean, *Geophys. Res. Lett.*, 37, doi:10.1029/2009GL040999, 2010.

Canney, M.S., V.A. Khokhlova, O.V. Bessonova, M.R. Bailey, and L.A. Crum, Shock-induced heating and millisecond boiling in gels and tissue due to high intensity focused ultrasound, *Ultrasound Med. Biol.*, 36, 250–267, 2010.

Castro, S.L., G.A. Wick, P.J. Minnett, A.T. Jessup, and W J. Emery, The impact of measurement uncertainty and spatial variability on the accuracy of skin and subsurface regression-based sea surface temperature algorithms, *Remote Sens. Environ.*, 114, 2666–2678, doi:10.1016/j.rse.2010.06.003, 2010.

Chen, H., A.A. Brayman, M.R. Bailey, and T.J. Matula, Blood vessel rupture by cavitation, *Urol. Res.*, 38, 321–326, doi:10.1007/s00240-010-0302-5, 2010.

Dadic, R., B. Light, and S.G. Warren, Migration of air bubbles in ice under a temperature gradient, with application to 'Snowball Earth', *J. Geophys. Res.*, 115, doi:10.1029/2010JD014148, 2010.

Dahl, P.H., Observations and modeling of angular compression and vertical spatial coherence in sea surface forward scattering, *J. Acoust. Soc. Am.*, 127, 96–103, doi:10.1121/1.3268594, 2010.

Das, A.K., Y. Hatano, and M. Mesbahi, Agreement over noisy networks, *IET Contr.-Theor. Appl.*, 4, 2416–2426, doi:10.1049/iet-cta.2009.0394, 2010.

Dearing, T.I., W.J. Thompson, C.E. Rechsteiner, and B.J. Marquardt, Characterization of crude oil products using data fusion of process Raman, infrared, and nuclear magnetic resonance (NMR) spectra, *Appl. Spectrosc.*, 65, 181–186, doi:10.1366/10-05974, 2010.

Dittrich, D., The conflicts facing those responding to cyberconflict, *;login: The USENIX Magazine*, 34, 7–15, 2010.

Dittrich, D., F. Leder, and T. Werner, A case study in ethical decision making regarding remote mitigation of botnets, in *Financial Cryptography and Data Security [Lecture Notes in Computer Science, volume 6054]* 216–230, doi:10.1007/978-3-642-14992-4_20 (Springer, 2010).

Donelan, M.A., B.K. Haus, W J. Plant, and O. Troianowski, Modulation of short wind waves by long waves, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005794, 2010.

Feely, R.A., S.R. Alin, J. Newton, C.L. Sabine, M. Warner, A. Devol, C. Krembs, and C. Maloy, The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary, *Estuar. Coast. Shelf Sci.*, 88, 442–449, doi:10.1016/j.ecss.2010.05.004, 2010.

Fricker, H.A., T. Scambos, S. Carter, C. Davis, T. Haran, and I. Joughin, Synthesizing multiple remote-sensing techniques for subglacial hydrologic mapping: Application to a lake system beneath MacAyeal Ice Stream, West Antarctica, *J. Glaciol.*, 56, 187–199, doi:10.3189/002214310791968557, 2010.

Fudge, T J., and B.E. Smith, Light propagation in firn: Application to borehole video, *J. Glaciol.*, 56, 614–624, doi:10.3189/002214310793146205, 2010.

Gaitan, D.F., R.A. Tessien, R.A. Hiller, J. Gutierrez, C. Scott, H. Tardif, B. Callahan, T J. Matula, L.A. Crum, R.G. Holt, C.C. Church, and J.L. Raymond, Transient cavitation in high-quality-factor resonators at high static pressures, *J. Acoust. Soc. Am.*, 127, 3456–3465, 2010.

Gregg, M.C., and L.J. Pratt, Flow and hydraulics near the sill of Hood Canal, a strongly sheared, continuously stratified fjord, *J. Phys. Oceanogr.*, 40, 1087–1105, doi:10.1175/2010JPO4312.1, 2010.

Harcourt, R.R., and E.A. D'Asaro, Measurement of vertical kinetic energy and vertical velocity skewness in oceanic boundary layers by imperfectly Lagrangian floats, *J. Atmos. Ocean. Technol.*, 27, 1918–1935, doi:10.1175/2010JTECHO731.1, 2010.

Harrison, J.A., A.F. Bouwman, E. Mayorga, and S. Seitzinger, Magnitudes and sources of dissolved inorganic phosphorus inputs to surface fresh waters and the coastal zone: A new global model, *Global Biogeochem. Cy.*, 24, doi:10.1029/2009GB003590, 2010.

Hefner, B.T., and D.R. Jackson, Dispersion and attenuation due to scattering from heterogeneities of the frame bulk modulus of a poroelastic medium, *J. Acoust. Soc. Am.*, 127, 3372–3384, 2010.

Heide-Jørgensen, M.P., K.L. Laidre, D. Borchers, T.A. Marques, H. Stern, and M. Simon, The effect of sea-ice loss on beluga whales (*Delphinapterus leucas*) in West Greenland, *Polar Res.*, 29, 198–208, 2010.

Heide-Jørgensen, M.P., K.L. Laidre, M.L. Burt, D.L. Borchers, T.A. Marques, R.G. Hansen, M. Rasmussen, and S. Fossette, Abundance of narwhals (*Monodon monoceros*) on the hunting grounds in Greenland, *J. Mammol.*, 91, 1135–1151, 2010.

Henyey, F.S., K.L. Williams, J. Yang, and D. Tang, Simultaneous nearby measurements of acoustic propagation and high-resolution sound-speed structure containing internal waves, *IEEE J. Ocean. Eng.*, 35, 684–694, doi:10.1109/JOE.2010.2044671, 2010.

Hickey, B.M., et al., including N.S. Banas, River influences on shelf ecosystems: Introduction and synthesis, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005452, 2010.

Howe, B.M., Y. Chao, P. Arabshahi, S. Roy, T. McGinnis, and A. Gray, A smart sensor web for ocean observation: Fixed and mobile platforms, integrated acoustics, satellites and predictive modeling, *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.*, 3, 507–521, doi:10.1109/JSTARS.2010.2052022, 2010.

Hwang, J.H., Y. Zhou, C. Warren, A.A. Brayman, and L.A. Crum, Targeted venous occlusion using pulsed high-intensity focused ultrasound, *IEEE Trans. Biomed. Eng.*, 57, 37–40, doi:10.1109/TBME.2009.2029865, 2010.

Hwang, P.A., and W.J. Plant, An analysis of the effects of swell and surface roughness spectra on microwave backscatter from the ocean, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005558, 2010.

Jackson, D.R., R.I. Odom, M.L. Boyd, and A.N. Ivakin, A geoacoustic bottom interaction model (GABIM), *IEEE J. Ocean. Eng.*, 35, 603–617, 2010.

Joughin, I., B.E. Smith, I.M. Howat, T. Scambos, and T. Moon, Greenland flow variability from ice-sheet-wide velocity mapping, *J. Glaciol.*, 56, 415–430, doi:10.3189/002214310792447734, 2010.

Karabutov, A.A., A.A. Karabutov, and O.A. Sapozhnikov, Determination of the elastic properties of layered materials using laser excitation of ultrasound, *Phys. Wave Phenom.*, 18, 297–302, doi:10.3103/S1541308X10040126, 2010.

Kelly, K.A., R.J. Small, R.M. Samelson, B. Qiu, T.M. Joyce, Y.-O. Kwon, and M.F. Cronin, Western boundary currents and frontal air-sea interaction: Gulf Stream and Kuroshio Extension, *J. Clim.*, 23, 5644–5667, doi:10.1175/2010JCLI3346.1, 2010

Khan, S.A., L. Liu, J. Wahr, I. Howat, I. Joughin, T. van Dam, and K. Fleming, GPS measurements of crustal uplift near Jakobshavn Isbrae due to glacial ice mass loss, *J. Geophys. Res.*, 115, doi:10.1029/2010JB007490, 2010.

Khokhlova, V.A., S.M. Bobkova, and L.R. Gavrilov, Focus splitting associated with propagation of focused ultrasound through the rib cage, *Acoust. Phys.*, 56, 665–674, doi:10.1134/S106377101005012X, 2010.

Kudela, R.M., A.R. Horner-Devine, N.S. Banas, et al., Multiple trophic levels fueled by recirculation in the Columbia River plume, *Geophys. Res. Lett.*, 37, doi:10.1029/2010GL044342, 2010.

Laidre, K.L., M.P. Heide-Jørgensen, W. Ermold, and M. Steele, Narwhals document continued warming of southern Baffin Bay, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005820, 2010.

Laidre, K.L., M.P. Heide-Jørgensen, M.L. Logsdon, L. Delwiche, and T.G. Nielsen, A whale of an opportunity: Examining the vertical structure of chlorophyll-a in high Arctic waters using instrumented marine predators, *Mar. Biol. Res.*, 6, 519–529, doi:10.1080/17451000903505616, 2010.

Laidre, K.L., M.P. Heide-Jørgensen, P. Heagerty, A. Cossio, B. Bergstrom, and M. Simon, Spatial associations between large baleen whales and their prey in West Greenland, *Mar. Ecol. Prog. Ser.*, 402, 269–284, doi:10.3354/meps08423, 2010.

Lee, C.M., and K.H. Brink, Observations of storm-induced mixing and Gulf Stream Ring incursion over the southern flank of Georges Bank: Winter and summer 1997, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005706, 2010.

Lee, T., S. Hakkinen, K. Kelly, and B. Qiu, Satellite observations of ocean circulation changes associated with climate variability, *Oceanography*, 23, 70–81, 2010.

Light, B., Theoretical and observational techniques for estimating light scattering in first-year Arctic sea ice, in *Light Scattering Reviews*, vol. 5, edited by A. Kokhanovsky, 331–392 (Springer-Praxis, Berlin, 2010).

Lindsay, R., New unified sea ice thickness climate data record, *Eos Trans. AGU*, 91, 405–406, doi:10.1029/2010EO440001, 2010.

Lynn, A.M., H. Bradford, E.D. Kantor, M. Andrew, P. Vicini, and G.D. Anderson, Ketorolac tromethamine: Stereo-specific pharmacokinetics and single-dose use in postoperative infants aged 2–6 months, *Pediatr. Anesth.*, doi:10.1111/j.1460-9592.2010.03484.x, 2010.

Marzban, C., and S. Sandgathe, Optical flow for verification, *Weather Forecast.*, 25, 1479–1494, doi:10.1175/2010WAF2222351.1, 2010.

Mayorga, E., S.P. Seitzinger, J.A. Harrison, E. Dumont, A.H.W. Beusen, A.F. Bouwman, B. Fekete, C. Kroeze, and G. Van Drecht, Global Nutrient Export from WaterSheds 2 (NEWS 2): Model development and implementation, *Environ. Model. Softw.*, 25, 837–853, doi:10.1016/j.envsoft.2010.01.007, 2010.

Mickett, J.B., Y.L. Serra, M.F. Cronin, and M.H. Alford, Resonant forcing of mixed layer inertial motions by atmospheric easterly waves in the northeast tropical Pacific, *J. Phys. Oceanogr.*, 40, 401–416, 2010.

