SCRIPPS STUDENT SYMPOSIUM

September 21, 2016
Scripps Seaside Forum

Dear SIO Community,

Thank you for joining us for the 3rd annual Scripps Student Symposium (S^3). The goal of S^3 is to provide a platform for Scripps graduate students to present and discuss their research with colleagues from all curricular groups. This student-inspired symposium was created to foster interdisciplinary collaboration amongst the student population and to introduce the new first-years to the wide variety of research Scripps has to offer.

In addition to enjoying the presentations, we hope that everyone is as excited as we are to hear from our keynote speaker, Dr. Sheila Walsh Reddy, who received her Ph.D. in Marine Biology from Scripps Institution of Oceanography in 2009 and is now a Behavioral Economist at The Nature Conservancy.

We would like to thank the organizers of last year's S^3 for continuing this newly formed Scripps tradition; we hope that Year 3 of S^3 will continue to inspire students for many years to come.

All the best,
The 2016 S^3 Organizing Committee

Mariela Brooks
John DeSanto
James Holmes
Lillian McCormick
Sara Rivera
William Savran
Josefin Stiller

Agenda

Wednesday, September 21st 2016
Keynote Speaker: Dr. Sheila Walsh Reddy, Scripps alumna 2009
Behavioral Economist, The Nature Conservancy

0800 - 0830	Registration Opens, Check-in.
0830 - 0845	Welcome from Dr. Margaret Leinen, Director of Scripps Institution of Oceanography
0900 - 1000	Oral Session 1: Past
1000 - 1130	Poster Session #1 and Coffee + Refreshments
1130 - 1245	Oral Session 2: Present
1245 - 1345	Lunch and Group Photo
1345 - 1500	Oral Session 3: Future
1500 - 1515	UC Ship Funds Presentation (Dr. Bruce Appelgate)
1515 - 1615	Poster Session #2 and Coffee + Refreshments
1615 - 1700	Keynote Address (Dr. Sheila Walsh Reddy)
1700 - 1730	Awards Ceremony and Closing
1730 - 1830	Social Hour with Refreshments in Surfside

Oral Sessions

Past

Present

Future

Contents

The Effect of Simulated Sea Turtle Grazing on *Thalassia testudinum* dominated seagrass beds in Bocas del Toro Panamá.

Abigail Cannon[1] †

Green turtle (*Chelonia mydas*) abundance in the Caribbean is estimated to only be 0.33% of what it was in pre-Colombian times (McClenachan et al. 2006). The severe reduction of this formerly abundant herbivore has likely dramatically altered the ecology of the seagrass beds where *C. mydas* formerly fed, but the conclusions of past studies of the effect of sea turtle grazing in the Caribbean have varied by location, possibly as a result of phosphorous availability (Holzer and McGlathery 2016). To determine how sea turtle grazing may have affected seagrass beds in Bocas del Toro in the past we simulated grazing by trimming *T. testudinum* blades with scissors over the course of six months. Highly grazed plots were trimmed every two weeks, lightly grazed plots were trimmed every four weeks, and control plots were not trimmed. We found grazing to have no effect on shoot density, but to reduce *T. testudinum* areal productivity as well as leaf width. While grazing reduced percent cover of *T. testudinum* no other organisms were able to colonize the newly opened space. Grazing also increased the vulnerability of *T. testudinum* to bioturbation by stingrays.

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Impacts of ENSO on air-sea Oxygen Exchange

Yassir Eddebbar[1] †

The effects of ENSO on air-sea O_2 exchange are assessed using continuous high precision measurements of atmospheric O_2 and CO_2 from the Scripps Flask Network over the 1992-2015 period. These observations suggest significant interannual variability of air-sea fluxes of O2 that likely originates in the tropical Pacific region, with El Niño events associated with anomalous outgassing of O_2 into the atmosphere, whereas La Niña conditions are associated with anomalous uptake of O_2 into the ocean. We explore driving mechanisms of the air-sea O_2 flux response to ENSO using a hindcast simulation of the Community Earth System Model (CESM). In CESM, we find this response is the net balance of large opposing fluxes, whereby changes in ventilation of low-O_2 waters dominate over weaker changes in the temperature-dependent solubility and biological productivity of O_2. This response, shared by other climate models, shows strong zonal asymmetry and is driven by changes in the source and rate of equatorial upwelling of low-O_2, nutrient-rich, cold waters during ENSO events. The impact of ENSO on air-sea O2 exchange underscores the complex response of the upper oceanic O_2 cycle to climate perturbations, informs the observed interannual to decadal trends in atmospheric O_2 and dissolved [O_2], and provides a unique and powerful test for ocean models.

