Symposium Sponsor

National Science Foundation
Funding provided through NSF standard grant: OCE-1031668

Principal Investigator
Jeffrey Schuffert
Consortium for Ocean Leadership

Symposium Coordinators
Charna Meth
Consortium for Ocean Leadership

Emily Powell
Consortium for Ocean Leadership

Kristin Ludwig
Consortium for Ocean Leadership

Steering Committee
John Delaney
University of Washington

Peter Folger
Congressional Research Service

Rick Murray
Boston University

Catherine O'Riordan
American Institute of Physics

Elizabeth Screaton
University of Florida
Dear Colleagues and Friends,

Today more than ever, marine geoscientists must cross the boundaries between traditional scientific disciplines to advance the frontiers of scientific research and to address the needs of society. They also must learn how to communicate better with policymakers and the public. With these goals in mind, the Consortium for Ocean Leadership organized and convened the second Marine Geoscience Leadership Symposium for early career scientists on April 18-22, 2011 in Washington, D.C. This proceedings volume collects the scientific abstracts submitted by the twenty-four selected participants and identifies the more than thirty invited speakers, panelists, and mentors from the academic, education, and policy communities.

The symposium focused on the different perspectives of leadership and on several aspects of building a successful academic career, such as proposal writing, research funding, collaborating across disciplines, and communicating to non-academic audiences. The participants met with program officers at the National Science Foundation, received professional training on effective communications and leadership techniques, and held a series of roundtable discussions with representatives from a variety of other government agencies, scientific organizations, and media outlets. Scott Doney, a senior scientist at the Woods Hole Oceanographic Institution, delivered the keynote address on career paths, pivotal moments of opportunity, and the importance of societally relevant science in a politically charged atmosphere. John Delaney of the University of Washington spoke on academic issues such as multi-disciplinary science initiatives, scientific history, and the mixing of science and politics.

The general themes of science policy and communicating to non-scientific audiences recurred throughout the symposium. As a more concrete unifying activity, the participants spent part of each day working in small groups tasked with developing new ideas for large, visionary oceanographic research projects and preparing presentations to solicit funding for their projects from a mock private foundation. Despite the diversity of specific research interests among the participants in each group, they collaborated successfully in devising a set of unique projects. Interestingly, each project focused on adapting and using some form of new technology on a broad, ocean-wide scale. The individual groups articulated their visions in lively presentations before the full symposium body.

This second Marine Geoscience Leadership Symposium refined the new paradigm for early career workshops established with the first symposium and, through its setting in our nation’s capital, offered unparalleled access to a wide array of decision makers in science funding and policy. The participants received invaluable exposure to leadership qualities and non-traditional skills that will help them navigate through the classroom, the laboratory, and beyond. They also gained a rare insight into the academic and policy world that will serve them and the community well in the years to come.

Sincerely,

Jeffrey D. Schuffert, Ph.D.
Director, U.S. Science Support Program
# TABLE OF CONTENTS

## ABSTRACTS

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barotropic and Baroclinic Responses to Basin-Wide Wind Forcing:</td>
<td>1</td>
</tr>
<tr>
<td>Insights on the Kuroshio from Observations and a 2-layer Model</td>
<td>1</td>
</tr>
<tr>
<td>Interrelated Controls of Vegetation and Hydrodynamic Regime</td>
<td>2</td>
</tr>
<tr>
<td>on Sedimentary Processes and Landform Evolution</td>
<td>2</td>
</tr>
<tr>
<td>Observations of Storm Morphodynamics using Coastal Lidar and Radar Imaging System (CLARIS):</td>
<td>3</td>
</tr>
<tr>
<td>Importance of Wave Refraction and Dissipation over Complex Surf-Zone Morphology</td>
<td>3</td>
</tr>
<tr>
<td>at a Shoreline Erosional Hotspot</td>
<td>3</td>
</tr>
<tr>
<td>U.S. Beaufort Shelf Subsea Permafrost/Gas Hydrates(?) Distribution from Legacy Seismic Data</td>
<td>4</td>
</tr>
<tr>
<td>The Release of Old Carbon from the Deep Ocean at the End of the Last Ice Age</td>
<td>5</td>
</tr>
<tr>
<td>Sediment Routing from Terrestrial Source Areas to Marine Depositional Sinks</td>
<td>6</td>
</tr>
<tr>
<td>Active Mid-Ocean Ridge Accretion: Fine-Scale Rates and Processes</td>
<td>7</td>
</tr>
<tr>
<td>Predicting the Growth of Deltaic Landforms.</td>
<td>9</td>
</tr>
<tr>
<td>Physical and Biological Mechanisms of Phytoplankton Blooms on the Outer Shelf of South Carolina</td>
<td>10</td>
</tr>
<tr>
<td>Late Pleistocene Changes in Northern Component Water: Inferences from Geochemical</td>
<td>11</td>
</tr>
<tr>
<td>and Sedimentological Records From Gardar Drift</td>
<td>11</td>
</tr>
<tr>
<td>The Use of Underwater Technology in Aquatic Education</td>
<td>12</td>
</tr>
<tr>
<td>Deciphering Tectonics in the Sedimentary Record</td>
<td>13</td>
</tr>
<tr>
<td>Arctic Sea-Ice Decline</td>
<td>14</td>
</tr>
<tr>
<td>Origin and Evolution of Ocean-Continental Transitional Zone in the Galicia Bank</td>
<td>15</td>
</tr>
<tr>
<td>Predicting Coastal Hazards with Process-Based Modeling and Data Assimilation</td>
<td>16</td>
</tr>
<tr>
<td>Take It or Leave It? The Redistribution of Sediment and Debris by Tsunamis.</td>
<td>17</td>
</tr>
<tr>
<td>Mixture Theory Simulation of Vortex Sand Ripple Dynamics</td>
<td>18</td>
</tr>
<tr>
<td>Microbial Community Response to the Deepwater Horizon Oil Spill</td>
<td>19</td>
</tr>
<tr>
<td>Late Holocene SST Variability From Northern Gulf of Mexico Sediments: Merging Inorganic and Molecular Organic Geochemical Proxies on Multidecadal to Centennial Timescales</td>
<td>20</td>
</tr>
<tr>
<td>Climate Change Across the Last 5 Million Years</td>
<td>21</td>
</tr>
<tr>
<td>Eco-Geomorphic Response of Tidal Salt-Marsh Platforms to Sea-Level Rise and Engineered Structures</td>
<td>22</td>
</tr>
<tr>
<td>The Ion Sorptive Properties of CaCO$_3$(s) in Seawater:</td>
<td>23</td>
</tr>
<tr>
<td>Implications for Ocean Acidification, Carbon Cycling, and CO$_2$(g) Sequestration</td>
<td>23</td>
</tr>
<tr>
<td>Multi-Centennial Proxy Records of Bering Sea Climate</td>
<td>24</td>
</tr>
<tr>
<td>Maine Salt Pools: Stratigraphic Description, Ecophysical Characterization, and Discussion of Their Role in Estuarine Landscape Change</td>
<td>25</td>
</tr>
</tbody>
</table>