Miksis-Olds, J.L., J.A. Nystuen, and S.E. Parks, Detecting marine mammals with an adaptive sub-sampling recorder in the Bering Sea, *Appl. Acoust.*, 71, 1087–1092, doi:10.1016/j.apacoust.2010.05.010, 2010.

Mondal, D., and D. Percival, Wavelet variance analysis for gappy time series, *Ann. Inst. Stat. Math.*, 62, 943–966, doi:10.1007/s10463-008-0195-z, 2010.

Mondal, D., and D.B. Percival, M-estimation of wavelet variance, *Annal. Inst. Stat. Math.*, 1–27, doi:10.1007/s10463-010-0282-9, 2010.

Moore, S.E., K.M. Stafford, and L.M. Munger, Acoustic and visual surveys for bowhead whales in the western Beaufort and far northeastern Chukchi seas, *Deep-Sea Res. II*, 57, 153–157, doi:10.1016/j.dsr2.2009.08.013, 2010.

Nystuen, J.A., S.E. Moore, and P.J. Stabeno, A sound budget for the southeastern Bering Sea: Measuring wind, rainfall, shipping, and other sources of underwater sound, *J. Acoust. Soc. Am.*, 128, 58–65, 2010.

Okopal, G., and P.J. Loughlin, Propagation-invariant classification of sounds in channels with dispersion and absorption, *J. Acoust. Soc. Am.*, 128, 2888–2897, doi:10.1121/1.3493420, 2010.

Owen, N.R., et al., In vivo evaluation of a mechanically oscillating dual-mode applicator for ultrasound imaging and thermal ablation, *IEEE Trans. Biomed. Eng.*, 57, 80–92, doi:10.1109/TBME.2009.2023994, 2010.

Panteleev, G., D.A. Nechaev, A. Proshutinsky, R. Woodgate, and J. Zhang, Reconstruction and analysis of the Chukchi Sea circulation in 1990–1991, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005453, 2010.

Park, J.-H., K.A. Donohue, D.R. Watts, and L. Rainville, Distribution of deep near-inertial waves observed in the Kuroshio Extension, *J. Oceanogr.*, 66, 709–717, doi:10.1007/s10872-010-0058-0, 2010.

Patoux, M., R.C. Foster, and R.A. Brown, A method for including mesoscale and synoptic-scale information in scatterometer wind retrievals, *J. Geophys. Res.*, 115, doi:10.1029/2009JD013193, 2010.

Peralta-Ferriz, C., and J. Morison, Understanding the annual cycle of the Arctic Ocean bottom pressure, *Geophys. Res. Lett.*, 37, doi:10.1029/2010GL042827, 2010.

Pickart, R.S., L J. Pratt, D J. Tores, T.E. Whitledge, A.Y. Proshutinsky, K. Aagaard, T.A. Agnew, G.W.K. Moore, and H.J. Dail, Evolution and dynamics of the flow through Herald Canyon in the western Chukchi Sea, *Deep-Sea Res. II*, doi:10.1016/j.dsr2.2009.08.002, 2010.

Plant, W J., W.C. Keller, K. Hayes, and G. Chatham, Normalized radar cross section of the sea for backscatter: 1. Mean levels, *J. Geophys. Res.*, 115, doi:10.1029/2009JC006078, 2010.

Plant, W J., W.C. Keller, K. Hayes, G. Chatham, and N. Lederer, Normalized radar cross section of the sea for backscatter: 2. Modulation by internal waves, *J. Geophys. Res.*, 115, doi:10.1029/2009JC006079, 2010.

Polyakov, I.V., et al., including M. Steele, Arctic Ocean warming contributes to reduced polar ice cap, *J. Phys. Oceanogr.*, 40, 2742–2756, doi:10.1175/2010JPO4339.1, 2011.

Proshutinsky, A., et al., including J. Morison, M. Steele, and R. Woodgate, The Arctic: Ocean [in *State of the Climate in 2009*], *Bull. Amer. Meteor. Soc.*, 91, S85–87, 2010.

Pyayt, A., J. Luo, A.K.-Y. Jen, L. Dalton, and A. Chen, Field-induced guiding optical devices made from electro-optic polymers, *Appl. Optics*, 49, 892–896, 2010.

Rainville, L., T.M.S. Johnston, G.S. Carter, M.A. Merrifield, R. Pinkel, P.F. Worcester, and B.D. Dushaw, Interference pattern and propagation of the M2 internal tide south of the Hawaiian Ridge, *J. Phys. Oceanogr.*, 40, 311–325, 2010.

Rawlins, M.A., et al., including M. Steele, C.M. Lee, M. Wensnahan, and R. Woodgate, Analysis of the Arctic system for freshwater cycle intensification: Observations and expectations, *J. Clim.*, 23, 5715–5737, doi:10.1175/2010JCLI3421.1, 2010.

Reynolds, R.M., D. Clark, E. Lettvin, and M. Schrader, Around the Americas expedition: Instrumenting a sailboat for science, *Sea Technol.*, 51, 45–48, 2010.

Rouseff, D., and D. Tang, Internal waves as a proposed mechanism for increasing ambient noise in an increasingly acidic ocean, *J. Acoust. Soc. Am.*, 127, EL235–EL239, 2010.

Seitzinger, S., E. Mayorga, A.F. Bouwman, C. Kroeze, A.H.W. Beusen, G. Billen, G. Van Drecht, E. Dumont, B.M. Fekete, J. Garnier, and J.A. Harrison, Global nutrient river export: A scenario analysis of past and future trends, *Glob. Biogeochem. Cy.*, 24, doi:10.1029/2009GB003587, 2010.

Shah, A., N. Owen, W. Lu, B. Cunitz, P. Kaczkowski, J. Harper, M. Bailey, and L. Crum, Novel ultrasound method to reposition kidney stones, *Urol. Res.*, 38, 491–495, doi:10.1007/s00240-010-0319-9, 2010.

Shcherbina, A.Y., M.C. Gregg, M.H. Alford, and R.R. Harcourt, Three-dimensional structure and temporal evolution of submesoscale thermohaline intrusions in the North Pacific subtropical frontal zone, *J. Phys. Oceanogr.*, 40, 1669–1689, doi:10.1175/2010JPO4373.1, 2010.

Simon, M., K.M. Stafford, K. Beedholm, C.M. Lee, and P.T. Madsen, Singing behavior of fin whales in the Davis Strait with implications for mating, migration and foraging, *J. Acoust. Soc. Am.*, 128, 3200–3210, doi:10.1121/1.3495946, 2010.

Sirevaag, A., M.G. McPhee, J.H. Morison, W.J. Shaw, and T.P. Stanton, Wintertime mixed layer measurements at Maud Rise, Weddell Sea, *J. Geophys. Res.*, 115, doi:10.1029/2008JC005141, 2010.

Smith, C.S., C.W. Branham, B J. Marquardt, and K.R. Mann, Oxygen gas sensing by luminescence quenching in crystals of Cu(xantphos)(pehn) complexes, *J. Am. Chem. Soc.*, 132, 14079–14085, 2010.

Sorensen M.D., A.R. Shah, M.S. Canney, O.A. Sapozhnikov, J.M. Teichman, and M.R. Bailey, Ureteroscopic ultrasound technology to size kidney stone fragments: Proof of principle using a miniaturized probe in a porcine model, *J. Endourol.*, 24, 939–942, 2010.

Speyer, G., P.J. Kaczkowski, A.A. Brayman, and L.A. Crum, Displacement analysis of diagnostic ultrasound backscatter: A methodology for characterizing, modeling, and monitoring high intensity focused ultrasound therapy, *J. Acoust. Soc. Am.*, 128, 104–120, 2010.

Stafford, K.M., S.E. Moore, P J. Stabeno, D.V. Holliday, J.M. Napp, D.K. Mellinger, Biophysical ocean observation in the southeastern Bering Sea, *Geophys. Res. Lett.*, 37, doi:10.1029/2009GL040724, 2010.

Steele, M., J. Zhang, and W. Ermold, Mechanisms of summertime upper Arctic Ocean warming and the effect on sea ice melt, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005849, 2010.

Szuts, Z.B., Relationship between ocean velocity and motionally induced electrical signals: 1. In the presence of horizontal velocity gradients, *J. Geophys. Res.*, 115, doi:10.1029/2009JC006053, 2010.

Szuts, Z.B., Relationship between ocean velocity and motionally induced electric signals: 2. In the presence of sloping topography, *J. Geophys. Res.*, 115, doi:10.1029/2009JC006054, 2010.

Talke, S.A., A.R. Horner-Devine, and C.C. Chickadel, Mixing layer dynamics in separated flow over an estuarine sill with variable stratification, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005467, 2010.

Thieu, V., E. Mayorga, G. Billen, and J. Garnier, Sub-regional and downscaled-global scenarios of nutrient transfer in river basins: The Seine-Scheldt-Somme case study, *Glob. Biogeochem. Cy.*, 24, doi:10.1029/2009GB003561, 2010.

Thomas, L.N., C.M. Lee, and Y. Yoshikawa, The subpolar front of the Japan/East Sea. Part II: Inverse method for determining the frontal vertical circulation, *J. Phys. Oceanogr.*, 40, 3–25, 2010.

Thomson, J., Observations of thermal diffusivity and a relation to the porosity of tidal flat sediments, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005968, 2010.

Thorsos, E.I., M.D. Richardson, and J.F. Lynch, Guest editorial: Special issue on sediment acoustic processes: Part III, *IEEE J. Ocean. Eng.*, 35, 449–452, doi:10.1109/JOE.2010.2060510, 2010.

Turgut, A., M. Orr, and D. Rouseff, Broadband source localization using horizontal-beam acoustic intensity striations, *J. Acoust. Soc. Am.*, 127, 73–83, 2010.

Vagle, S., C. McNeil, and N. Steiner, Upper ocean bubble measurements from the NE Pacific and estimates of their role in air-sea gas transfer of the weakly soluble gases nitrogen and oxygen, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005990, 2010.

Wain, D.J., and D.R. Rehmann, Transport by an intrusion generated by boundary mixing in a lake, *Water Resour. Res.*, 46, doi:10.1029/2009WR008391, 2010.

Williams, K.L., S.G. Kargl, E.I. Thorsos, D.S. Burnett, J.L. Lopes, M. Zampolli, and P.L. Marston, Acoustic scattering from a solid aluminum cylinder in contact with a sand sediment: Measurements, modeling, and interpretation, *J. Acoust. Soc. Am.*, 127, 3356–3371, doi:10.1121/1.3419926, 2010.

Woodgate, R.A., T. Weingartner, and R. Lindsay, The 2007 Bering Strait oceanic heat flux and anomalous Arctic sea-ice retreat, *Geophys. Res. Lett.*, 37, doi:10.1029/2009GL041621, 2010.

Yan, W., E. Mayorga, X. Li, S.P. Seitzinger, and A.F. Bouwman, Increasing anthropogenic nitrogen inputs and riverine DIN exports from the Changjiang River basin under changing human pressures, *Glob. Biogeochem. Cy.*, 24, doi:10.1029/2009GB002575, 2010.

Yang, J., D. Rouseff, D. Tang, and F.S. Henyey, Effect of the internal tide on acoustic transmission loss at midfrequencies, *IEEE J. Ocean. Eng.*, 35, 3–11, 2010.