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Artisanal fisheries in the Gulf of California and the need for economic diversification

Alfredo Giron-Nava[1] †, Andrew F Johnson[1], Marcia Moreno-Baez[2], Andres Cisneros-Montemayor[3], Octavio Aburto-Oropeza[1]

The Nature Conservancy's Mapping Ocean Wealth (MOW) project has the objective of collecting information about the value of marine and coastal ecosystems around the world. In the Gulf of California, one of the project focal areas, artisanal fisheries provide not only economic value, but also social and cultural value to local coastal communities. Unfortunately, marine resources in the region have been overexploited for decades, and today the economic benefits of the fisheries to local communities have been severely compromised. Between 1998 and 2008 the annual earnings per fisher were reduced on average by $400 USD, which represents 20% of their annual incomes. As part of this project, we calculated the theoretical Maximum Sustainable Yield (MSY) for 18 important commercial fish species and estimated that today the total landings and revenues generated are one order of magnitude smaller than they would be under a sustainable (MSY) scenario. Even if fishing is reduced to sustainable levels, the problem of too many fishers still remains. Fewer resources and potential earnings would have to be distributed among a greater number of fishers in the region, which would result in very small revenues per individual in many areas (∼$500 USD per month). It is therefore necessary to plan for economic diversification in the region if a sustainable fishing future is sort. This must include non-extractive activities such as ecotourism. Cabo Pulmo and La Laguna San Ignacio are two successful examples of such diversification on the Baja California peninsula, where communities that used to exclusively rely on fisheries, now balance livelihoods with tourism. The Gulf of California has many opportunities to diversify its economic activities, and ecotourism is a good place to start. Non-Governmental Organizations, scientists, managers and local communities must collaborate to think about solutions to balance extractive activities with conservation objectives so that livelihoods can be maintained whilst natural populations preserved into the future.

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Seasonal patterns in calcium carbonate production of a Bermuda coral reef

Travis Courtney[1] †, Andreas Andersson[1]

Coral reef net ecosystem calcification has decreased in recent decades for many Caribbean coral reefs primarily due to changes in benthic community composition. These declines threaten the long-term ability for coral reefs to maintain the calcium carbonate structure sustaining the broad range of ecosystem services that humans depend on. In this study, net ecosystem calcification of a Bermuda rim reef community was measured approximately monthly along with measurements of seawater temperature, light, carbonate chemistry, Chl-a, and nutrients to record seasonal patterns in reef-scale calcification over a two-year study period. The results show that net ecosystem calcification rates are highest during the warmest summer months and suggest temperature is the primary control on net ecosystem calcification rates over annual time scales. The results further highlight the importance for higher-frequency monitoring of coral reef calcification and provide insight into how coral reef structure and ecosystem services will be impacted by continued changes in sea surface temperatures, ocean chemistry, and benthic community composition.

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In situ robotic sampling of surface ocean microbial eukaryotes reveals new insights into community metabolism

Bethany Kolody[1] †, John McCrow[2], Frank Aylward[3], Kristina Fontanez[4], Francisco Chavez[5], Christopher Scholin[5], Edward DeLong[6], Andrew Allen[1]

Phytoplankton productivity serves as the ultimate regulator of marine biogeochemical cycles. It is uniquely responsible for providing organic carbon to oceanic food webs and driving the metabolic response of heterotrophic marine microbes and, in turn, ecosystem dynamics across the world's oceans. An in situ robotic sampler, the environmental sample processor (ESP), enabled us to conduct real-time lagrangian, size-fractionated transcriptional profiling of microbial populations at 3-hr intervals over 2 days in an upper mixed layer water mass off of Monterey Bay, CA (USA). Here, we report on the phylogenetic identity and transcriptional dynamics of microbes recovered from a large size-class (> 5.0 micron). The most abundant and transcriptionally active genera in this size class consisted of Synechococcus, Ostreococcus, pelagophytes, haptophytes, diatoms, ciliates, fungi, archaea, proteobacteria, and viruses. We show that all major phytoplankton taxa, with the notable exception of multiple dinoflagellates, exhibit robust 24-hour transcriptional periodicity in response to sunlight availability. Such patterns were not discernible in heterotrophic prokaryotes, fungi, or viruses. However, weighted gene correlation network analysis did reveal unique modules of conserved gene expression in these and other groups. Our results identify and highlight molecular and cellular features that govern regulation of microbial physiology by diel periodicity. Further we establish new linkages between the molecular basis for phytoplankton metabolism and pelagic ecosystem biogeochemistry.