## GUEST SPEAKERS

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
</tr>
</tbody>
</table>

## WORKSHOP PANELISTS

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
</tr>
</tbody>
</table>

## PARTICIPANTS

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
</tr>
</tbody>
</table>
Barotropic and Baroclinic Responses to Basin-Wide Wind Forcing: Insights on the Kuroshio from Observations and a 2-layer Model

Magdalena Andres
Woods Hole Oceanographic Institution

The Kuroshio in the East China Sea (ECS-Kuroshio) responds to the large-scale North Pacific wind stress curl field at two time scales. These two responses are related to barotropic and baroclinic modes which reach the ECS via different waveguides. Variability in the ECS-Kuroshio is assessed by comparing satellite altimetry, historical hydrography, and the Pacific Decadal Oscillation index (PDO) with the latter used as a proxy for the large-scale wind stress curl forcing. Sea-level difference across the ECS-Kuroshio is positively correlated with PDO at zero-lag and negatively correlated at 7-year lag. In contrast, pycnocline-steepness and PDO are uncorrelated at zero-lag and negatively correlated at 7-year lag. These signals in the ECS-Kuroshio, considered together with wind stress curl anomalies in the open ocean, are consistent with a barotropic response to the wind at zero-lag. The barotropic response is likely forced in the central North Pacific by wind stress curl anomalies of opposite sign, one of which is centered at ECS latitudes (~27°N) while the other sits further north. In contrast, the signals which lag PDO by 7 years are consistent with a baroclinic mode which represents the ocean's time-integrated response to the wind stress curl along a single latitude band between 24°N and 27°N.
In the coastal zone, harsh, changeable conditions have constrained the parameters within which life may flourish. During much of my training as an oceanographer and geologist, the effects of the biosphere on physical processes were assumed to be inconsequential in this ecotone, and were largely ignored. However, advances in our understanding of various biofilms, together with the wider dissemination of hydrodynamic studies into the geosciences community (e.g. FitzGerald et al., 2008; Townend et al., 2010), have resulted in an explosion of research at the intersection of the biosphere, hydrosphere and geosphere. My research focuses on the interrelated controls of vegetation and hydrodynamic regime on sedimentary processes and landform evolution on nested spatial and temporal scales.

A recent contribution of my work has been to combine high-resolution LiDAR data with multispectral, multitemporal high-resolution imagery in a GIS to develop an empirical database of the distribution of geomorphologic features across the largest coastal wetland and estuarine system in New England (Millette et al., 2010; Argow et al., 2010). Working with colleagues at the Geoprocessing Lab at Mount Holyoke, I am mining the resulting dataset to discover robust patterns and to develop scientific questions, which must then be further assessed in the field, lab, or through numerical modeling. Preliminary results from this systems-wide approach have facilitated quantification of the relationship between marsh elevation and the distribution of key marsh features, such as the concentration of pannes and ponds (Millette et al, 2010). These observations then drive field and lab process and modeling studies to determine ecological, hydrologic, and geologic controls on the evolution of coastal landforms.
Observations of Storm Morphodynamics using Coastal Lidar and Radar Imaging System (CLARIS): Importance of Wave Refraction and Dissipation over Complex Surf-Zone Morphology at a Shoreline Erosional Hotspot

Katherine Brodie
U.S. Army Core of Engineers Field Research Facility

Substantial development of our nation’s coastlines and heightened hurricane activity in the last decade has placed a demand on the scientific community for accurate predictions of coastal change during storms. Unfortunately, monitoring the impact of storms on beaches has mostly focused on analysis of “pre” and “post” storm data, with sparse data during storms, leaving researchers with little guidance on how to improve predictive models. Complicating predictions further, storm impact is rarely homogenous along a coastline: storm response can range from rapid shoreline retreat to beach accretion to little change. In fact, the physics of erosional hotspots—areas that experience heightened erosion relative to adjacent regions—that occur along straight uninterrupted sections of barrier islands, remain unexplained. This dissertation strives to elucidate the behavior of erosional hotspots during storms, through observations of the beach and nearshore, from dune to 1 km offshore, and a wave modeling exercise.

To observe the energetic beach and surf-zone during storms, we develop Coastal Lidar and Radar Imaging System (CLARIS), a mobile remote sensing system that integrates a terrestrial scanning laser with an X-band marine radar system and covers large distances during storms. CLARIS enables remote measurements of beach topography, nearshore bathymetry (from radar-derived wave celerity measurements), surf-zone wave parameters, and maximum water levels. We first present details on the new methodology, then use CLARIS to observe a 10 km section of coastline that encompasses an erosional hotspot on the Outer Banks of North Carolina every 12 hours during a Nor’Easter.

Data reveal that complex bathymetry offshore of the hotspot is mirrored by shoreline undulations of the same scale, and that both morphologies persist during the storm, contrary to common observations of shoreline and surf-zone linearization by large storm waves. Wave modeling results suggest that wave refraction over the complex bathymetry forces flow patterns which may enhance the shoreline morphology during storms. In addition, semi-daily surveys of the beach indicate that spatial and temporal patterns of erosion are strongly correlated to changes in wave steepness, with recovery of 50% or more of the initial erosion within 12 hours of the storm peak as waves remain large (>2.5 m), but transition to long period swell. We end by showing that wave dissipation within the inner-surf zone is more effective than predicted inundation elevations or wave heights at explaining spatial variations in the amount of beach volume change during the studied moderate Nor’Easter.
Methane hydrates store significantly more methane than free gas with the same volume. Because of this higher storage capacity, gas hydrates are of interest as a possible factor in climate change and as an exploitable fossil fuel. These crystalline compounds are only stable within low-temperature and high-pressure conditions, and are associated with Arctic permafrost. The shallow-water (<100 m water depth) continental shelves in the circum-Arctic Ocean have been submerged due to sea-level rise that began with the onset of long-term warming at the end of the last glaciation. These shelves host now-degrading terrestrial permafrost and possibly substantial deposits of dissociating gas hydrates. On the U.S. Beaufort margin, subsea permafrost has never been systematically mapped, and the best insights about the possible condition of the permafrost and associated gas hydrate have emerged from a limited number of offshore boreholes and numerical studies with sometimes contrasting predictions of permafrost’s seaward extent. This study uses industry-collected multichannel seismic data to map velocity anomalies indicative of permafrost. The high velocity refractor (HVR) occurs over 550 km of coastline, and extends nowhere more than ~30 km from shore. Mapped HVR increases our direct measurements of subsea permafrost by four orders of magnitude. These results can be used to: 1) reconcile disparities between model-predicted and borehole-verified offshore permafrost distribution; and 2) spatially constrain where to expect hydrate dissociation.
The Release of Old Carbon from the Deep Ocean at the End of the Last Ice Age