Yasin, J.A., C. Kroeze, and E. Mayorga, Nutrients export by rivers to the coastal waters of Africa: Past and future trends, *Glob. Biogeochem. Cy.*, 24, doi:10.1029/2009GB003568, 2010.

You, Y., T. Sanford, and C.-T. Liu, Climate monitoring of the Indonesian throughflow, *Eos Trans. AGU*, 91, doi:10.1029/2010EO020002, 2010.

Yuldashev, P., S. Ollivier, M. Averiyanov, O. Sapozhnikov, V. Khokhlova, and P. Blanc-Benon, Nonlinear propagation of spark-generated N-waves in air: Modeling and measurements using acoustical and optical methods, *J. Acoust. Soc. Am.*, 128, 3321–3333, doi:10.1121/1.3505106, 2010.

Yuldashev, P.V., L.M. Krutyanskii, V.A. Khokhlova, A.P. Brysev, and F.V. Bunkin, Distortion of the field of a focused finite amplitude ultrasonic beam behind the random phased layer, *Acoust. Phys.*, 56, 467–474, doi:10.1134/S106377101004010X, 2010.

Yuldashev, P.V., N.A. Bryseva, M.V. Averiyanov, Ph. Blanc-Benon, and V.A. Khokhlova, Statistical properties of nonlinear diffracting N-wave behind a random phase screen, *Acoust. Phys.*, 56, 158–167, doi:10.1134/S1063771010020065, 2010.

Zhang, J., M. Steele, and A. Schweiger, Arctic sea ice response to atmospheric forcings with varying levels of anthropogenic warming and climate variability, *Geophys. Res. Lett.*, 37, doi:10.1029/2010GL044988, 2010.

Zhang, J., R. Woodgate, and R. Moritz, Sea ice response to atmospheric and oceanic forcing in the Bering Sea, *J. Phys. Oceanogr.*, 40, 1729–1747, doi:10.1175/2010JPO4323.1, 2010.

Zhang, J., Y.H. Spitz, M. Steele, C. Ashjian, R. Campbell, L. Berline, and P. Matrai, Modeling the impact of declining sea ice on the Arctic marine planktonic ecosystem, *J. Geophys. Res.*, 115, doi:10.1029/2009JC005387, 2010.

Zhao, Z., M.H. Alford, J.A. MacKinnon, and R. Pinkel, Long-range propagation of the semidiurnal internal tide from the Hawaiian Ridge, *J. Phys. Oceanogr.*, 40, 713–736, 2010.

Articles in Proceedings and Selected Abstracts, 2010

Andrew, R.K., and J.A. Mercer, A doubly resonant source and associated signals in the 2009/2010–2011 Philippine Sea experiment, *J. Acoust. Soc. Am.*, 128, 2385, 2010.

Andrew, R.K., B.M. Howe, and J.A. Mercer, Long-time trends in low-frequency traffic noise for four sites off the North American west coast, *J. Acoust. Soc. Am.*, 127, 1783, 2010.

Arabshahi, P., B.M. Howe, Y. Chao, S. Businger, and S. Chien, A virtual ocean observatory for climate and ocean science: Synergistic applications from SWOT and XOVWMM, *2010 Fall Meeting, AGU, San Francisco, CA, 13–17 December*, abstract IN41D-07.

Arabshahi, P., B.M. Howe, Y. Chao, S. Roy, T. McGinnis, and A. Gray, A smart sensor web for ocean observation: System design, modeling, and optimization, in *Proc., NASA Earth Science Technology Forum, 22–24 June, Arlington, VA*, 17 pp. (2010).

Arbab, M.H., D.P. Winebrenner, and E.I. Thorsos, Application of wavelet transforms in terahertz spectroscopy of rough surface targets, in *Proc., SPIE - Terahertz Technology and Applications III, San Francisco, 27 January*, L.P. Sadwick and C.M.M. O'Sullivan, eds., paper no. 760106 (SPIE, 2010).

Bassett, C., J. Thomson, and B. Polagye, Characterizing underwater noise at a tidal energy site, in *Proc., MTS/IEEE Oceans 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664387 (MTS/IEEE, 2010).

Blanc-Benon, P., M.V. Averiyanov, S. Ollivier, and V.A. Khokhlova, Random focusing of nonlinear N-waves in fully developed turbulence: Laboratory scale experiment and theoretical analysis, *J. Acoust. Soc. Am.*, 127, 1883, 2010.

Bobkova, S., A. Shaw, L. Gavrilov, V. Khokhlova, and J. Hand, Feasibility of HIFU tissue ablation in the presence of ribs using a 2D random phased array, in *Proc., Ninth International Symposium on Therapeutic Ultrasound, Aix-en-Provence, 24–26 September 2009*, K. Hynynen and J. Souquet, eds., 27–30 (AIP, 2010).

Bourassa, M., et al., including K.A. Kelly, Remotely sensed winds and wind stresses for marine forecasting and ocean modeling, in *Proc., OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21–25 September 2009*, J. Hall, et al., eds. (ESA Publication WPP-306, 2010).

Canney, M.S., T.D. Khokhlova, V.A. Khokhlova, M.R. Bailey, J.H. Hwang, and L.A. Crum, Tissue erosion using shock wave heating and millisecond boiling in HIFU fields, in *Proc., Ninth International Symposium on Therapeutic Ultrasound, Aix-en-Provence, 24–26 September 2009*, K. Hynynen and J. Souquet, eds., 36–39 (AIP, 2010).

Canney, M.S., T.D. Khokhlova, Y.N. Wang, V.A. Khokhlova, M.R. Bailey, and L.A. Crum, Tissue erosion using millisecond boiling in high-intensity focused ultrasound fields, *J. Acoust. Soc. Am.*, 127, 1760, 2010.

Cazzanti, L., D. Egnor, G.S. Edelson, and A. Das, Improved multipath robustness of DFH modulation in the underwater acoustic channel, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664088 (MTS/IEEE, 2010).

Chandrayadula, T.K., J.A. Colosi, P.F. Worcester, M.A. Dzieciuch, J.A. Mercer, B.M. Howe, and R.K. Andrew, Statistics of acoustic normal mode energy for low frequency long range propagation in the ocean: Comparisons between observations and theory, *J. Acoust. Soc. Am.*, 128, 2395, 2010.

Cronin, M.F., et al., including K.A. Kelly, Monitoring ocean-atmosphere interactions in western boundary current extensions, in *Proc., OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21–25 September 2009*, J. Hall, et al., eds. (ESA Publication WPP-306, 2010).

Crum, L., M. Bailey, J.H. Wang, V. Khokhlova, and O. Sapozhnikov, Therapeutic ultrasound: Recent trends and future perspectives, in *Physics Procedia, vol. 3-International Congress on Ultrasonics, Santiago Chile, January 2009*, Luis Gaete Garreton, ed., 25–35 (Elsevier, 2010).

Dahl, P.H., and J.W. Choi, Observations of 0th order head waves in the Yellow Sea, in *Proc., Second International Shallow-Water Acoustics Conference (SWAC'09), Shanghai, 16–20 September 2009*, 133–139 (AIP, 2010).

Dall'Osto, D.R., and P.H. Dahl, Implications of signal intensity fluctuations on vector sensor array processing, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5663783 (MTS/IEEE, 2010).

Delarue, J., D.K. Mellinger, K.M. Stafford, and C.L. Berchok, Where do the Chukchi Sea fin whales come from? Looking for answers in the structure of songs recorded in the Bering Sea and Western North Pacific, *J. Acoust. Soc. Am.*, 127, 1758, 2010.

Epler, J., B. Polagye, and J. Thomson, Shipboard acoustic Doppler current profiler surveys to assess tidal current resources, in *Proc.,* *MTS/IEEE Oceans 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664387 (MTS/IEEE, 2010).

España, A.L., K.L. Williams, S.G. Kargl, M. Zampolli, T.M. Marston, and P.L. Marston, Measurements and modeling of the acoustic scattering from an aluminum pipe in the free field and in contact with a sand sediment, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664603 (MTS/IEEE, 2010).

Farquharson, G., S J. Frasier, B. Raubenheimer, and S. Elgar, Surf zone surface displacement measurements using interferometric microwave radar, in *Proc., Int. Geosci. Remote Sens. Symp. (IGARSS), Honolulu, 25–30 July*, 2428–2431, doi:10.1109/IGARSS.2010.5650521 (IEEE, 2010).

Ganse, A.A., and J.A. Mercer, Towed CTD (conductivity, temperature, and depth) chain measurements in the 2010 Philippine Sea experiment, *J. Acoust. Soc. Am.*, 128, 2386, 2010.

Ganse, A.A., R.I. Odom, Variation of uncertainty and resolution with problem formulation in continuous geoacoustic inversion, *J. Acoust. Soc. Am.*, 127, 1937, 2010.

Hanusa, E., D.W. Krout, and M. Gupta, Estimation of position from multistatic Doppler measurements, in *Proc., 13th Conference on Information Fusion, Edinburgh, 26–29 July* (IEEE, 2010).

Hanusa, E., W.H. Mortensen, D.W. Krout, and J. McLaughlin, Improving target tracking performance by incorporating classification information, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664500 (MTS/IEEE, 2010).

Henry, S.C., S. Schecklman, G.P. Kniffin, L.M. Zurk, and A. Chen, Measurement and modeling of rough surface effects on terahertz spectroscopy, in *Proc., SPIE - Terahertz Technology and Applications III, San Francisco, 27 January*, L.P. Sadwick and C.M.M. O'Sullivan, eds., paper no. 760108 (SPIE, 2010).

Kargl, S.G., K.L. Williams, T.M. Marston, J.L. Kennedy, and J.L. Lopes, Acoustic response of unexploded ordnance (UXO) and cylindrical targets, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664392 (MTS/IEEE, 2010).

Khokhlova, V.A., M.S. Canney, M.R. Bailey, and L.A. Crum, Ultra fast thermal effect of high intensity focused ultrasound (HIFU) and localized boiling in tissue due to exposure of shock waves, in *Physics Procedia, vol. 3-International Congress on Ultrasonics, Santiago, Chile, January 2009*, Luis Gaete Garreton, ed. (Elsevier, 2010).

Khokhlova, V.A., O.V. Bessonova, J.E. Soneson, M.S. Canney, M.R. Bailey, and L.A. Crum, Bandwidth limitations in characterizing of high intensity focused ultrasound fields in the presence of shocks, in *Proc., Ninth International Symposium on Therapeutic Ultrasound, Aix-en-Provence, 24–26 September 2009*, K. Hynynen and J. Souquet, eds., 363–366 (AIP, 2010).

Khokhlova, V.A., O.V. Bessonova, M.V. Averiyanov, J.E. Soneson, and R.O. Cleveland, Modeling of nonlinear shock wave propagation and thermal effects in high-intensity focused ultrasound fields, *J. Acoust. Soc. Am.*, 127, 1827, 2010.

Kreider, W., M.R. Bailey, O.A Sapozhnikov, and L.A. Crum, Potential temperature limitations of bubble-enhanced heating during HIFU, in *Proc., Ninth International Symposium on Therapeutic Ultrasound, Aix-en-Provence, 24–26 September 2009*, K. Hynynen and J. Souquet, eds., 367–370 (AIP, 2010).