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Seismometer orientations via automated Rayleigh-wave arrival angle measurements

Adrian Doran[1] †, Gabi Laske[1]

After more than ten years of operations of the U.S. ocean bottom seismometer instrument pool (OBSIP), there is still need for a consistent and accurate procedure to determine the orientation of the horizontal seismometer components of passive-source free-fall broadband OBSs with respect to Geographic North. We present a new automated and high-accuracy algorithm to obtain this information during post-processing of the data. Like some previous methods, our new method, DLOPy, is based on measuring intermediate-period surface wave arrival angles from teleseismic earthquakes. A crucial new aspect of DLOPy is the consultation of modern global dispersion maps when setting up the analysis window. We repeat measurements at several frequencies to lower biases from wave propagation in laterally heterogeneous structure. We also include measurements from higher wave orbits to further lower biases caused by uneven geographical data coverage. We demonstrate the high accuracy of our technique through benchmark tests against a well-established "hands-on" but slow technique using data from instruments of the Global Seismographic Network (GSN) for which orientations are well documented. We present results for all Cascadia Initiative (CI) deployments, along with a number of other OBS experiments.

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Carbon and Nitrogen Cycling in the California Current Ecosystem-LTER Domain

Brandon Stephens[1] †, Lihini Aluwihare[1]

Eastern boundary currents are sites of enhanced primary production supporting higher trophic levels and fisheries, and the productivity in these systems is by and large limited by the vertical supply of nutrients from subeuphotic zone waters (Chavez and Messié, 2009). Global and regional models suggest that the supply of nutrients may be altered by increasing frequency of extreme El Niño events and under future global warming scenarios (Cai et al., 2014; Gruber et al., 2011). Strong historical El Niño events can be proxies for future warming scenarios and have led to significant reductions in net primary production as observed for the 1982-83 and 1998-99 events in the California and Peru Currents. In this presentation we discuss carbon and nitrogen cycling dynamics for the recent warming events (2014-2016) for the California Current Ecosystem. Data suggest surface accumulating and sinking organic matter is similar to estimates of net oxygen production, a proxy of exportable production. Additionally, we highlight processes such as euphotic zone nitrate regeneration, which can contribute up to 30% of nitrate utilization by phytoplankton. Unutilized nitrate, living biomass and organic matter can also be advected from nearshore environments where the extent of cross-shore nitrogen transport has implications for food webs of nearby nutrient-depleted oligotrophic gyre.

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Influence of Aggregation on Benthic Reefscape Dynamics

Marlene Brito-Millan[1] †, Brad Werner[1], Stuart Sandin[1], Dylan McNamara[2]

Investigations of spatio-temporal patterns and dynamics of reefscapes are fundamental in understanding emergent reef states over various time scales. Reefscape patterns, particularly aggregation and composition (fractional cover), set the context for competitive processes affected by neighborhood interactions. Yet, the mechanism by which reefscape patterns influence competitive interactions and affect system behavior has not been fully characterized. Here, a quantitative dynamical analysis focuses on the effect of varying initial reefscape pattern on the emergent spatio-temporal dynamics of the reefscape. Both long-time scale (attractor) and short-to-intermediate time scale (pathway) characteristics are captured in the context of a coral reef benthic model of coral-algae competition. Trajectories of fractional cover were divided into phases describing the path towards the attractor (repelling, transient, attracting, attractor) and were quantified by duration and characteristic timescale. For both coral and macroalgae, increasing initial coral colony aggregation from over-dispersed to clumped produced a doubling in the repelling phase timescale and transient duration of trajectories. Underlying these delay trends was the geometry of competitors, in terms of shape and length of interacting borders, on the balance between ecological processes of recruitment, growth, mortality and competition. Further reefscape scenario analyses showed that aggregation has both a beneficial and deleterious effect on coral growth and persistence that depends on coral competitive dominance tied to overall reef condition. Aggregation level pattern evolution was also tracked as the fractional number of coral-to-coral border interactions over the entire lattice, which revealed the existence of an aggregation pattern attractor. Lastly, spatio-temporal forecasting confirmed the presence of nonlinear dynamics in transient self-organizing phases of trajectories. Accounting for the clumping-induced delay in coral cover change importantly 1) captures a feedback between reefscape pattern and smaller-scale neighborhood interactions, 2) impacts modeled reef projections, and 3) changes the expectation of reefscape evolution which influences reef stakeholders' decisions