Sean P. Bryan
Woods Hole Oceanographic Institution

Understanding the mechanisms responsible for changes in atmospheric CO2 concentrations over glacial-interglacial cycles remains one of the most difficult and longstanding problems in the fields of paleoceanography and paleoclimatology and a challenge to our understanding of the natural carbon cycle. Most current hypotheses attempting to explain lower glacial CO2 concentrations call upon increased storage of carbon in the deep ocean as a result of ocean circulation and/or biological productivity changes. Reconstruction of radiocarbon (14C) concentrations in the ocean and atmosphere represents a potentially powerful tool for tracing carbon fluxes in the past. Atmospheric radiocarbon concentrations decreased sharply at the end of the last glacial period at the same time as atmospheric CO2 concentrations were increasing. We examine whether the ocean may have provided a source of 14C-depleted CO2 to the atmosphere at the end of the last glacial period by reconstructing oceanic radiocarbon concentrations.

We measured radiocarbon ages of benthic foraminifera from three sediment cores: MV99-GC31/PC08 from 705 m water depth off the coast of Baja California, and RC27-14 and RC27-23 from 600 m and 820 m water depth, respectively, in the Arabian Sea. Benthic foraminiferal radiocarbon ages, combined with independent calendar age control, were used to reconstruct seawater radiocarbon concentrations at the core sites during the last deglaciation. These reconstructions reveal very low seawater radiocarbon concentrations at the same time as atmospheric CO2 was rising. These results suggest that some portion of the glacial deep ocean was well isolated from the atmosphere allowing its 14C to decay away. Increased isolation from the atmosphere would allow carbon to build up in the deep ocean. At the end of the last glacial period, this isolated deep water was mixed up in to the upper ocean, releasing 14C-depleted CO2 to the atmosphere.
Sediment transfer across Earth’s surface influences geomorphology, soil and arable land distribution, and geochemical cycling of particulate and dissolved loads. A comprehensive assessment of sediment fluxes from land to the deep sea over thousands of years of climate change is lacking and of importance in separating anthropogenic influences from natural processes. Cosmogenic radionuclide-derived denudation rates from onshore river catchments are paired with depositional rates from their corresponding deep-sea depositional systems in tectonically active Southern California. These measurements provide calculations of sediment fluxes over thousands of years, the range over which global sea-level changes operate. During periods of both low and high sea level, land and deep-sea sediment fluxes do not show imbalances that might be expected in the wake of major sea-level changes. Thus, sediment-transfer processes of small, tectonically active systems might be fundamentally different from those of larger systems that drain entire continents, in which sediment storage in flood plains and continental shelves can exceed millions of years. In small systems, depositional changes offshore can reflect onshore changes when viewed over thousands of years. This result is contrary to arguments that environmental signals, for example, climatic and/or tectonic changes, are destroyed during sediment transport.
Active Mid-Ocean Ridge Accretion: Fine-Scale Rates and Processes

Brian M. Dreyer
University of California, Santa Cruz

Much of my current research activity entails reconstructing the recent geological, petrological, and volcanological histories of the intermediate spreading-rate Juan de Fuca (JdF) mid-ocean ridge off the Pacific coast of the western US. This work attempts to refine our knowledge of the ridge magmatic plumbing system, where new oceanic crust is created, by studying its expression on the youngest seafloor. A great deal has been learned about mid-ocean ridge morphology, volcanic, and magmatic processes since the advent of seafloor observation, but details on fundamental finer-scale crustal accretionary processes and their rates remain elusive (Perfit & Chadwick Jr, 1998). There remains persistent lack of data to constrain the chronological framework of submarine volcanic eruptions, such as recurrence interval, episodicity, volcanic/magmatic flux, and the temporal/geospatial links between mantle melting and eruption. Mantle-melting and magmatic processes and their complex interplay with tectonism at mid-ocean ridges are partly reflected in the variability of geochemical, petrological, and morphological parameters of erupted lava. Therefore, careful study of variance in the mosaic of lava sequences in the ridge axis can offer insight into timescales and pathways of melt generation, differentiation, and replenishment in crustal reservoirs. This then can link eruptive processes to their deeper underpinnings. Study of the fine-scale evolution in ridge neovolcanic zones greatly benefits from a high-resolution investigation because melt production, transport, accumulation, and eventual eruption processes can vary on the segment-scale over decades (Rubin et al., 2005). In practical terms, this requires evaluating age relationships among lava flow sequences (Christie, 1994, Rubin & MacDougall, 1990), which in turn demands the ability to sample and date individual flow units (Rubin et al., 2001) in order to capture a representative range of variability through time. The intermediate-spreading JdF ridge expresses a high temporal and spatial sensitivity to variations in magmatic and tectonic conditions (Canales et al., 2005).

Recent technological and methodological developments make the reconstruction of the recent history of the JdF ridge (Endeavour, CoAxial, Axial, northern Cleft segments) possible via 1) seafloor mapping at meter-scale resolution, 2) detailed ROV observations to determine superpositional relationships, and 3) the application of complementary microfossil-radiocarbon, short-lived uranium-series, and magnetic paleointensity techniques to constrain the ages of young submarine lava flows. Early results from Axial Seamount follow, but similar work is in progress for additional segments. Axial Seamount hosts the shallowest (~1.5 km below seafloor; Carbotte et al., 2008) and most robust axial magma chamber of the JdF. Multibeam mapping and coregistered sidescan data at Axial since 2006 total ~73 km2 and include the summit caldera and rim. Inflation since the historical 1998 eruption suggest that the magma chamber will be replenished in ~22 years (Chadwick et al., 2006, Nooner & Chadwick, 2009). Nine distinct lightly sedimented (~600a) lava flows within the caldera suggests multi-decadal eruption recurrence. We infer a petrologic shift occurred within the last millennium: eight lava flows from the summit caldera and flanks have minimum eruption ages of 600-1200a, MgO ≥7.5 wt%, and are plagioclase-phyric. In contrast, younger lavas (undated but with thin sediment cover) from the same areas are aphyric with lower MgO, possibly reflecting enhanced crystal separation or longer magma residence times since ~600 a. Analysis of volcaniclastics recovered with ROV pushcores are underway and allow depth profiling studies.