Krout, D.W., and E. Hanusa, Likelihood surface preprocessing with the JPDA algorithm: Metron data set, in *Proc., 13th Conference on Information Fusion, Edinburgh, 26–29 July* (IEEE, 2010).

Kwok, R., et al., including J. Morison, C. Peralta-Ferriz, and M. Steele, Combining satellite altimetry, time-variable gravity, and bottom pressure observations to understand the Arctic Ocean: A transformative opportunity, in *Proc., OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21–25 September 2009*, J. Hall, et al., eds. (ESA Publication WPP-306, 2010).

Li, Z., L.M. Zurk, and B. Ma, Vertical arrival structure of shipping noise in deep water channels, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664539 (MTS/IEEE, 2010).

Livingston, E., and J. Simmen, Fifteen years of U.S.–China cooperative research in underwater acoustics: 1995–2010, in *Proc., Second International Shallow-Water Acoustics Conference (SWAC'09), Shanghai, 16–20 September 2009*, 1–10 (AIP, 2010).

Lynch, S.D., G.L. D'Spain, K. Heaney, A.B. Baggeroer, P. Worcester, and J. Mercer, Dependence of the structure of the shallow convergence zone on deep ocean bathymetry, *J. Acoust. Soc. Am.*, 127, 1962, 2010.

MacKinnon, J., et al., including M. Alford, J. Girton, M. Gregg, E. Kunze, and T. Sanford, Using global arrays to investigate internal-waves and mixing, in *Proc., OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 2), Venice, Italy, 21–25 September 2009*, J. Hall, et al., eds. (ESA Publication WPP-306, 2010).

Marston, T.M., P.L. Marston, and K.L. Williams, Scattering resonances, filtering with reversible SAS processing, and applications of quantitative ray theory, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664606 (MTS/IEEE, 2010).

Mayorga, E., T. Tanner, R. Blair, A.V. Jaramillo, N. Lederer, C.M. Risien, and C. Seaton, The NANOOS Visualization System (NVS): Lessons learned in data aggregation, management and reuse, for a user application, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5663792 (MTS/IEEE, 2010).

Mercer, J., R. Andrew, A. Ganse, A. White, and G. D'Spain, The University of Washington's Applied Physics Laboratory's participation in the Philippine Sea 2009 and Philippine Sea 2010 experiments: A summary, *J. Acoust. Soc. Am.*, 128, 2385, 2010.

Moore, S.E., K.M. Stafford, C.L. Berchok, H. Melling, and O. Wiig, Including passive acoustic capability in Arctic ocean observing systems, *J. Acoust. Soc. Am.*, 127, 1756, 2010

Owsley, L., and J. McLaughlin, Modeling acoustic target response by component, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664273 (MTS/IEEE, 2010).

Plant, W.J., Dual-polarized, coherent microwave backscatter from rough water surfaces at low grazing angles, in *Proc., Int. Geosci. Remote Sens. Symp. (IGARSS), Honolulu, 25–30 July*, 4729–4732, doi:10.1109/IGARSS.2010.5652954 (IEEE, 2010).

Plant, W.J., W.C. Keller, K. Hayes, and G. Chatham, Characteristics of internal waves in the South China Sea observed by a shipboard coherent radar, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664440 (MTS/IEEE, 2010).

Polagye, B., J. Epler, and J. Thomson, Limits to the predictability of tidal current power, in *Proc., MTS/IEEE Oceans 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664588 (MTS/IEEE, 2010).

Reinhall, P.G., and P.H. Dahl, Acoustic radiation from a submerged pile during pile driving, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5663872 (MTS/IEEE, 2010).

Sadowski, P., L. Cazzanti, and M.R. Gupta, Bayesian and pairwise local similarity discriminant analysis, in *Proc., Second Int. Workshop on Cognitive Inf. Process., Elba, Italy, 14–16 June*, 287–292, doi:10.1109/CIP.2010.5604118 (IEEE, 2010).

Salin, B.M., M.B. Salin, and R.C. Spindel, Investigation of the influence of wind waves on the spectral and angular characteristics of sea surface reverberation from a CW source, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664527 (MTS/IEEE, 2010).

Speyer, G., P. Kaczkowski, A. Brayman, and L. Crum, Backscatter monitoring of high intensity focused ultrasound therapy using a parametric treatment model, in *Proc., Ninth International Symposium on Therapeutic Ultrasound, Aix-en-Provence, 24–26 September 2009*, K. Hynynen and J. Souquet, eds., 62–65 (AIP, 2010).

Stephen, R.A., S.T. Bolmer, M.A. Dzieciuch, P.F. Worcester, R.K. Andrew, J.A. Mercer, J.A. Colosi, and B.M. Howe, Bathymetric scattering and seafloor interface waves in long-range ocean acoustic propagation, *J. Acoust. Soc. Am.*, 128, 2396, 2010.

Stockham, M.L., P.H. Dahl, and P.G. Reinhall, Characterizing underwater noise from industrial pile driving at close range, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5663899 (MTS/IEEE, 2010).

Tang, D., Mid-frequency acoustics in SW'06, in *Proc., Second International Shallow-Water Acoustics Conference (SWAC'09), Shanghai, 16–20 September 2009*, 28–34 (AIP, 2010).

Thomson, J., M. Richmond, B. Polagye, and V. Durgesh, Quantifying turbulence for tidal power applications, in *Proc., MTS/IEEE OCEANS 2010, Seattle, 20–23 September*, doi:10.1109/OCEANS.2010.5664600 (MTS/IEEE, 2010).

Thorsos, E.I., F.S. Henyey, W.T. Elam, B.T. Hefner, S.A. Reynolds, and J. Yang, Transport theory for shallow water propagation with rough boundaries, in *Proc., Second International Shallow-Water Acoustics Conference (SWAC'09), Shanghai, 16–20 September 2009*, 99–105 (AIP, 2010).

Toporkov, J.V., P.A. Hwang, M.A. Sletten, S.J. Frasier, G. Farquharson, D. Perkovic, Observation of a boat and its wake with a dual-beam along-track interferometric SAR, in *Proc., Int. Geosci. Remote Sens. Symp. (IGARSS), Honolulu, 25–30 July*, 1940–1943, doi:10.1109/IGARSS.2010.5649709 (IEEE, 2010).

Worcester, P.F., R.K. Andrew, A.B. Baggeroer, J.A. Colosi, G. D'Spain, M.A. Dzieciuch, K.D. Heaney, B.M. Howe, J.N. Kemp, and J.A. Mercer, Acoustic propagation and ambient noise in the Philippine Sea: The 2009 and 2010–2011 Philippine Sea experiments, *J. Acoust. Soc. Am.*, 128, 2385, 2010.

Yang, J., J.X. Zhou, and P.H. Rogers, Data–model comparisons for sea surface waves from the ASIAEX East China Sea Experiment, in *Proc., Second International Shallow-Water Acoustics Conference (SWAC'09), Shanghai, 16–20 September 2009*, 149–162 (AIP, 2010).

Yu, J., P. Kaczkowski, L. Crum, and S. Mitchell, Detection of blunt force trauma liver injuries using shear wave elastography, *J. Acoust. Soc. Am.*, 128, 2362, 2010

Yuldashev, P., M. Averiyanov, V. Khokhlova, O. Sapozhnikov, S. Ollivier, and P. Blanc-Benon, Measurement of shock N-waves using optical methods, in *Proc., 10ème Congrès Français d'Acoustique, Lyon, 12–16 April*, 6 pp. (Société Française d'Acoustique, 2010).

Technical Reports and Memoranda, issued in 2009

Andrew, R.K., *The APL-UW Multiport Acoustic Projector System*, APL-UW TR 0902, December 2009.

Elam, W.T., G. Seidler, T. Fister, K. Nagel, and L. Buck, *Predicting the Utility of Non-Resonant Inelastic X-ray Scattering (NRIXS) for Standoff Explosives Detection*, APL-UW TR 0903, November 2009.

Shulenberger, E., and J. Olsonbaker, *Solving the Shortage of STEM Personnel in Navy Laboratories: Strategic Plan for Navy Investments in STEM Education Targeted at the Navy After Next*, APL-UW TR 0901, June 2009.

Articles in Journals, Books, and Book Chapters, 2009

Anand, A., and P.J. Kaczkowski, Noninvasive determination of in situ heating rate using kHz acoustic emission and focused ultrasound, *Ultrasound Med. Biol.*, 35, 1662–1671, 2009.

Asher, W.E., The effects of experimental uncertainty in parameterizing air–sea gas exchange using tracer experiment data, *Atmos. Chem. Phys.*, 9, 131–139, 2009.

Asher, W.E., and T.M. Litchendorf, Visualizing near-surface concentration fluctuations using laser-induced fluorescence, *Exp. Fluids*, 46, 243–253, 2009.

Asher, W.E., W. Luo, K.W. Campo, D.A. Bender, K.W. Robinson, J.S. Zogorski, and T.E. Pankow, Application of a source apportionment model in consideration of volatile organic compounds in an urban stream, *Environ. Toxicol. Chem.*, 26, 1606–1613, doi:10.1897/06-557R.1, 2007.

Banas N.S., P.S. MacDonald, and D.A. Armstrong, Green crab larval retention in Willapa Bay, Washington: An intensive Lagrangian modeling approach, *Estuar. Coast.*, 32, 893–905, doi:10.1007/s12237-009-9175-7, 2009.

Banas, N.S., E J. Lessard, R.M. Kudela, P. MacCready, T.D. Peterson, B.M. Hickey, and E. Frame, Planktonic growth and grazing in the Columbia River plume region: A biophysical model study, *J. Geophys. Res.*, 114, doi:10.1029/2008JC004993, 2009.

Banas, N.S., P. MacCready, and B.M. Hickey, The Columbia River plume as along-shelf barrier and cross-shelf exporter: A Langrangian model study, *Cont. Shelf Res.*, 29, 292–301, doi:10.1016/j.csr.2008.03.011, 2009.

Bell, B.M., J.V. Burke, G. Pillonetto, An inequality constrained nonlinear Kalman–Bucy smoother by interior point likelihood maximization, *Automatica*, 45, 25–33, doi:10.1016/j.automatica.2008.05.029, 2009.

Bessonova, O.V., and V.A. Khokhlova, Spatial structure of high intensity focused ultrasound beams of various geometry, *Phys. Wave Phenom.*, 17, 45–49, 2009.

Bessonova, O.V., V.A. Khokhlova, M.R. Bailey, M.S. Canney, and L.A. Crum, Focusing of high intensity ultrasound beams and ultimate values of shock wave parameters, *Acoust. Phys.*, 55, 463–473, 2009.

Bobkova, S.M., S.A. Tsysar, V.A. Khokhlova, and V.G. Andreev, Diffraction effects accompanying focused ultrasonic pulse propagation in a medium with a thermal inhomogeneity, *Acoust. Phys.*, 55, 474–481, 2009.

Chen, Y., E.K. Garcia, M.R. Gupta, A. Rahimi, and L. Cazzanti, Similarity-based classification: Concepts and algorithms, *J. Machine Learn. Res.*, 10, 747–776, 2009.