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Blowing Smoke? Increased Carbon Monoxide (CO) Levels in Marine Mammals

Mike Tift[1] †

Carbon monoxide (CO) is known for the toxic property of binding tightly to hemoglobin, forming carboxyhemoglobin (COHb), and can prevent oxygen delivery to tissues when COHb values get too high. However, the recent discovery of 1) heme degradation leading to natural CO production in the body, and 2) therapeutic properties from moderate CO exposure has shed new light on the gas. This natural production of CO in the body leads to approximately 0.4 - 1% COHb in non-smoking humans. The most promising therapeutic potential of moderate CO exposure has been attributed reduction in specific conditions (inflammation, apoptosis, cell proliferation) associated with ischemia-reperfusion events. Due to the increased heme protein stores and repetitive ischemia-reperfusion events associated with the dive response in diving animals, we wanted to investigate endogenous CO levels in the breath (ppm CO) and blood (% carboxyhemoglobin - COHb) of four species of cetaceans (Bottlenose dolphins, short-finned pilot whales, killer whales and beluga whales) and two pinniped species (northern elephant seals and Hawaiian monk seals). Our findings show that animals with the most elevated heme protein stores (elephant seals, monk seals and beluga whales) have increased exhaled CO levels (23ppm, 6ppm and 7ppm, respectively) that mimic those seen in human cigarette smokers (> 6 ppm). However, only the elephant seal displayed dramatic elevations in blood CO with values as high as 17.6% COHb (chronic cigarette smoker: 6-15% COHb). These high values are hypothesized to result from elevated erythrocyte turnover in a species with the highest mass-specific mammalian blood volume and hemoglobin concentrations. We suggest that these natural elevations in CO potentially serve to protect the animals against injuries related to consistent ischemia-reperfusion events associated with a lifestyle of breath-holding and the dive-response.

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Development of a dual solid-state pH-AT sensor

Ellen Briggs[1] †, Todd Martz[1], Sergio Sandoval[2], Andrew Kummel[2]

Here we report on our progress toward development of a solid state, reagentless sensor capable of rapid and simultaneous measurement of pH and Total Alkalinity (AT) using ion sensitive field effect transistor (ISFET) technology. The goal of this work is to provide a means of continuous, direct measurement of the seawater carbon dioxide system through measurement of two master variables (pH and AT). ISFET-based pH sensors that achieve 0.001 precision are presently in widespread use on autonomous oceanographic platforms. Modifications to an ISFET allow a nL-scale acid-base titration of total alkalinity to be carried out in ∼10 s. Titrant, H^+, is generated through the electrolysis of water on the surface of the chip eliminating the requirement of external reagents. Initial characterization has been performed titrating individual components (i.e. OH^-, HCO_3^-, CO_3^{2-}, PO_4^{3-}) of seawater AT. Based on previous work by others in simple acid-base systems and our preliminary results in seawater we feel that it is within reach to set a benchmark goal of ∼10 μmol kg^{-1} precision in AT. The estimated resolution of this dual pH-AT sensor translates to approximately 0.5 and 0.7% error in Total Dissolved Inorganic Carbon (CT) and pCO_2 respectively and would have a number of immediate applications for investigating biogeochemical processes where strong gradients exist over short distances and in rapidly changing environments.

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Metabologenomics: reading the code of life in the seek for novel drugs from the sea

Tiago Leao[1,2], Guilherme Castelao[3], Paige Dubelko[1], Evgenia Glukhov[1], Lena Gerwick[1], William Gerwick[1] †