A high degree of magma mixing (homogenization) in the magma reservoir beneath Axial is inferred from a limited range in trace element (e.g., La/Yb) and Pb-isotopic ratios compared to adjacent segments; compositions are very similar to basalts of the Cobb-Eickleberg chain. New data confirm
that Axial has the lowest (230Th)/(232Th) on the JdF, but (230Th)-excesses are similar to adjacent segments, suggesting source compositions are more variable than melting processes on the southern JdF ridge. Subsets of 226Ra and 210Pb measurements are in progress. There are fundamental contrasts between JdF ridge segments, highlighted by differences in (230Th)-excesses, inferred source petrology, geochemical variances, and excess crustal inflations. We aim to unravel the relationships between the aforementioned and characteristics of the melt column (i.e., porosity, lithology, potential temperature), melt dynamics (e.g., mantle upwelling), and their variability beneath the JdF ridge axis.
Depositional systems are places on the Earth’s surface where sediments are actively being deposited, as for example in river deltas. I am interested in these systems because through years to millennia of deposition they record the history of the earth. Also, they are societally relevant because the active deposition produces rich soils that have attracted humans for centuries. Currently, my research focuses on how river deltas form and evolve through time. Deltas are an important resource; 10% of the humans live around deltas and a significant percentage of oil and natural gas is recovered from ancient deltas. I am interested in predicting how deltas behave so hazards are mitigated and oil exploration strategies are more successful. Deltas commonly have branching channel networks (e.g., the Mississippi delta) and the network forms when a prograding delta channel splits (or bifurcates) around a sandbar deposited at the river mouth. The sandbar location determines the bifurcation point and thus the network pattern. Using numerical models, I found that the distance to the sandbar from the river mouth is proportional to the momentum flux at the river mouth. As channels bifurcate and take less flow, their momentum flux decreases, and bifurcations become more closely spaced. Thus the channel network of deltas is inherently predictable.
As part of a project recently funded by NSF, my co-PIs and I will investigate physical and biological mechanisms that initiate and sustain phytoplankton blooms on the outer shelf of South Carolina. Visible from satellite ocean color imagery, the blooms persist from January into March on the outer shelf of Long Bay. North and south of Long Bay, eddies on the shoreward front of the Gulf Stream upwell cold, nutrient-rich deep water onto the shelf, providing significant nutrient flux that could potentially trigger bloom activity. However, previous studies have shown that the Charleston Gyre, a Gulf Stream recirculation feature off Long Bay, inhibits frontal eddy nutrient transport.

We propose three alternate transport mechanisms consistent with the observed seasonal and alongshelf pattern: 1) variability in the magnitude and position of the Charleston Gyre, 2) input of nutrients from internal tides generated at the shelfbreak (permitted in Long Bay but defocused by the Gulf Stream north or south), or 3) interaction of the internal tide with the position/magnitude of the Charleston Gyre. The physical transport mechanism may be important biologically, as small but regular nutrient input over months from an internal tide may favor different phytoplankton species than larger event-based inputs. Further, the duration of the bloom suggests that its composition may change over time, with significant implications for higher trophic levels and fisheries.

Our observatory is designed to identify the physical transport mechanism, quantify nutrient input onto the shelf, and quantify/characterize the bloom assemblage and how its composition changes over time. Continuous shipboard sampling and towed profilers will complement a moored cross-shore array of physical and bio-optical instruments. Two gliders will serve as mobile assets autonomously collecting parallel physical/bio-optical datasets, each with a different mission; one will be a quasi-stationary profiler at the shelf edge, while the other maps physical/bio-optical parameters on a cross-shore transect.

While deployed, the gliders will be subject to strong currents that exceed the glider’s flight speed. Using operational forecast models, we will use engineering control theory to explore alternate patterns of glider motion that take advantage of ocean currents to sample more efficiently. We will explore and test vehicle control strategies based on vehicle position, feature avoidance/tracking/mapping, and permutations of these based on the operational ocean model forecast. Similar strategies can also be implemented to guide shipboard sampling. These novel applications of engineering to oceanography will significantly improve the scientific value of the physical/biological data collected.
Late Pleistocene oceanic circulation variability within the North Atlantic, a critical region of deep-water formation, was reconstructed using paleoceanographic proxies that reconstruct surface and deepwater changes. My study focuses on changes in Iceland Scotland Overflow Water (ISOW), one of the largest contributors to North Atlantic Deep Water (NADW). Each NADW component reflects the regional climate within its formation region; thus, different climates may produce different deepwater states by changing the relative contribution from each component. Southern Gardar Drift is bathed by ISOW, thus the accumulating sediments are ideal for examining ISOW. A high-resolution record of the Younger Dryas cold event provides an analog for abrupt climate events. The benthic foraminiferal δ13C record from core 11JPC (~2700m) on Gardar Drift reveals NADW shoaled during the early and late Younger Dryas. These reductions are coincident with increased meltwater from Northern Hemisphere ice sheets, linking surface freshening to NADW production changes on abrupt timescales.
The Use of Underwater Technology in Aquatic Education

Mark Gleason
Great Lakes Naval Memorial and Museum

The impact of technology within natural resources education programs is a pertinent topic for land managers and educators. My dissertation efforts involved creating a large number of education programs to research the impacts of technology on the public’s understanding of the aquatic world. These education programs were designed to use a remotely operated vehicle (ROV), an underwater robot as their central focus.

The ROV impacts on the participants were observed in a variety of environmental education programs that had individuals from a wide range of backgrounds and ages. Participants from age 12 to 86 were allowed to either observe first hand or operate an ROV in connection or see a live long distance program. All of the programs used the ROV with an Aquatic Environmental Education program and were model after Dr. Robert Ballard’s JASON program.

This study was conducted with partners in the National Park Service, U.S. Forest Service, and several non-profit environmental organizations. Of approximately the 3,000 participants in the educational programs, 324 individuals completed questionnaires that were analyzed. The instrument included quantitative and qualitative questions. Questionnaire results indicated that most participants had a very positive perception of the use of underwater ROV technology to increase their understanding of the underwater natural resources connected with our public lands. This research has resulted in a large number of ROV educational programming, based on the success of the dissertation research, being offered in the Great Lakes region.
Deciphering Tectonics in the Sedimentary Record

Leah J. Hogarth
University of California, San Diego

The sedimentary record reflects the processes of the environment in which sediments are deposited and preserved. These processes include global sea-level change (eustasy), tectonics, and sediment supply. It is often difficult, however, to separate the sedimentary signal of tectonics from that of eustasy. On active margins, tectonic deformation can act at rates comparable to the rates of sea-level change and can impart a significant influence on stratigraphic architecture. By using high-resolution seismic reflection images along with sediment cores and other data, I can examine sediment architecture at or near the scale at which individual strata are formed. This allows me to determine the relative roles of these processes in their formation and preservation. Using this high-resolution approach on the California margin, I have shown that tectonic deformation imparts a significant control on sediment preservation, especially since ~8,000 years ago when sea-level rise due to deglaciation slowed significantly. In addition, I have developed better constraints for the recency and timing of deformation events on this active margin.