Chickadel, C.C., A.R. Horner-Devine, S.A. Talke, and A.T. Jessup, Vertical boil propagation from a submerged estuarine sill, *Geophys. Res. Lett.*, 36, doi:10.1029/2009GL037278, 2009.

Cole, S.T., D.L. Rudnick, B.A. Hodges, and J.P. Martin, Observations of tidal internal wave beams at Kauai Channel, Hawaii, *J. Phys. Oceanogr.*, 39, 421–436, 2009.

Colosi, J.A., J. Xu, P.F. Worcester, M.A. Dzieciuch, B.M. Howe, and J.A. Mercer, Temporal and vertical scales of acoustic fluctuations for 75-Hz, broadband transmissions to 87-km range in the eastern North Pacific Ocean, *J. Acoust. Soc. Am.*, 126, 1069–1083, 2009.

Darby, D.A., J. Ortiz, L. Polyak, S. Lund, M. Jakobsson, and R.A. Woodgate, The role of currents and sea ice in both slowly deposited central Arctic and rapidly deposited Chukchi–Alaskan margin sediments, *Global Planet. Change*, 68, 56–70, doi:10.1016/j.gloplacha.2009.02.007, 2009.

Das, A., and M. Mesbahi, Distributed linear parameter estimation over wireless sensor networks, *IEEE Trans. Aerosp. Electron. Syst.*, 45, 1293–1306, 2009.

Dittrich, D., Malware to crimeware: How far have they gone, and how do we catch up? *;login: The USENIX Magazine*, 34, 35–44, 2009.

Dmitrenko, I.A., et al., including R.A. Woodgate, Seasonal modification of the Arctic Ocean intermediate water layer off the eastern Laptev Sea continental shelf break, *J. Geophys. Res.*, 114, doi:10.1029/2008JC005229, 2009.

Donelan, M.A., and W J. Plant, A threshold for wind-wave growth, *J. Geophys. Res.*, 114, doi:10.1029/2008JC005238, 2009.

Dushaw, B.D., P.F. Worcester, W.H. Munk, R.C. Spindel, J.A. Mercer, B.M. Howe, K. Metzger Jr., T.G. Birdsall, R.K. Andrew, M.A. Dzieciuch, B.D. Cornuelle, and D. Menemenlis, A decade of acoustic thermometry in the North Pacific Ocean, *J. Geophys. Res.*, 114, doi:10.1029/2008JC005124, 2009.

Egnor, D., G.S. Edelson, L. Cazzanti, and J. Hsieh, Differential frequency hopping (DFH) modulation for underwater acoustic communications and networking, *U.S. Navy J. Underwater Acoust.*, 59, 301–314, 2009.

Fairall, C.W., M.L. Banner, W.L. Peirson, W. Asher, and R.P. Morison, Investigation of the physical scaling of sea spray spume droplet production, *J. Geophys. Res.*, 114, doi:10.1029/2008JC004918, 2009.

Foster, R.C., Boundary-layer similarity under an axisymmetric, gradient wind vortex, *Boundary-Layer Meteorol.*, 131, 321–344, 2009.

Francis, J.A., D.M. White, J.J. Cassano, W J. Gutowski, L.D. Hinzman, M.M. Holland, M.A. Steele, and C J. Vorosmarty, An arctic hydrologic system in transition: Feedbacks and impacts on terrestrial, marine, and human life, *J. Geophys. Res.*, 114, doi:10.1029/2008JG000902, 2009.

Gerig, A.L., A.P. Lyons, E. Pouliquen, and K.L. Williams, Comparison of seafloor roughness and scattered acoustic temporal decorrelation, *IEEE J. Ocean. Eng.*, 34, 423–430, 2009.

Gregg, M.C., and J.K. Horne, Turbulence, acoustic backscatter and pelagic nekton in Monterey Bay, *J. Phys. Oceanogr.*, 38, 1097–1114, 10.1175/2008JPO4033.1, 2009.

Grigorieva, N.S., G.M. Fridman, J.A. Mercer, R.K. Andrew, M.A. Wolfson, B.M. Howe, and J.A. Colosi, The interference component of the acoustic field corresponding to the Long-Range Ocean Acoustic Propagation Experiment, *J. Acoust. Soc. Am.*, 125, 1919–1929, 2009.

Gurarie, E., R. Andrews, and K.L. Laidre, A novel method for identifying behavioral changes in animal movement data, *Ecol. Lett.*, 12, 395–408, 2009.

Handa, R.K., M.R. Bailey, M. Paun, S. Gao, B.A. Connors, L.R. Willis, and A.P. Evan, Pretreatment with low-energy shock waves induces renal vasoconstriction during standard SWL: A treatment protocol known to reduce lithotripsy-induced renal injury, *Brit. J. Urol. Int.*, 103, 1270–1274, doi:10.1111/j.1464-410X.2008.08277.x, 2009.

Harrison, J., R. Maranger, R. Alexander, A. Giblin, P.A. Jacinthe, E. Mayorga, S. Seitzinger, D. Sobota, and W. Wollheim, The regional and global significance of nitrogen removal in lakes and reservoirs, *Biogeochemistry*, 93, 143–157, 2009.

Hefner, B.T., D.R. Jackson, K.L. Williams, and E.I. Thorsos, Mid- to high-frequency acoustic penetration and propagation measurements in a sandy sediment, *IEEE J. Ocean. Eng.*, 34, 372–387, 2009.

Huang, P., T.B. Sanford, and J. Imberger, Heat and turbulence kinetic energy for surface layer cooling induced by the passage of Hurricane Frances (2004), *J. Geophys. Res.*, 114, doi:10.1029/2009JC005603, 2009.

Hwang, J.H., Y.-N. Wang, C. Warren, M.P. Upton, F. Starr, Y. Zhou, and S.B. Mitchell, Preclinical in vivo evaluation of an extracorporeal HIFU device for ablation of pancreatic tumors, *Ultrasound Med. Biol.*, 35, 967–975, 2009.

Inoue, R., and W.D. Smyth, Efficiency of mixing forced by unsteady shear flow, *J. Phys. Oceanogr.*, 39, 1150–1166, 2009.

Jach, T., J.N. Ullom, and W.T. Elam, The microcalorimeter X-ray detector: A true paradigm shift in X-ray spectroscopy, *Eur. Phys. J. Special Topics*, 169, 237–242, 2009.

Jackson, D.R., M.D. Richardson, K.L. Williams, A.P. Lyons, C.D. Jones, K.B. Briggs, and D. Tang, Acoustic observation of the time dependence of the roughness of sandy seafloors, *IEEE J. Ocean. Eng.*, 34, 407–422, 2009.

Jayne, S.R. et al., including L. Rainville, The Kuroshio Extension and its recirculation gyre, *Deep-Sea Res. I*, 56, 2088–2099, doi:10.1016/j.dsr.2009.08.006, 2009.

Jessup, A.T., W.E. Asher, M. Atmane, K. Phadnis, C.J. Zappa, and M.R. Loewen, Evidence for complete and partial surface renewal at an air–water interface, *Geophys. Res. Lett.*, 36, doi:10.1029/2009GL038986, 2009.

Jiang, C., L. Thompson, K.A. Kelly, and M.F. Cronin, The roles of intraseasonal Kelvin waves and tropical instability waves in SST variability along the equatorial Pacific in an isopycnal ocean model, *J. Clim.*, 22, 3470–3487, 2009.

Johnson, J.T., R.J. Burkholder, J.V. Toporkov, D.R. Lyzenga, and W.J. Plant, A numerical study of the retrieval of sea surface height profiles from low grazing angle radar data, *IEEE Trans. Geosci. Remote Sens.*, 47, 1641–1650, 2009.

Joughin, I., S. Tulaczyk, J.L. Bamber, D. Blankenship, J.W. Holt, T. Scambos, and D.G. Vaughan, Basal conditions for Pine Island and Thwaites glaciers, West Antarctica, determined using satellite and airborne data, *J. Glaciol.*, 55, 245–257, 2009.

Kadko, D., and K. Aagaard, Glimpses of Arctic Ocean shelf–basin interaction from submarine-borne radium sampling, *Deep Sea Res. I*, 56, 32–40, doi:10.1016/j.dsr.2008.08.002, 2009.

Khokhlova, T.D., M.S. Canney, D. Lee, K.I. Marro, L.A. Crum, V.A. Khokhlova, and M.R. Bailey, Magnetic resonance imaging of boiling induced by high intensity focused ultrasound, *J. Acoust. Soc. Am.*, 125, 2420–2431, 2009.

Kim, A.Y., C. Marzban, D.B. Percival, and W. Stuetzle, Using labeled data to evaluate change detectors in a multivariate streaming environment, *Signal Process.*, 89, 2529–2536, doi:10.1016/j.sigpro.2009.04.011, 2009.

Koutnik, M.R., E.D. Waddington, and D.P. Winebrenner, A method to infer past surface mass balance and topography from internal layers in martian polar layered deposits, *Icarus*, 204, 458–470, doi:10.1016/j.icarus.2009.06.019, 2009.

Krawczynski, M J., M.D. Behn, S.B. Das, and I. Joughin, Constraints on the lake volume required for hydro-fracture through ice sheets, *Geophys. Res. Lett.*, 36, 10.1029/2008GL036765, 2009.

Kreider, W., M.R. Bailey, and J.A. Ketterling, Beamwidth measurement of individual lithotripter shock waves, *J. Acoust. Soc. Am.*, 125, 1240–1245, 2009.

Krout, D.W., W.L.J. Fox, and M.A. El-Sharkawi, Probability of target presence for multistatic sonar ping sequencing, *IEEE J. Ocean. Eng.*, 34, 603–609, 2009.

Kucewicz, J.C., M.R. Bailey, P J. Kaczkowski, and S.J. Carter, Focused ultrasound: Concept for automated transcutaneous control of hemorrhage in austere settings, *Aviat. Space Environ. Med.*, 80, 391–394, 2009.

Kwok, R., and D.A. Rothrock, Decline in Arctic sea ice thickness from submarine and ICESat records: 1958–2008, *Geophys. Res. Lett.*, 36, doi:10.1029/2009GL039035, 2009.

Kwok, R., G.F. Cunningham, M. Wensnahan, I. Rigor, H.J. Zwally, and D. Yi, Thinning and volume loss of the Arctic Ocean sea ice cover: 2003–2008, *J. Geophys. Res.*, 114, doi:10.1029/2009JC005312, 2009.

Laidre, K.L., P. Heagerty, M.P. Heide-Jørgensen, L. Witting, and M. Simon, Sexual segregation of common minke whales (*Balaenoptera acutorostrata*) and sex ratio of catches in Greenland, *ICES J. Mar. Sci*, 66, 2253–2266, doi:10.1093/icesjms/fsp191, 2009.

Laidre, K.L., R.J. Jameson, E. Gurarie, S J. Jeffries, and H. Allen, Spatial habitat use patterns of sea otters in coastal Washington, *J. Mammal.*, 90, 906–917, 2009.

Lee, I.-H., R.-C. Lien, J.T. Liu, and W.-S. Chuang, Turbulent mixing and internal tides in Gaoping (Kaoping) Submarine Canyon, Taiwan, *J. Mar. Syst.*, 76, 383–396, doi:10.1016/j.jmarsys.2007.08.005, 2009.