Cyanobacteria are major sources of biologically-captured oxygen, nitrogen and carbon in many different ecosystems. In addition to the importance of their primary metabolism, some cyanobacteria are also a prolific source for unique secondary metabolites (also known as natural products). These metabolites tend to have powerful biological properties and work through distinct and often-times unique pharmacological mechanisms, making them important tool compounds as well as drug leads. Traditional chemical investigations of the cyanobacterial genus Moorea already yielded the isolation of over 190 new compounds in the last two decades. However, the modern genomics revolution revealed that the number and diversity of compounds found in microbes till date are only the tip of the iceberg, which raised new expectations for the future of natural products discovery. Unfortunately, incomplete genomic information has hampered the discovery of novel compounds using genome mining approaches of Moorea strains. Therefore, we report the first complete genome of filamentous marine tropical cyanobacterium, Moorea producens PAL, along with the improvement of other three Moorea draft genomes. Our analyses revealed the vast and rare metabolic potential in those well chemically investigated strains, highlighting that these strains are still a great source for genome-guided isolation of new natural products. By reading the genomes of Moorea spp. (more specifically their natural product genes), we are unfolding key paradigms in these cyanobacteria, such as: how to prioritize pathways leading to the discovery of novel compounds, how to boost their production and how to select the most suitable isolation techniques.

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Predicting fisheries bycatch risk for dynamic spatial management

Brian Stock[1,2] †, Eric Ward[3,4], Tomo Eguchi[5,6], Brice Semmens[1,2]

Nearly all marine fisheries have at least some bycatch, which concerns commercial and recreational fishermen, resource managers, conservationists, and the public. High bycatch rates reduce the efficiency and sustainability of fisheries, but even extremely low bycatch rates can be a problem for protected or rebuilding species. Spatial fishing practices affect bycatch rates, and understanding spatiotemporal patterns in bycatch offers a possibility to move from static time-area closures to dynamic, near real-time management. We demonstrate the ability of powerful new modeling tools to produce spatial bycatch prediction maps for two large U.S. fisheries (West Coast groundfish trawl and Hawaii longline targeting swordfish). We compare the performance of different spatial modeling frameworks (INLA-SPDE, GAMs, and random forests) for species with a range of bycatch rates (e.g. leatherback turtle 0.75%, blue shark 96.2%), calculating the percent bycatch reduction under alternative management actions (percent fishing removed).

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Small Molecule Accurate Recognition Technology (SMART): A Digital Frontier to Reshape Natural Products Research

Chen Zhang[1] †, William Gerwick[2]

In most natural products research (NPR), the characterization of novel compounds as well as the dereplication of known compounds entails the collection and analysis of NMR spectra. This involves the running of 1D and 2D NMR spectroscopic experiments for the purpose of partial structure construction, assemblage and relative stereochemistry determination. As exciting advancements in the rapid genetic and proteomic approaches have made their way into NPR, conventional NMR practices have become one of several bottlenecks in the characterization and dereplication of new compounds. In regard to this challenge, we leveraged the advantages of Non Uniform Sampling Nuclear Magnetic Resonance (NUS NMR) and Artificial Intelligence (AI) to create Small Molecule Accurate Recognition Technology (SMART) as a tool to speed up marine natural products discovery. Fast NMR techniques like NUS NMR have the potential to further reduce detection limits while maintaining the same sampling time and quality. Next, we applied over 4100 experimental Heteronuclear Single Quantum Correlation (HSQC) spectra for the AI training. The outcome is that the AI algorithm provided us with structurally insightful embedding maps with nodes and clusters representing correlations of related families of natural products. By testing different HSQC spectra using this algorithm, we can greatly accelerate the rate of known compound identification as well as rapidly generating hypotheses about the relationship of new molecules to those used for the training - based entirely on their NMR properties.

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Understanding Human Induced Climate Change in the presence of Natural Variability

Anna Merrifield[1] †

Variations in air temperature and precipitation are inherent to the chaotic climate system, making it difficult for researchers to answer a favorite question of the public: Did this happen because of global warming? Using a state of the art global climate model, we will investigate regional trends in air temperature and precipitation anticipated to occur over North America if greenhouse gas (GHG) emissions continue unchecked. A statistical method will be used to separate the trends into forced (human-induced) and internal (naturally driven) components in order to quantify the human contribution to warming and precipitation changes in the 21st century.