This work is important for understanding the evolution of continental margins, which are often associated with the occurrence of natural resources such as petroleum. In addition, an improved understanding of the tectonic history of a region will allow scientists to build better probabilistic models of the occurrence of geohazards such as earthquakes.
The Arctic sea-ice cover has declined strongly over recent decades, especially in summer. Whether this sea-ice loss is due mainly to anthropogenic changes or if it is influenced strongly by natural variability is still an open question. Given the importance of the sea-ice cover for the native populations in the Arctic and animals living on the Arctic sea-ice (i.e. Polar bears), better projections of the Arctic sea-ice decline over the 21st century are needed, so that adaptation and mitigation strategies can be developed. Ensemble simulations with climate models can be used to study the role of natural variability versus forced changes in the Arctic sea-ice. Results from ensemble simulations with one of the current state-of-the-art global climate models, the Community Climate System Model version 4 (CCSM4), show a large influence of natural variability on the simulated sea-ice decline. These results suggest that the forced Arctic sea-ice loss has been enhanced by natural variability.
I use seismic methods to understand continental rifting processes. Rifting is a fundamental tectonic process that enables breaking apart of continents and creation of oceanic basins. Rifting is associated with varying amounts of magmatism. Geodynamic processes associated with excess magmatism creating oceanic crust are well understood. Little understood are processes associated with limited magmatism (magma-starved rifts) where formation of oceanic crust is debatable. The type of crust observed at magma-starved rifts has different seismic character as compared to pure oceanic or pure continental crust; its regional expanse is referred to as an “Ocean-Continent Transitional Zone (OCTZ).” The origin and evolution of OCTZs elude scientific understanding to date. Studying OCTZs is crucial as they can provide new insights into magma-starved rifting and in turn into the processes that govern plate tectonics.

The Galicia Bank Region of offshore Iberia offers a unique opportunity to study an OCTZ through seismic methods due to a thin overlying sedimentary cover and the absence of salt. Considerable speculation occurs in the literature regarding the composition and emplacement mechanism of OCTZ in the Galicia Bank. The most common hypothesis postulates the OCTZ to comprise unroofed mantle overlaid by rifted continental crust. Magmatism is theoretically expected to accompany mantle upwelling, however, evidence of magmatism is yet to be found in the Galicia Bank. The objective of my research is to investigate the structure and stratigraphy of OCTZ in the Galicia Bank. My hypothesis is that OCTZ in the Galicia Bank comprises both magmatic and mantle rocks. I am testing my hypothesis using multichannel and ocean-bottom-seismometer seismic data.

Existing seismic images of the Galicia Bank OCTZ in literature only allow the shallow structures to be interpreted confidently – the overlying sediments and continental blocks; the underlying mantle remains unresolved. I am applying advanced seismic modeling methods such as Reverse Time Migration and Full Waveform Inversion to image features below the rotated continental blocks; these features may hold key to understanding the origin and emplacement of OCTZ in the Galicia Bank.
Coastal regions continuously evolve due to winds, waves, and varying water levels through coupled and complex nonlinear processes. These processes vary significantly over days to decades and over short (meters) and long (hundreds of kilometers) distances along the coast. When these processes are associated with dramatic events such as hurricanes and tsunamis, coastal areas can be devastated and reshaped in a matter of hours. Protecting lives and assets from the wide range of coastal hazards that exist (rip currents, long-term shoreline erosion, storm surge inundation, tsunamis, etc) requires predictive capabilities for hydrodynamics and sediment transport that span a wide range of spatial and temporal scales. These predictions must include alongshore differences in the geomorphology as well as chronic long-term and short-term changes in climatology.

There are two primary methods of forecasting the changing state of a coastal system. Process-based numerical models provide highly resolved (in space and time) representations of the dominant dynamics in a physical system but must employ certain parameterizations due to computational limitations. The predictive capability may also suffer from the lack of reliable initial or boundary conditions. Alternately, historical rates and trends can be extrapolated from direct observations of coastal processes and used for forecasting the coastal state. While these observations represent the real-world rather than modeled conditions, they suffer from instrument noise, lack necessary spatial and temporal resolution, and do not consider that accelerations in the estimated rates may occur.

This research focuses on the combination of these two pieces of information to make more reliable forecasts of nearshore hydrodynamics and coastal change. Of primary importance is the development of adequate process-based models and data assimilation strategies that are efficient, applicable for use with highly nonlinear models, and able to quantify the remaining forecast uncertainty. The primary goal is to use the models to provide information on spatial and temporal scales needed by coastal managers and to use sparse physical observations to guide models and constrain uncertainty.
Take It or Leave It? The Redistribution of Sediment and Debris by Tsunamis

Breanyn MacInnes
University of Washington

We have long recognized that tsunamis are highly destructive when they come onshore. Coastal, low-lying communities around the world, especially those near active subduction zones, are vulnerable to the effects of tsunami inundation. My research, and my passion, is to explore and understand the onland effects of tsunamis, with the aim of enabling individuals and communities to reduce their vulnerability to future effects. Tsunami redistribution of sediment is the starting point for all of my research. In particular, my recent work investigates tsunami deposition and tsunami erosion in order to enable better predictions of how often events occur, and how tsunamis alter landscapes.

Tsunami deposits provide an estimate of the recurrence and size of past events in a given area. Tsunami deposition has been relatively well studied (at least in comparison to tsunami erosion and sediment transport) because after a tsunami’s passage, we can exactly measure the thickness of deposits and their spatial extent. Overtime, tsunami deposits accumulate in the soil cover of coastal landscapes. My excavations in low-lying coastal areas reveal numerous tsunami layers as coherent sand sheets in the soil. By adding dates to excavations (using tephrochronology or radiometric dating), I can predict the frequency of local tsunamis. When I trace continuous deposits through many excavations, I can reconstruct the spatial extent and predict the size of tsunamis that affect that coast. For my particular field area in the Russian Far East, excavation dating is an ongoing process—preliminary work suggests a large tsunami every ~200 years.

Tsunami erosion is more challenging to quantify than deposition, even if it is as necessary to understand in order to reduce vulnerability. The destructive power of a tsunami is an important variable to constrain how infrastructure and the landscape will react to inflow and outflow. My tsunami erosion investigations began by chance—a large tsunami occurred in the Russian Far East (Kuril Islands) in 2006, only 3 months after I had been surveying for paleotsunami deposits in the exact same area. In returning to the Kuril Islands, I compared before-and-after coastal topographic measurements to determine that tsunami erosion was significantly more extensive than deposition (up to 50 times greater). However, erosion amount and erosional features varied widely, while deposition did not vary dramatically along the coast, and appeared to depend primarily on the availability of sediment more than any other factor. Erosion was more extensive on steeper coasts, suggesting that outflow of the tsunami was an important contributor. Erosion was also uneven, such that the few locations where humans had altered the landscape were significantly more susceptible to erosion.