Lien, R.-C., and T.B. Sanford, Vorticity and turbulence in the wake of a bridge pier, *IEEE J. Ocean. Eng.*, 34, 307–314, doi:10.1109/JOE.2009.2019383, 2009.

Light, B., R.E. Brandt, and S.G. Warren, Hydrohalite in cold sea ice: Laboratory observations of single crystals, surface accumulations, and migration rates under a temperature gradient, with application to 'Snowball Earth,' *J. Geophys. Res.*, 114, doi:10.1029/2008JC005211, 2009.

Lindsay, R.W., J. Zhang, A. Schweiger, M. Steele, and H. Stern, Arctic sea ice retreat in 2007 follows thinning trend, *J. Climate*, 22, 165–176, 2009.

Liu, K.-K., S. Seitzinger, E. Mayorga, J. Harrison, and V. Ittekkot, Fluxes of nutrients and selected organic pollutants carried by rivers, in *Watersheds, Bays, and Bounded Seas: The Science and Management of Semi-Enclosed Marine Systems*, E.R. Urban, Jr., et al., eds., 141–167 (Washington, D.C., Island Press, 2009).

Liu, Y., P. MacCready, B.M. Hickey, E.P. Drever, P.M. Kosro, and N.S. Banas, Evaluation of a coastal ocean circulation model for the Columbia River plume in summer 2004, *J. Geophys. Res.*, 114, doi:10.1029/2008JGC004929, 2009.

MacCready, P., N.S. Banas, B.M. Hickey, and E. Dever, A model study of tide- and wind-induced mixing in the Columbia River estuary and plume, *Cont. Shelf Res.*, 29, 278–291, doi:10.1016/j.csr.2008.03.015, 2009.

Macdonald, A.M., S. Mecking, P.E. Robbins, J.M. Toole, G.C. Johnson, L. Talley, M. Cook, and S.E. Wijffels, The WOCE-era 3-D Pacific Ocean circulation and heat budget, *Prog. Oceanogr.*, 281–325, doi:10.1016/j.pocean.2009.08.002, 2009.

MacGregor, J.A., K. Matsuoka, M.R. Koutnik, E.D. Waddington, M. Studinger, and D.P. Winebrenner, Millennially averaged accumulation rates for the Vostok Subglacial Lake region inferred from deep internal layers, *Ann. Glaciol.*, 50, 25–34, 2009.

Marshall, J., et al. including M.C. Gregg and K.A. Kelly, The CLIMODE field campaign: Observing the cycle of convection and restratification over the Gulf Stream, *Bull. Am. Met. Soc.*, 90, 1337–1350, 2009.

Martin, J.P., C.M. Lee, C.C. Eriksen, C. Ladd, and N.B. Kachel, Glider observations of kinematics in a Gulf of Alaska eddy, *J. Geophys. Res.*, 114, doi:10.1029/2008JC005231, 2009.

Marzban, C., and S. Sandgathe, Verification with variograms, *Weather Forecast.*, 24, 1102–1120, doi:10.1175/2009WAF2222122.1, 2009.

Marzban, C., S. Sandgathe, H. Lyons, and N. Lederer, Three spatial verification techniques: Cluster analysis, variogram, and optical flow, *Weather Forecast.*, 24, 1457–1471, 2009.

Mass, C.F., S. Joslyn, J. Pyle, P. Tewson, T. Gneiting, A. Raftery, J. Baars, J.M. Sloughter, D. Jones, and C. Fraley, PROBCAST: A web-based portal to mesoscale probabilistic forecasts, *Bull. Am. Meteorol. Soc.*, 90, 1009–1014, 2009.

McGinnis, T., Seafloor drilling, in *Drilling in Extreme Environments*, Y. Bar-Cohen and K. Zacny, eds., 309–345 (Whiley-VCH, Weinheim, 2009).

McPhee, M.G., A. Proshutinsky, J.H. Morison, M. Steele, and M.B. Alkire, Rapid change in freshwater content of the Arctic Ocean, *Geophys. Res. Lett.*, 36, doi:10.1029/2009GL037525, 2009.

Mercer, J.A., J.A. Colosi, B.M. Howe, M.A. Dzieciuch, R. Stephen, and P.F. Worcester, LOAPEX: The long-range ocean acoustic propagation experiment, *IEEE J. Ocean. Eng.*, 34, 1–11, 2009.

Moum, J.N., R.-C. Lien, A. Perlin, J.D. Nash, M.C. Gregg, and P.J. Wiles, Sea surface cooling at the equator by subsurface mixing in tropical instability waves, *Nature Geosci.*, 2, 761–765, 2009.

Perovich, D.K., T.C. Grenfell, B. Light, et al., Transpolar observations of the morphological properties of Arctic sea ice, *J. Geophys. Res.*, 114, 10.1029/2008JC004892, 2009.

Piper, J.E., R. Lim, E.I. Thorsos, and K.L. Williams, Buried sphere detection using a synthetic aperture sonar, *IEEE J. Ocean. Eng.*, 34, 485–494, 2009.

Plant, W.J., The ocean wave height variance spectrum: Wavenumber peak versus frequency peak, *J. Phys. Oceanogr.*, 39, 2382–2383, 2009.

Plant, W.J., R. Branch, G. Chatham, C.C. Chickadel, K. Hayes, B. Hayworth, A. Horner-Devine, A. Jessup, D.A. Fong, O.B. Fringer, S.N. Giddings, S. Monismith, and B. Wang, Remotely sensed river surface features compared with modeling and in situ measurements, *J. Geophys. Res.*, 114, doi:10.1029/2009JC005440, 2009.

Proshutinsky, A., R. Krishfield, M. Steele, et al., The Arctic: Oceans [in *State of the Climate in 2008*], *Bull. Amer. Meteor. Soc.*, 90, S99–102, 2009.

Rainville, L., and R.A. Woodgate, Observations of internal wave generation in the seasonally ice-free Arctic, *Geophys. Res. Lett.*, 36, 10.1029/2009GL041291, 2009.

Rawlins, M.A., M. Steele, M.C. Serreze, C J. Vorosmarty, W. Ermold, R.B. Lammers, K.C. McDonald, T.M. Pavelsky, A. Shilomanov, and J. Zhang, Tracing freshwater anomalies through the air–land–ocean system: A case study from the Mackenzie River Basin and the Beaufort Gyre, *Atmos. Oceans*, 47, 79–97, doi:10.3137/OC301.2009, 2009.

Rouseff, D., M. Badiey, and A. Song, Effect of reflected and refracted signals on coherent underwater acoustic communication: Results from the Kauai experiment (KauaiEx 2003), *J. Acoust. Soc. Am.*, 126, 2359–2366, 2009.

Sapozhnikov, O.A., A.V. Morozov, and D. Cathignol, Acousto-optic interaction in laser vibrometry in a liquid, *Acoust. Phys.*, 55, 365–375, 2009.

Sapozhnikov, O.A., W. Kreider, and M.R. Bailey, Effect of elastic waves in the metal reflector on bubble dynamics at the focus of an electrohydraulic lithotripter, *Nelineinyi mir (Nonlinear World)*, 7, 575–580, 2009 (in Russian).

Shaw, W.J., T.P. Stanton, M.G. McPhee, J.H. Morison, and D.G. Martinson, Role of the upper ocean in the energy budget of Arctic sea ice during SHEBA, *J. Geophys. Res.*, 114, doi:10.1029/2008JC004991, 2009.

Shcherbina, A.Y., M.C. Gregg, M.H. Alford, and R.R. Harcourt, Characterizing thermohaline intrusions in the North Pacific subtropical frontal zone, *J. Phys. Oceanogr.*, 39, 2735–2756, 2009.

Shepherd, A., A. Hubbard, M. King, M. McMillan, and I. Joughin, Greenland ice sheet motion coupled with daily melting in late summer, *Geophys. Res. Lett.*, 36, 10.1029/2008GL035758, 2009.

Sinelnikov, Y.D., T. Fjield, and O.A. Sapozhnikov, The mechanism of lesion formation by focused ultrasound ablation catheter for treatment of atrial fibrilation, *Acoust. Phys.*, 55, 647–656, 2009.

Smith, B.E., H.A. Fricker, I.R. Joughin, and S. Tulaczyk, An inventory of active subglacial lakes in Antarctica detected by ICESat (2003–2008), *J. Glaciol.*, 55, 573–595, doi:10.3189/002214309789470879, 2009.

Sorensen, M.D., J.M.H. Teichman, and M.R. Bailey, A proof of principle of a prototype ultrasound technology to size stone fragments during ureteroscopy, *J. Endourol.*, 23, 1161–1164, 2009.

Stafford, K.M., J.J. Citta, S.E. Moore, M.A. Daher, and J.E. George, Environmental correlates of blue and fin whale call detections in the North Pacific Ocean from 1997 to 2002, *Mar. Ecol. Prog. Series*, 395, 37–53, doi:10.3354/meps08362, 2009.

Stephen, R.A., S. Thompson Bolmer, M.A. Dzieciuch, P.F. Worcester, R.K. Andrew, L.J. Buck, J.A. Mercer, J.A. Colosi, and B.M. Howe, Deep seafloor arrivals: An unexplained set of arrivals in long-range ocean acoustic propagation, *J. Acoust. Soc. Am.*, 126, 599–606, 2009.

Stern, H.L., and R.W. Lindsay, Spatial scaling of Arctic sea ice deformation, *J. Geophys. Res.*, 114, doi:10.1029/2009JC005380, 2009.

Stevenson, J.M., et al., including J. Luby, R.T. Miyamoto, M. Grund, G. Anderson, and M. Hazen, An at-sea, autonomous, closed-loop concept study for detecting and tracking submerged objects, *U.S. Navy J. Underwater Acoust.*, 59, 671–690, 2009.

Stewart, M.S., M. Delgado, K. Ryan, and B. Ash, Persistent littoral undersea surveillance network (PLUSNet): Sea trial perspectives, *U.S. Navy J. Underwater Acoust.*, 59, 691–714, 2009.

Sun, H., A. Chen, A. Szep, and L.R. Dalton, Efficient fiber coupler for vertical silicon slot waveguides, *Opt. Express*, 17, 22571–22577, 2009.

Sun, H., A. Chen, and L.R. Dalton, A reflective microring notch filter and sensor, *Opt. Express*, 17, 10731–10737, 2009.

Sun, H., A. Chen, and L.R. Dalton, Enhanced evanescent confinement in multiple-slot waveguides and its application in biochemical sensing, *IEEE Photonics J.*, 1, 48–57, 2009.

Tang, D., F.S. Henyey, B.T. Hefner, and P.A Traykovski, Simulating realistic-looking sediment ripple fields, *IEEE J. Ocean. Eng.*, 34, 444–450, 2009.

Tang, D., K.L. Williams, and E.I. Thorsos, Utilizing high-frequency acoustic backscatter to estimate bottom sand ripple parameters, *IEEE J. Ocean. Eng.*, 34, 431–443, 2009.

Thomson, J., and A.T. Jessup, A fourier-based method for the distribution of breaking crests from video observations, *J. Atmos. Ocean. Technol.*, 26, 1663–1671, 2009.