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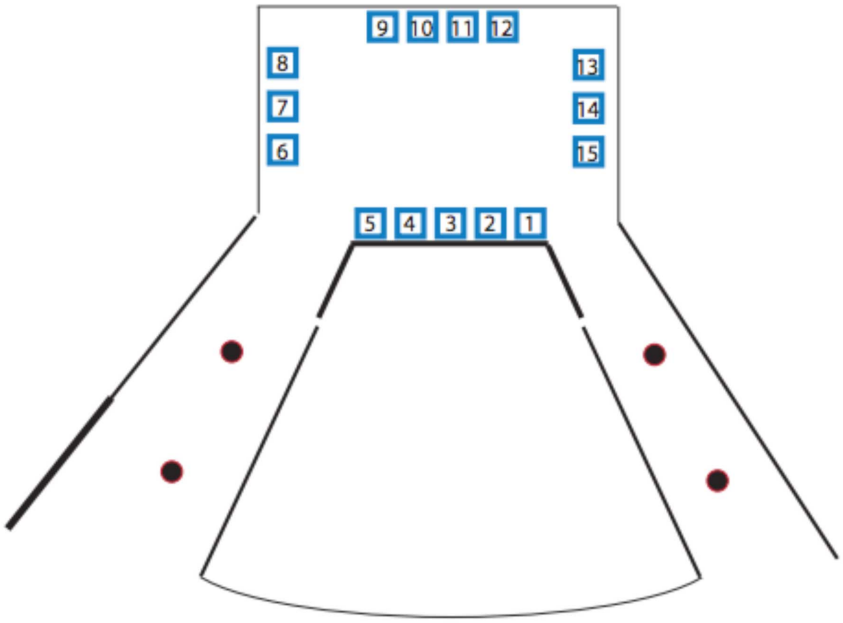
Poster Map



Coral Competitive Networks: Consistent Interspecific Dynamics Demonstrated using Large-Area Imagery

Calvin Tsang[1,2] †, Estefani Zepeda[1], Clinton Edwards[1], Yoan Eynaud[1], Stuart Sandin[1]

A large-scale examination of coral-coral competition using digitized photomosaics constructed from large-area imaging technology in the Sandin Lab. This study focuses on interspecific competitive networks between major coral species in different sites along the perimeter of Palmyra Atoll in the Line Islands. The purpose is to understand how spatial patterns may evolve over time between key hermatypic species considering growth forms and life histories. Previously constrained to small-scale studies, limited interaction pairs and inconsistent competition parameters, the combination of this technology with applied spatial ecological techniques allows assessment of massive competitive change previously unachievable in reef dynamics. Using this approach we will attempt to determine if there are consistent rules of engagement that species follow in interspecific coral interactions and how this relates to the eventual development of the reef.

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Observations of arrested internal lee waves at a tall, steep submarine ridge

Celia Ou[1] [†], Shaun Johnston[1]

Abrupt, steep topography in the western Pacific may generate arrested internal lee waves as the strong, steady currents flow past them. As part of ONR's Flow Encountering Abrupt Topography (FLEAT) program, spatial surveys with shipboard ADCP and a towed CTD (SeaSoar) were conducted over a submarine ridge near Merir Island in the midst of the North Equatorial Countercurrent (NECC). We observed a strong mean flow in the NECC ranging from 0.3 to 1.0 m/s in the upper 400 m upstream of Merir Island. We found oscillations in density and velocity with horizontal wavelengths of 10 to 20 km, and intrinsic periods of O(0.1-1 days). These oscillations persisted over the 2 days of the survey. The depth-integrated internal wave energy flux was 3 kW/m westward. The mean vertical energy flux was 0.3 W/m2. Vertical energy flux divergence suggests dissipation of O(-6 log(W/kg)).

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Ocean temperature reconstruction of the MIS 5-4 transition from ice cores: noble gas thermometry

Sarah Shackleton[1] †, J. A. Menking[2], B. Bereiter[3], E. J. Brook[2], D. Baggenstos[3], A. Seltzer[1], J. P. Severinghaus[1]

Understanding the mechanisms controlling atmospheric CO_2 for glacial-interglacial cycles has been an active area of research in the paleoclimate community for decades. About one third of the drawdown of atmospheric CO_2 of the last glacial inception occurred rapidly at about 70 kyr during the Marine Isotope Stage 5-4 transition. Here we present an ocean temperature reconstruction from this period to quantify the CO_2 drawdown due to changes in temperature-driven solubility.

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Seismogeodetic Observations of the June 10, 2016 M5.2 Borrego Springs Earthquake

Dara Goldberg[1], Jessie Saunders[1] †, Jennifer Haase[1], Yehuda Bock[1]

On June 10, 2016 a M5.2 earthquake struck Borrego Springs, California, near the San Jacinto Fault. The earthquake was widely felt in southern California, and was observed on seismic and geodetic (GPS) instrumentation located up to 100 km from the source. We present lessons from this event pertaining to the capabilities of a protoype earthquake early warning system developed at Scripps. Our system is the first seismogeodetic approach to earthquake early warning, relying on the optimal combination of high rate GPS observations and strong motion accelerations to produce a single data stream of broadband velocities and displacements. Seismogeodesy requires collocated GPS and accelerometer instrumentation. To that end, our group has developed a low cost geodetic module and MEMS accelerometer package (SIO GAP) that is installed on the vertical leg of existing continuous GPS stations. The SIO GAP combines the GPS and accelerometer data, which is then communicated to our central servers in real time. So far, SIO GAPs have been installed at 17 GPS stations spanning the San Andreas, San Jacinto, and Elsinore Faults and at 10 GPS stations in the San Francisco Bay Area.