In summary, studying all aspects of tsunamis onland flow and their ability to redistribute sediment is necessary to decrease the vulnerability of individuals and communities. By studying paleotsunami deposits we can determine how often and, sometimes, how big past events have been. By studying erosion we can determine where, when, and why tsunamis are more destructive. The long-term goal of my research will be to help enable individuals and communities to make better urban planning decisions, and be more aware of their risk for future tsunami events.
All bathymetric change ultimately results from sediment entrainment and deposition occurring at the fluid-sediment interface inside the wave bottom boundary layer (WBBL). Despite the apparent accessibility of the phenomena, highly turbulent, sediment-laden flow remains poorly understood and difficult to quantify mainly because of our failure to understand the fundamental interaction forces driving sediment transport. However, with recent advances in high performance computing, it is now possible to perform highly resolved simulations of fluid-sediment dynamics in the WBBL that accurately model the evolution of sandy seabeds. Here, we present a three-dimensional bottom boundary layer model (SedMix3D) employing mixture theory for highly resolved simulations of the coupled interactions between fluid and sediment. Mixture theory treats the fluid-sediment and sediment-sediment interactions. SedMix3D solves the unfiltered Navier Stokes equations for the fluid-sediment mixture with and additional equation describing sediment flux to simulate sand ripple morphology in domains covering up to ~1m^2 of the seabed. Modeled ripple geometries range from a single ripple to multiple ripples with varying heights, lengths, and steepness. The model predicts ripple heights and lengths of three-dimensional ripples within 10% of values determined by existing ripple predictor formula. SedMix3D also predicts the merging and separation of ripples as they transition from an initial state to an equilibrium state. Quantitative comparisons of simulated time-varying vorticity and bulk flow statistics with laboratory measurements are in excellent agreement. SedMix3D allows for the quantification of the effects of seabed morphology on the generation and dissipation of boundary layer turbulence. We compare two-dimensional to three-dimensional simulations to find that the vortex dynamics over sand ripples are highly three-dimensional. Two-dimensional flow simulations are inadequate for the numerical modeling of turbulent flow in the WBBL. We also examine the differences in turbulence production over two-and three-dimensional ripple geometries. Simulations of flow over a three-dimensional ripple field produced a substantial increase in the production of boundary layer turbulence when compared to the same simulation with a two-dimensional ripple field. The excess turbulence significantly increases the boundary layer thickness. Ultimately, all process-based models for nearshore bathymetric evolution are limited by shortcomings in fundamental knowledge of multiphase boundary layer physics. SedMix3D provides an unprecedented level of detail for the study of fluid-sediment interactions that is impossible to obtain with available measuring technologies in the field or laboratory.
Microbial Community Response to the Deepwater Horizon Oil Spill

Molly Redmond
University of California, Santa Barbara

The sinking of the Deepwater Horizon in April, 2010 caused one of the world’s largest oil spills. This spill was unusual due to large natural gas component (~40%) and water depth, leading to the formation of deep water oil and gas plumes and rapid changes in the deep water microbial communities. In May and June, plume samples were dominated (up to 100% of sequences) by three types of Gammaproteobacteria: a novel group of Oceanospirillales, Colwellia, and Cycloclasticus. By September, the methylotrophs Methylococcaceae, Methylophaga, and Methylophilaceae accounted for up to 35% of sequences in plume samples and methane concentrations had decreased from ~100 μM to <20 nM. The novel Oceanospirillales and Colwellia were undetectable in 16S rRNA gene clone libraries from the September samples, but after ten days of incubation with ethane, propane, benzene, or crude oil, Colwellia was again one of the dominant members of the microbial community and the Oceanospirillales had also increased in relative abundance. While these bacteria have not previously been linked to hydrocarbon degradation, this suggests that they are able to bloom rapidly in response to hydrocarbon inputs, either by direct consumption of hydrocarbons or by consumption of metabolic byproducts of hydrocarbon degradation by other bacteria.
Late Holocene SST Variability From Northern Gulf of Mexico Sediments: Merging Inorganic and Molecular Organic Geochemical Proxies on Multidecadal to Centennial Timescales

Julie Richey
University of Washington

Accurate reconstruction of natural climate variability over the past millennium is critical for predicting responses to future climate change. The climate of the last 1,000 years was punctuated by two prominent events: the Medieval Warm Period (MWP) from 800-1300 A.D. and the Little Ice Age (LIA) from 1400-1850 A.D. The impact of, and evidence for these events derives primarily from the middle latitudes of the Northern Hemisphere continents, largely from tree rings and mountain glaciers. Remarkably little attention has been given to the low latitude climate of the last millennium and its potential impact on the middle and high latitudes even though massive fluxes of latent heat, moisture and momentum originate there. This research is focused on reconstructing sea surface temperature (SST) variability in the Gulf of Mexico (GOM) during this important time interval.

The major research questions addressed are: (1) What was the GOM surface temperature response during the LIA and the MWP, and is that signal reproducible among different northern GOM basins? (2) Can changes in upper water column structure (i.e. ocean mixed layer depth) in the GOM during the LIA and MWP be inferred from temperature offsets between Mg/Ca and TEX86-based temperature reconstructions?

The major findings include: (1) The magnitude of temperature variability in the GOM over the past millennium is much larger than that estimated from Northern Hemisphere temperature reconstructions. The MWP was characterized by SSTs in the GOM that were equivalent to the modern core-top SST, while the LIA (400-150 yrs BP) was marked by a series of multidecadal intervals that were 2-2.5°C cooler than modern. This LIA cooling was replicated in the Mg/Ca-SST records from three different well-dated northern GOM basins (Pigmy, Garrison and Fisk Basins), which is consistent with the LIA cooling estimated from sclerosponge, coral and foraminifera-based SST estimates spanning the Atlantic Warm Pool (2) Changes in GOM mixed layer depth over the past millennium are inferred from offsets between paleotemperature estimates from proxy recorders with distinctive depth habitats (Mg/Ca of Globigerinoides ruber, and TEX86 from marine crenarchaeota). Maximum mixed layer depth was inferred during the MWP, with minimum mixed layer depth during the LIA. Increased mixed layer depth may have pre-conditioned the GOM for intensification of tropical cyclone activity during the MWP.
Climate Change Across the Last 5 Million Years

Sindia Sosdian
Cardiff University

The Pliocene and Pleistocene epochs span the last ~5.3 million years of Earth history, and represent a transition between two contrasting modes of Earth’s climate system. In the “Pliocene Warm Period” (PWP), mean global temperatures were ~3°C warmer than today, and continental ice sheets were reduced in size. In contrast, the Pleistocene was characterized by large amplitude glacial-interglacial cycles, when continental ice sheets advanced and retreated across North America and Europe. The mid-Pleistocene transition (MPT) represents a threshold in this cold mode of the climate system, after which time northern hemisphere ice sheets persisted longer than previously observed. The causes and mechanisms of the Plio-Pleistocene climate transitions are poorly understood, but likely involve complex interactions between radiative forcing, ice sheet dynamics, ocean circulation and the global carbon cycle. My research is aimed at quantifying such aspects of the climate system during Plio-Pleistocene climate transitions.