Thomson, J., J.R. Gemmrich, and A.T. Jessup, Energy dissipation and the spectral distribution of whitecaps, *Geophys. Res. Lett.*, 36, doi:10.1029/2009GL038201, 2009.

Trossman, D.S., L. Thompson, K.A. Kelly, and Y.-O. Kwon, Estimates of North Atlantic ventilation and mode water formation for winters 2002–06, *J. Phys. Oceanogr.*, 39, 2600–2617, 2009.

Tsysar, S.A., O.A. Sapozhnikov, and V.G. Andreev, Acoustic tomography of temperature distribution in a medium heated by a focused ultrasound beam, *Bull. Russ. Acad. Sci. Phys.*, 73, 529–532, 2009.

Tu, J., J. Guan, Y. Qiu, and T.J. Matula, Estimating the shell parameters of SonoVue microbubbles using light scattering, *J. Acoust. Soc. Am.*, 126, 2954–2962, 2009.

Tyler, R.H., Ocean tides heat Enceladus, *Geophys. Res. Lett.*, 36, doi:10.1029/2009GL038300, 2009.

Vage, K., R.S. Pickart, V. Thierry, G. Reverdin, C.M. Lee, B. Petie, T.A. Agnew, A. Wong, and M.H. Ribergaard, Surprising return of deep convection to the subpolar North Atlantic Ocean in winter 2007–2008, *Nature Geosci.*, 2, 67–72, doi:10.1038/ngeo382, 2009.

Vorosmarty, C., D. Conley, P. Doll, J. Harrison, P. Letitre, E. Mayorga, J. Milliman, S. Seitzinger, J. van der Gun, and W. Wollheim, The Earth's natural water cycles, in *The United Nations World Water Development Report 3: Water in a Changing World*, 166–180 (Paris: UNESCO World Water Assessment Programme, 2009).

Wang, C.-C., and D. Tang, Seafloor roughness measured by a laser line scanner and a conductivity probe, *IEEE J. Ocean. Eng.*, 34, 459–465, 2009.

Wang, C.-C., B.T. Hefner, and D. Tang, Evaluation of laser scanning and stereo photography roughness measurement systems using a realistic model seabed surface, *IEEE J. Ocean. Eng.*, 34, 466–475, 2009.

Wang, J., J. Zhang, E. Watanabe, M. Ikeda, K. Mizobata, J.E. Walsh, X. Bai, and B. Wu, Is the dipole anomaly a major driver to record lows in arctic summer sea ice extent? *Geophys. Res. Lett.*, 36, doi:10.1029/2008GL036706, 2009.

Wanninkhof, R., W.E. Asher, D.T. Ho, C. Sweeney, and W.R. McGillis, Advances in quantifying air–sea gas exchange and environmental forcing, *Ann. Rev. Mar. Sci.*, 1, 213–244, doi:10.1146/annurev.marine.010908.163742, 2009.

Williams, K.L., Forward scattering from a rippled sand/water interface: Modeling, measurements, and determination of the plane wave, flat surface reflection coefficient, *IEEE J. Ocean. Eng.*, 34, 399–406, 2009.

Williams, K.L., Sand acoustics: The effective density fluid model, Pierce/Carey expressions, and inferences for porous media modeling, *J. Acoust. Soc. Am.*, 125, EL164–EL170, doi:10.1121/1.3097681, 2009.

Williams, K.L., D.R. Jackson, D. Tang, K.B. Briggs, and E.I. Thorsos, Acoustic backscattering from a sand and a sand/mud environment: Experiments and data/model comparisons, *IEEE J. Ocean. Eng.*, 34, 388–398, 2009.

Zappa, C.J., D.T. Ho, W.R. McGillis, M.L. Banner, J.W.H. Dacey, L.F. Bliven, B. Ma, and J. Nystuen, Rain-induced turbulence and air–sea gas transfer, *J. Geophys. Res.*, 114, doi:10.1029/2008JC005008, 2009.

Zhao, Z., and M.H. Alford, New altimetric estimates of mode-1 M2 internal tides in the central North Pacific Ocean, *J. Phys. Oceanogr.*, 39, 1669–1684, 2009.

Zhou, Z., A. Chen, L.-S. Feng, X.-J. Xin, and C.-X. Yu, Terahertz generation and detection setup based on pump-probe scheme, *Microw. Opt. Technol. Lett.*, 51, 1617–1619, doi:10.1002/mop.24413, 2009.

Articles in Proceedings and Selected Abstracts, 2009

Bessonova, O.V., V.A. Khokhlova, M.S. Canney, M.R. Bailey, and L.A. Crum, Nonlinear derating method for high intensity focused ultrasound (HIFU) fields, in *Proc., IEEE International Ultrasonics Symposium, Rome, Italy, 20–23 September*, 216–219, doi:10.1109/ULTSYM.2009.5441494 (IEEE, 2009).

Blanc-Benon, P., M.V. Averiyanov, R.O. Cleveland, and V.A. Khokhlova, Nonlinear acoustic wave propagation in inhomogeneous moving media, *J. Acoust. Soc. Am.*, 126, 2201, doi:10.1121/1.3248613, 2009.

Canney, M.S., V.A. Khokhlova, O.A. Sapozhnikov, Y.A. Pishchalnikov, A.D. Maxwell, M.R. Bailey, and L.A. Crum, Improved impulse response for hydrophone measurements in therapeutic ultrasound fields, *J. Acoust. Soc. Am.*, 125, 2740, 2009.

Cazzanti, L., and M.R. Gupta, Regularizing the local similarity discriminant analysis classifier, in *Proc., International Conference on Machine Learning and Applications, Miami Beach, 13–15 December*, 184–189, doi:10.1109/ICMLA.2009.12 (IEEE, 2009).

Cazzanti, L., M.R. Gupta, and S. Srivastava, Fusing similarities and Euclidean features with generative classifiers, in *Proc., 12th International Conference on Information Fusion, Seattle, 6–9 July*, 224–231 (IEEE, 2009).

Chen, H., A.A. Brayman, M.R. Bailey, and T.J. Matula, Direct observation of microbubble interactions with ex vivo microvessels, *J. Acoust. Soc. Am.*, 125, 2680, 2009.

Chen, H., J. Kucewicz, W. Kreider, A. Brayman, M. Bailey, and T. Matula, Observations of bubble-vessel interaction in ultrasound fields, in *Proc., IEEE International Ultrasonics Symposium, Rome, Italy, 20–23 September*, 23–26 (IEEE, 2009).

Crum, L.A., M.S. Canney, M.R. Bailey, O.V. Bessonova, and V.A. Khokhlova, Toward a better understanding of high intensity focused ultrasound therapy using the Khokhlov–Zabolotskaya–Kuznetsov equation, *J. Acoust. Soc. Am.*, 126, 2201, doi:10.1121/1.3248617, 2009.

Dahl. P.H., D. Tang, and J.W. Choi, The evolution of vertical spatial coherence with range from source, *J. Acoust. Soc. Am.*, 125, 2511, 2009.

Das, A.K., P. Arabshahi, T. Wen, and W. Su, On feature based automatic classification of single and multitone signals, in *Proc., Ninth IASTED International Conference on Wireless and Optical Communications, Banff, Alberta, 6–8 July* (Acta Press, 2009).

Dushaw, B.D., A personal perspective on unilateral hearing loss, *J. Acoust. Soc. Am.*, 125, 2632, 2009.

Dushaw, B.D., Antipodal acoustic propagation and a half-century of ocean warming, *J. Acoust. Soc. Am.*, 126, 2158, doi:10.1121/1.3248390, 2009.

Dushaw, B.D., M.A. Dzieciuch, and P.F. Worcester, On the time-mean state of ocean models and the properties of long-range acoustics, *J. Acoust. Soc. Am.*, 125, 2492, 2009.

Gooch, S., J. Thomson, B. Polagye, and D. Meggitt, Site characterization for tidal power, in *Proc., MTS/IEEE Oceans 2009, Biloxi, MS, 26–29 October* (MTS/IEEE, 2009).

Gray, A., P. Arabshahi, S. Roy, N. Jensen, L. Tracy, N. Parrish, and C. Hsieh, Tradeoffs and design choices for a software defined acoustic modem: A case study, in *Proc., Fourth ACM Workshop on Underwater Networks, Berkeley, CA, 3 November* (Association for Computing Machinery, 2009).

Hazen, M., and M.R. Gupta, Gradient estimation in global optimization algorithms, in *Proc., IEEE Congress on Evolutionary Computation, Trondheim, Norway, 18–21 May*, 1841–1848, doi:10.1109/CEC.2009.4983165 (IEEE, 2009).

Hefner, B.T., and D.R. Jackson, The role of porosity fluctuations in scattering from sand sediments and in propagation losses within the sediment, *J. Acoust. Soc. Am.*, 126, 2168, doi:10.1121/1.3248436, 2009.

Hefner, B.T., D.R. Jackson, and J. Calantoni, The effects of scattering from heterogeneities in porosity during sound propagation through sand sediments, *J. Acoust. Soc. Am.*, 125, 2746, 2009.

Henyey, F.S., Anomalous dispersion and pulse propagation in oceanic bubble clouds, *J. Acoust. Soc. Am.*, 125, 2611, 2009.

Henyey, F.S., Center for the studies of nonlinear dynamics, 1982–1985, *J. Acoust. Soc. Am.*, 126, 2157, doi:10.1121/1.3248384, 2009.

Henyey, F.S., K.L. Williams, and D. Tang, Measurements of acoustic propagation with accompanying high-resolution sound speed structure containing internal waves, *J. Acoust. Soc. Am.*, 125, 2512, 2009.

Hsieh, J.B., D. Rouseff, A. Song, and M. Badiey, Sonar Simulation Toolset modeling for underwater acoustic communications and networking, *J. Acoust. Soc. Am.*, 125, 2580, doi:10.1121/1.3139590, 2009.

Hwang, J.H. and L.A. Crum, Current status of clinical high-intensity focused ultrasound, in *Proc., 31st International Conference of the IEEE EMBS, Minneapolis, MN, 2–6 September*, 130–133, doi:10.1109/IEMBS.2009.5335244 (IEEE, 2009).

Jackson, D.R., Scattering by sinusoidal pressure-release surfaces, *J. Acoust. Soc. Am.*, 126, 2166, doi:10.1121/1.3248428, 2009.

Jamieson, K.G., M.R. Gupta, and D.W. Krout, Sequential Bayesian estimation of the probability of detection for tracking, in *Proc., 12th International Conference on Information Fusion, Seattle, 6–9 July*, 641–648 (IEEE, 2009).

Jones, C.D., and D.R. Jackson, Midfrequency backscatter imaging of fish schools in a shallow water waveguide, *J. Acoust. Soc. Am.*, 125, 2550, 2009.

Kaczkowski, P.J., M.R. Bailey, V.A. Khokhlova, and O.A. Sapozhnikov, A Schlieren system for optical visualization of ultrasonic fields, *J. Acoust. Soc. Am.*, 125, 2742, 2009.

Kargl, S.G., K.L. Williams, E.I. Thorsos, and J.L. Lopes, Synthetic aperture sonar simulations of cylindrical targets, *J. Acoust. Soc. Am.*, 125, 2733, 2009.