The Borrego Springs earthquake was detected by 11 of these stations in southern California, as well as by observatory grade strong motion instruments. We compare seismogeodetic combinations using observatory-grade accelerometers to those using SIO GAPs to demonstrate the capabilities of these low-cost instruments in the field. We demonstrate the earthquake early warning products possible for the Borrego Springs event using the seismogeodetic approach, and show the utility of the seismogeodetic velocities for detection of first seismic arrivals as well as the results of our rapid event location and shaking onset prediction. From the location estimate, we estimate the moment magnitude using a simple scaling relation from peak ground displacement measured from the seismogodetic displacement.

This event was also observed on seismogeodetic instrumentation used for structural monitoring at a parking garage at the Automatous University of Baja California Faculty of Medicine in Mexicali. The observations show the building response, and demonstrate the feasibility of structural monitoring using seismogeodesy.

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Development of Seawater Dissolved Gas Extraction and Laser-based DIC and δ13C-DIC Analysis System

Mariela K Brooks[1] †, William Paplawsky[1], Andreas J Andersson[1], Ralph F Keeling[1]

The ocean plays a critical role in the global carbon cycle and it is especially important to improve our understanding of how marine carbon uptake and storage may respond to climate change. The $^{13}C/^{12}C$ ratio of dissolved inorganic carbon (δ^{13}C-DIC) in seawater is a powerful tool for quantifying important aspects of the marine carbon cycle, especially when combined with measurements of total DIC and Alkalinity (ALK). Currently, high precision measurements of δ13C-DIC ratios are made using isotope ratio mass spectrometers (IRMS) which have significant limitations in terms of reliability, analytical costs, and complexity. Here I present the development of a seawater gas extraction system to interface with a new laser-based isotope measurement instrument offering a simplified method and streamlined sample introduction that will reduce sample size and run-time while optimizing precision, cost, and reliability. The new analyzer uses a continuous-wave quantum cascade laser (QCL) and multi-pass optical absorption cells. Bypassing the need for additional analytical steps such as CO_2 vacuum-based extractions, the QCL and seawater gas extraction system will facilitate high precision measurements of δ^{13}C-DIC and DIC that can be made directly on seawater samples. Pioneering the use of QCL for discrete seawater samples, this project will upgrade the current isotopic seawater carbon analysis capabilities at Scripps, making it more feasible to continue to maintain the Scripps seawater δ^{13}C-DIC time series records while also providing the opportunity to significantly broaden the application of these important biogeochemical values and this technology.

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Metagenomic analysis of Brachiostoma floridae as a key chordate host-microbiome system

Jessica Blanton[1] †, Eric E. Allen[2], Nicholas D. Holland[3]

Continued exploration of new animal models is necessary to broaden our fundamental understanding of the principles that drive and sustain host-microbiome relationships. To date, extensive investigation of these systems using high throughput sequencing approaches have focused on relatively few chordates, primarily zebrafish, mice and humans. This bottleneck is largely due to technical and cost limitations in obtaining sufficient data from the microbial component against a high background of host DNA. Brachiostoma floridae (the Florida lancelet) is a member of the cephalochordates and holds an important phylogenetic position in relation to the vertebrates. Due to its evolutionary placement, Brachiostoma are of great interest for comparative studies in developmental biology, immunology, and evolutionary genomics. Here we explore the potential for microbiome studies in this basal chordate by providing a preliminary analysis of the community composition and potential activities of the gut microbiota. Using shotgun metagenomics, we establish that extracted DNA of gut contents from Brachiostoma is less than 8% host, and up to 30% bacterial. Furthermore, comparative 18S rRNA sequence profiles of gut contents from other chordates, including hagfish, sharks and bony fishes, showed these systems often contain up to 90% host sequences, while wild and cultured Brachiostoma host sequences constitute less than 10% of the read abundance. These results indicate that targeted methods to identify microbiome constituents and potential diet items are relatively simple and straightforward in Brachiostoma. This work demonstrates that Brachiostoma floridae serves as a tractable, phylogenetically significant system to explore host-microbiome interactions in wild and laboratory settings.