Geochemical proxies and tracers can be used to provide quantitative records of various components of Earth’s climate system. Foraminifera incorporate more magnesium into their shells in warmer waters. An empirical relationship between these two parameters has been constrained using modern foraminifera, which can be applied to the fossil record. In the work presented, I used Mg/Ca ratios in benthic foraminifera paired with oxygen isotopes to construct high-resolution records of deep ocean temperature and global ice volume to understand the underlying mechanisms of Pliocene-Pleistocene climate transitions.
Eco-Geomorphic Response of Tidal Salt-Marsh Platforms to Sea-Level Rise and Engineered Structures

Susan Taylor
Dewberry

The long-term stability of tidal marshes is related to feedbacks among surface slope, sedimentation, primary production, and the relative rate of sea-level rise. Global sea level over the past 100 years has risen at a rate of 1 to 2 mm yr\(^{-1}\). The study sites for this research are located at Bogue Banks and Cedar Island, North Carolina, where the entire marsh environment exists within less than a meter of relief near high tide. The proposed research consists of three parts aimed at understanding the fundamental physics and coupling of the physical and ecological responses to sea-level rise and engineered structures. The first component is focused on understanding how macrophytes trap sediment; this includes monitoring inundation duration and frequency for semi-diurnal and wind driven tides. A flow model is developed, based on depth-integrated equations of conservation of mass and momentum and parameterized with drag coefficients at transitional Reynolds numbers, to account for the drag force due to plant stems. The flow model developed here differs from previous models of marsh platform hydrodynamics that suggest a wave-like flooding, but do not explicitly account for the drag associated with vegetation. The second part considers deep time using analytical and numerical methods to simulate the effect of changing rates of sea level rise and sediment supply on the stratigraphy and carbon accumulation in a coastal salt marsh. Simulations also explore the effects of organic decomposition on marsh accretion rates. The third component deals with the response to sea-level rise by engineering the shoreline using soft stabilization. The geomorphic response to engineered structures, in particular the use of oyster shells, has yet to be studied. Using data reported in the literature, this work will compile the response to stabilization methods and simulate oyster shell designs to determine biological productivity and sedimentation as a function of modified flooding from obstructions, indirect impacts (e.g. accretion, drowning of marsh plants), and the ability of salt marshes to accrete sediments and maintain their elevation relative to sea level. Due to significant eco-geomorphic feedbacks, predictive models of intertidal systems that describe biological and physical processes separately fail to give a full sense of the geomorphic behavior. This research consists of detailed field campaigns aimed at time averaged representations of the physical processes that are relevant to long-term (100+ years) salt-marsh platform evolution.
Upon contact with water, CaCO3(s) surfaces undergo hydration and relaxation, which, in turn, lead to the formation of one of the most pervasive, and reactive mineral-water interfaces in nature. Chemical reactions at the CaCO3(s)-water interface play a key role in the solution chemistry of aquatic systems by regulating pH and alkalinity and governing the mobility/bioavailability of trace metals, organic pollutants, and radionuclides. They also impact the long-term biogeochemical cycling of major elements (C, Ca, H, etc.), affect important biomineralization processes, and influence the chemistry of volatile inorganic and organic acids in the atmosphere. In addition, numerous engineering processes ranging from the manufacturing of biomaterials to the optimization of oil recovery, nuclear waste disposal, and CO2(g) sequestration technologies largely rely on physical-chemical processes at the CaCO3(s)-water interface. Surprisingly, despite numerous studies focused on this interface, much controversy still surrounds some of its most fundamental physical-chemical properties (e.g., the pH of the isoelectric point, the point of zero net surface charge, the proton and lattice-derived ion sorption properties). This is largely due to the lack of suitable physical-chemical approaches allowing a rigorous characterization of ion sorption equilibria over expanded compositional ranges. In this study, we developed a novel titration protocol that allows, for the first time, the accurate monitoring of the chemistry of CaCO3(s)-H2O(l)-CO2(g) systems during surface titrations conducted over a broad range of chemical conditions. Accurate pCO2 measurements are obtained using a gas-recirculation device and a last-generation Cavity Ring-Down Spectrometer (CRDS) that correctly accounts for water vapor interferences with minimum sample perturbation, a major advantage over conventional IR spectrometer-based strategies. Our approach yields high-quality ion sorption data suitable for the calibration of predictive ion exchange/sorption thermodynamic models for CaCO3(s) surfaces in aqueous solutions. While we initially focus on the proton and lattice-derived ion sorptive properties of high-purity calcite powders in dilute aqueous solutions, our experiments will be extended to chemical conditions closely resembling those of seawater exposed to increasing atmospheric CO2(g) scenarios and will include other CaCO3(s) minerals preponderant in marine systems (aragonite and magnesian calcites). Our results will likely improve our current understanding of the ocean’s carbon cycle, ocean acidification, the calcification of calcareous marine species, and the geosequestration of CO2(g).
A part of my dissertation research is the investigation of the upper oceanic crustal architecture using downhole geophysical logs. I analyzed the architecture of 15 m.y. old superfast spreading East Pacific Rise crust drilled at Ocean Drilling Program Hole 1256D in the eastern Pacific. An intact upper oceanic crustal section was penetrated at this site to a depth of 1507 meter beneath the seafloor. Although core recovery rates were low and recovered rock types biased, the multiple passes of various wire-line logs with excellent data quality allow the entire igneous stratigraphy of the hole to be reconstructed, providing a quantitative foundation for chemistry, physical properties, and biological studies on a crustal-scale. In situ crustal architecture was mapped from resistivity imagery (electrofacies by Formation MicroScanner®) combined with recovered cores and other logs. Highlights of this research are: (1) most of the extrusive section consists of massive flows and fragmented formations including breccias, which has important implications for the magnetic source layer and pathways of hydrothermal alteration; (2) the dike complex is composed of sheeted-dikes dipping away from the paleo-spreading axis consistent with submersible observations at other sites in the eastern Pacific; (3) the crustal construction processes from ridge axis to abyssal plain during 0-50 kyr time are consistent with previous seismic reflection studies based on the integration of our stratigraphy model with lava flow observations from the southern East Pacific Rise.
Salt marshes are critical components of our coastal systems. Salt pools, shallow, water-filled depressions are common features found throughout north-temperate salt-marsh environments. Despite this, little is known regarding their origin, stratigraphic signature, characterization, or potential role in driving surficial changes in salt-marsh systems. This study combines approaches from geology (Dutch cores, surface sediment samples), ecology (eco-physical surveys, remote data loggers), and spatial information sciences (time series analyses of aerial photographs) to characterize pools of six Maine salt marshes (from south to north: Moody Marsh, Ogunquit; Webhannet Marsh, Wells; Maquoit Bay Marsh, Brunswick; Grand Marsh, Gouldsboro; Addison Marsh, Addison, and Lubec Spit Marsh, Lubec). Overall, our study results indicate that marsh pools are highly dynamic, that this dynamism is recorded in the geologic record, and that total pool area within Maine marshes is increasing by a slight to moderate amount. Finer-scale investigations of pool aquatic conditions reveal that this dynamism is seen at the pool scale in terms of variability in pool salinities, temperatures, and water levels and that groundwater flows may influence surficial pool morphologies, a new insight into these systems. Our work demonstrates the dynamic nature of Maine’s salt-marsh and salt-pool environments, though it does not appear that Maine’s salt marshes are transitioning to open-water states at the rapid time scales observed for other regions, like the Mid-Atlantic or Gulf Coasts. Rather, Maine marshes appear to be in a state of dynamic equilibrium. Overall, this work has far-reaching implications for (1) geoscientists who infer sea-level fluctuations from temperate salt marsh stratigraphic records, (2) ecologists interested in the application of landscape concepts, spatial statistics, and multivariate approaches to estuarine systems, and, (3) coastal managers who seek to improve policies governing these dynamic environments, including restoration efforts.
GUEST SPEAKERS