Khokhlova, V.A., O.V. Bessonova, M.S. Canney, M.R. Bailey, J.E. Soneson, and L.A. Crum, Modeling weak shocks produced by high-intensity focused ultrasound, *J. Acoust. Soc. Am.*, 125, 2600, doi:10.1121/1.3081393, 2009.

Kikuchi, T., S. Nishino, R. Woodgate, B. Rabe, U. Schauer, and S. Pisarev, Confluence and mixing of Atlantic, Pacific and Siberian shelf water masses around the Mendeleev Ridge of the Arctic Ocean, *Eos Trans. AGU*, 90, Fall Meet. Suppl., Abstract GC51A-0715, 2009.

Kreider, W., H. Chen, M.R. Bailey, A.A. Brayman, and T.J. Matula, Potential mechanisms for vessel invagination caused by bubble oscillations, in *Proc., IEEE International Ultrasonics Symposium, Rome, Italy, 20–23 September*, 353–356, doi:10.1109/ULTSYM.2009.5441744 (IEEE, 2009).

Kreider, W., M.R. Bailey, O.A. Sapozhnikov, and L.A. Crum, Impact of temperature on bubbles excited by high intensity focused ultrasound, *J. Acoust. Soc. Am.*, 125, 2742, doi:10.1121/1.3050272, 2009.

Krout, D.W., and D. Morrison, PDAFAI vs. PDAFAIwTS: TNO blind dataset and SEABAR '07, in *Proc., 12th International Conference on Information Fusion, Seattle, 6–9 July*, 1845–1850 (IEEE, 2009).

Lu, W., A. Shah, B.W. Cunitz, P.J. Kaczkowski, O.A. Sapozhnikov, and M.R. Bailey, Radiation pressure from ultrasound to help kidney stones pass, *J. Acoust. Soc. Am.*, 126, 2213, doi:10.1121/1.3248749, 2009.

Matveev, A.L., P.I. Korotin, V.I. Turchin, D. Rouseff, and R.C. Spindel, Experimental study of acoustic forward scattering on a marine shelf, in *Proc., 3rd International Conference on Sensor Technologies and Applications, Athens, Greece, 18–23 June*, 284–288 (IEEE, 2009).

Maxwell, A.D., T.-Y. Wang, C.C. Cain, J.B. Fowlkes, Z. Xu, O.A. Sapozhnikov, and M.R. Bailey, The role of compressional pressure in the formation of dense bubble clouds in histotripsy, in *Proc., International Ultrasonics Symposium, Rome, 20–23 September*, 81–84, doi:10.1109/ULTSYM.2009.5441398 (IEEE, 2009).

Mourad, P.D., C. Marzban, and M. Kliot, Towards predicting intracranial pressure using transcranial Doppler and arterial blood pressure data, *J. Acoust. Soc. Am.*, 125, 2514, 2009.

Mourad, P.D., F. Roberts, and C. McInnes, The Ultreo: A novel toothbrush that combines sonic and ultrasonic physics, *J. Acoust. Soc. Am.*, 125, 2561, 2009.

Mourad, P.D., M. Kliot, and J.G. Jarvik, Transcutaneous acoustic palpation (TAP) for the localization of peripheral, painful tissue, *J. Acoust. Soc. Am.*, 125, 2554, 2009.

Nystuen, J.A., M.B. Hanson, C. Emmons, P. Wade, and J. Miksis-Olds, Detection of killer whale presence using low duty cycle recorders, *J. Acoust. Soc. Am.*, 125, 2616, 2009.

Odom, R.I., and A.A. Ganse, The second order resolution operator of a nonlinear ocean acoustics inverse problem, *J. Acoust. Soc. Am.*, 125, 2501, 2009.

Odom, R.I., and K. James, Modeling gradients in ocean acoustics, *J. Acoust. Soc. Am.*, 125, 2501, 2009.

Owsley, L.M.D., J.J. McLaughlin, L.G. Cazzanti, and S.R. Salaymeh, Using speed technology to enhance isotope ID and classification, *Conference Record, Nuclear Science Symposium, Orlando, 24 October–1 November*, 629–635, doi:10.1109/NSSMIC.2009.5402002 (IEEE, 2009).

Parrish, N., S. Roy, and P. Arabshahi, Impact of bottom type on OFDM underwater communications, *J. Acoust. Soc. Am.*, 125, 2580, 2009.

Parrish, N., S. Roy, and P. Arabshahi, Symbol by symbol Doppler rate estimation for highly mobile underwater OFDM, in *Proc., Fourth ACM Workshop on Underwater Networks, Berkeley, CA, 3 November* (Association for Computing Machinery, 2009).

Rawlins, M.A., et al. including R.A. Woodgate, Analysis of the arctic system for freshwater cycle intensification: Observations and expectations, *Eos Trans. AGU*, 90, Fall Meet. Suppl., Abstract GC42A-05, 2009.

Risien, C.M., J.C. Allan, R. Blair, A.V. Jaramillo, D. Jones, P.M. Kosro, D. Martin, E. Mayorga, J.A. Newton, T. Tanner, and S.A. Uczekaj, The NANOOS Visualization System: Aggregating, displaying, and serving data, in *Proc., MTS/IEEE Oceans, Biloxi, MS, 26–29 October* (MTS/IEEE, 2009).

Rudenko, O.V., V.A. Khokhlova, and M.R. Hamilton, Historical aspects of the Khokhlov–Zabolotskaya equation and its generalizations, *J. Acoust. Soc. Am.*, 126, 2200, doi:10.1121/1.3248604, 2009.

Sapozhnikov, O.A., Group analysis of the Khokhlov–Zabolotskaya type equations, *J. Acoust. Soc. Am.*, 126, 2200, doi:10.1121/1.3248606, 2009.

Shah, A., M. Paun, J. Kucewicz, O.A. Sapozhnikov, M. Dighe, H.A. McKay, M.D. Sorensen, and M.R. Bailey, Investigation of an ultrasound imaging technique to target kidney stones in lithotripsy, *J. Acoust. Soc. Am.*, 125, 2620, 2009.

Sorensen, M.D., A. Shah, M.S. Canney, O.A. Sapozhnikov, J.M.H. Teichman, and M.R. Bailey, Ureteroscopic ultrasound technology to size kidney stone fragments: Proof of principle using a miniaturized probe in a porcine model, *J. Acoust. Soc. Am.*, 125, 2622, 2009.

Soukup, D.J., and R.I. Odom, Seismo-acoustic modal scattering by volume heterogeneities in shallow water sediments, *J. Acoust. Soc. Am.*, 126, 2159, doi:10.1121/1.3248392, 2009.

Speyer, G., P. Kaczkowski, A. Brayman, M. Andrew, and L. Crum, Bounds on thermal dose estimates using ultrasonic backscatter monitoring of heating, in *Proc., 8th International Symposium on Therapeutic Ultrasound, Minneapolis, MN, 10–13 September 2008*, 251–255, doi:10.1063/1.3131424 (AIP, 2009).

Stafford, K., S. Moore, C. Berchok, and D.K. Mellinger, Acoustic sampling for marine mammals in the Beaufort Sea July 2007–March 2008, *J. Acoust. Soc. Am.*, 125, 2587, 2009.

Sun, H., A. Chen, and L.R. Dalton, Multiple slot waveguides for enhanced biochemical sensing, in *Proc., IEEE/LEOS International Conference on Optical MEMS and Nanophotonics, Clearwater, FL, 17–20 August*, 21–22, doi:10.1109/OMEMS.2009.5338626 (2009).

Tang, D., and D.R. Jackson, Measurement and modeling of broadband Bragg scattering from a sinusoidal surface, *J. Acoust. Soc. Am.*, 125, 2661, 2009.

Tang, D., D. Rouseff, F. Henyey, and J. Yang, Single-path acoustic scintillation results from the Shallow Water 2006 Experiment, *J. Acoust. Soc. Am.*, 126, 2172, doi:10.1121/1.3248459, 2009.

Thorsos, E.I., F.S. Henyey, J. Yang, and S.A. Reynolds, Ray versus mode differences in reverberation modeling solutions for environments with high boundary scattering loss, *J. Acoust. Soc. Am.*, 126, 2209, doi:10.1121/1.3248702, 2009.

Tsysar, S.A., and O.A. Sapozhnikov, Ultrasonic holography of 3D objects, in *Proc., International Ultrasonics Symposium, Rome, 20–23 September*, 737–740, doi:10.1109/ULTSYM.2009.5441458 (IEEE, 2009).

Williams, K., J. Lopes, E. Thorsos, and P. Marston, Measurement and modeling of solid cylinders near interfaces, *J. Acoust. Soc. Am.*, 125, 2701, doi:10.1121/1.3097681, 2009.

Zhou, Y., S.G. Kargl, and J.H. Hwang, Producing uniform lesion pattern in HIFU ablation, in *Proc., 8th International Symposium on Therapeutic Ultrasound, Minneapolis, MN, 10–13 September 2008*, 91–95, doi:10.1063/1.3131478 (AIP, 2009).

Advise & Counsel

Our Advisory Board ensures that the Laboratory's research and development programs are consistent with the highest goals of university research and education, while supporting the missions of the agencies we serve.

Thomas J. Cable
Chairman
(Ret.) Cable & Howse Ventures

RADM Jeffrey B. Cassias
(Ret.) U.S. Navy Commander,
Submarine Force, U.S. Pacific Fleet

VADM Kevin J. Cosgriff
(Ret.) Commander,
U.S. Naval Forces CentCom

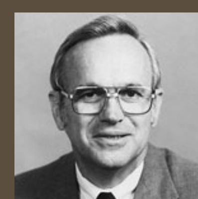
Phil E. DePoy
(Ret.) Chair, Expeditionary Warfare
Naval Postgraduate School

Pamela A. Drew
Senior Vice President,
Enterprise Systems, TASC

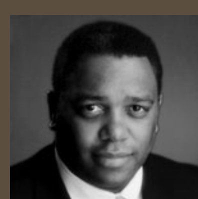
RADM Winford G. Ellis
Chair, Undersea Warfare
Naval Postgraduate School

John M. Fluke, Jr.
Chairman, Fluke Capital
Management, L.P.

Lisa J. Graumlich
Dean, College of the Environment
University of Washington
ex officio



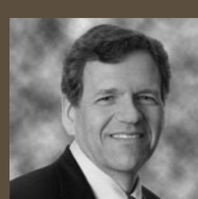
Robert M. Hillyer
(Ret.) Senior Vice President,
Science Applications
International Corporation



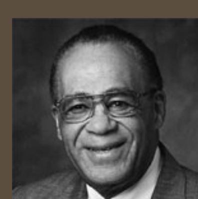
Ronald S. Howell
CEO, Washington
Research Foundation

Ellen E. Lettvin
Vice President, Science & Education
Pacific Science Center

Mary E. Lidstrom
Vice Provost for Research,
University of Washington
ex officio



Matt O'Donnell
Dean, College of Engineering
University of Washington
ex officio



John B. Slaughter
President & CEO, National Action
Council for Minorities in Engineering
President Emeritus, Occidental College

Paul E. Speer
President,
Center for Naval Analyses

Biennial Report Twenty-Eleven

Applied Physics Laboratory - University of Washington