Mel Briscoe  
Consortium for Ocean Leadership  
mbriscoe@oceanleadership.org

Patrick Clemins  
American Association for the Advancement of Science  
pclemins@aaas.org

John R. Delaney  
University of Washington  
jdelaney@u.washington.edu

Scott Doney  
Woods Hole Oceanographic Institution  
sdoney@whoi.edu

Susan Finn  
ESI International  
www.esi-intl.com

Peter Folger  
Congressional Research Service  
pfolger@crs.loc.gov

Robert Gagosian  
Consortium for Ocean Leadership  
rgagosian@oceanleadership.org

Staci Lewis  
Consortium for Ocean Leadership  
slewis@oceanleadership.org

Katie Matthews  
International Seafood Sustainability Foundation  
(formerly U.S. Department of State)  
kmatthews@iss-foundation.org

Rick Murray  
Boston University  
rickm@bu.edu

Catherine O’Riordan  
American Institute of Physics  
coriordan@aip.org

Barbara Ransom  
The National Science Foundation  
bransom@nsf.gov

Craig Schiffries  
Deep Carbon Observatory Secretariat; Carnegie Institution of Washington  
(formerly Geological Society of America)  
cschiffries@ciw.edu

Liz Screaton  
University of Florida  
screaton@ufl.edu

Matthew Wright  
Consortium for Ocean Leadership  
(formerly Communication Partnership for Science and the Sea)  
mwright@oceanleadership.org
WORKSHOP PANELISTS

Working with the Press

Declan Fahy
American University
fahy@american.edu

Kristin Ludwig
National Science Foundation
(formerly Consortium for Ocean Leadership)
kludwig@nsf.gov

Peter Weiss
American Geophysical Union
pweiss@agu.org

Matthew Wright
Consortium for Ocean Leadership
(formerly Communication Partnership for Science and the Sea)
mwright@oceaneleadership.org

Science Informing Policy: Gulf Oil Spill

David Curtiss
American Association of Petroleum Geologists
dcurtiss@aapg.org

Peter Folger
Congressional Research Service
pfolger@crs.loc.gov

Chris Reddy
Woods Hole Oceanographic Institution
creddy@whoi.org

Shelby Walker
National Oceanic and Atmospheric Administration
Gulf Coast Ecosystem Restoration Task Force
shelby.walker@noaa.gov

Kevin Wheeler
Consortium for Ocean Leadership
kwheeler@oceaneleadership.org

Science Informing Policy: Climate Change

Tim Cowles
Consortium for Ocean Leadership
tcowles@oceaneleadership.org

Maria Honeycutt
National Oceanic and Atmospheric Administration
Coastal Services Center
maria.honeycutt@noaa.gov

William Hooke
American Meteorological Society
hooke@ametsoc.org

Jane Leggett
Congressional Research Service
jaleggett@crs.loc.gov

Ana Unruh Cohen
House Natural Resources Committee
ana.unruhcohen@mail.house.gov

Policy Influencing Science: Science at Sea

John Delaney
University of Washington
jdelaney@u.washington.edu

Robert Gagosian
Consortium for Ocean Leadership
rgagosian@oceaneleadership.org

Elizabeth Tirpak
U.S. Department of State
tirpakej@state.gov

Robert Winokur
U.S. Navy
robert.s.winokur@navy.mil

Policy Influencing Science: Science at the Poles

John Farrell
U.S. Arctic Research Commission
jfarrell@arctic.gov

Kathryn Moran
University of Victoria
(formerly Office of Science and Technology Policy)
kmoran@uvic.ca

Roberta Marinelli
National Science Foundation
rmarinel@nsf.gov

Jeff Schuffert
Consortium for Ocean Leadership
jshuffert@oceaneleadership.org

David Titley
RADM, U.S. Navy
david.titley@navy.mil
PARTICIPANTS

Magdalena Andres
Wood Hole Oceanographic Institution
mandres@whoi.edu

Brian Dreyer
University of California, Santa Cruz
bdreyer@ucsc.edu

Brittina Argow
Wellesley College
bargow@wellesley.edu

Doug Edmonds
Boston College
douglas.edmonds@bc.edu

Kate Brodie
U.S. Army Core of Engineers Field Research Facility
Katherine.L.Brodie@usace.army.mil

Catherine Edwards
Skidaway Institute of Oceanography
catherine.edwards@skio.usg.edu

Laura Brothers
United States Geological Survey
lbrothers@usgs.gov

Aurora Elmore
Durham University (formerly University of New England)
aurora.elmore@durham.ac.uk

Sean Bryan
Woods Hole Oceanographic Institution
sbryan@whoi.edu

Mark Gleason
Great Lakes Naval Memorial and Museum
gleason@mtu.edu

Jacob Covault
U.S. Geological Survey
jcovault@usgs.gov

Leah Hogarth
University of California, San Diego
lhogarth@ucsd.edu