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Nitrification contributions to Nitrate Utilization in the California Current Ecosystem-LTER Domain

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One of the persisting paradigms in oceanography is that deep ocean nitrate and atmospheric nitrogen fixation contribute new sources of nitrogen in support of the base of the food web, and that under steady state conditions the amount of nitrogen exported from the euphotic zone should equal the supply of new nitrogen (Eppley and Peterson, 1979). However, model-based studies in the California Current demonstrate local export to be out of balance with supply due to the lateral advection of nutrients, living biomass and organic matter (e.g., Plattner et al., 2005). Further, mesocosm incubations and in situ stable isotope data for the central California Current show that a portion of the nitrate supply is actually derived from recycled sources (i.e., due to nitrification) within the euphotic zone and is therefore a nitrate source that is not "new" to the euphotic zone (Wankel et al., 2007; Santoro et al., 2013). Such studies focusing on nitrification have not been able to directly address the interaction of nitrate supply and export due to limited sampling schemes. To address this need the California Current Ecosystem Long-term Ecological Research (CCE-LTER) site affords the advantage of a diverse set of in situ measurements made on a unique set of water parcels followed over the course of several days. Data presented here focus on the contribution of euphotic zone-based nitrification while comparing to the rates of subsurface nitrate supply and sinking export of organic nitrogen. At times, euphotic zone nitrification can contribute up to 30% of nitrate utilization by phytoplankton. Accounting for nitrification, sinking export still only represents half of nitrate supply for coastal CCE-LTER regions suggesting the lateral transport of nitrate and organic matter to play a role in the cross-shore balance of new and export production. Ultimately, the strength of cross-shore nitrogen transport has implications for the support of food webs in the nearby nutrient-depleted oligotrophic gyre.

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Comparing Bacterial Abundances in the California Current Ecosystem Region Across El Niño, "Normal"; and Blob Years

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Heterotrophic marine bacteria, through the microbial loop, play a substantial role in oceanic nutrient cycling. Up to 50% of marine primary production is channeled through the microbial loop, but that fraction is highly variable over time and space. While the microbial loop is well acknowledged, its impact in marine food webs and biogeochemical cycles, on both spatial and temporal scales, are understudied. My research uses data collected through the California Current Ecosystem (CCE) Long Term Ecological Research (LTER) to discern changes in heterotrophic bacterial abundance and size on both of these scales to address the impact of the microbial loop within the CCE. This study specifically looks at how the microbial contribution is affected by recent El Niño and the warm Blob years compared to "normal" years.

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Benthic Boundary Layer: Possible Source of Iron to the CCE

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The benthic boundary layer, BBL, is a layer of resuspended sediment just above the ocean bottom. It is thought that iron from the BBL may be transported to the upper water column providing phytoplankton and other organisms a vital micronutrient to carry out various biological processes. Various studies of the BBL have been conducted in Northern and Central California but few around the region of Pt. Conception, a region regularly studied by the California Current Ecosystem (CCE) LTER program. Iron has been shown to be a limiting nutrient in the CCE but the cycling and sources of iron in the CCE are not fully known. During the Spring 2016 CCE process cruise a study of the BBL at six sites along the coast of the CCE study region was carried out. Samples for dissolved iron, total dissolvable iron, and iron speciation were collected. Transmissometer results show a prominent BBL north of Pt. Arguello at the outflow of the Santa Ynez river. Results from iron analysis reveal a large pool of iron in the particulate form, well over 100nM. Although the extent of transport this iron undergoes is not well known, and more work needs to be done, without significant dust input in the CCE region the BBL may provide a significant supply of iron to the CCE.

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Characterization of the molecular mechanisms of iron acquisition in the marine copiotroph Alteromonas macleodii ATCC 27126

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Through significant progress made in recent decades, marine bacteria are now recognized as the major facilitators of the turnover of organic matter in the oceans through the breakdown and remineralization of carbon and its associated nutrients. As 'first responders' to bloom events and other episodes of particle enrichment, the Alteromonas genus plays an especially important role in this cycling. However, many of the molecular mechanisms underlying these processes have yet to be explored. This is particularly true for remineralization processes of the micronutrient iron. As is true for most organisms, heterotrophic bacteria have a necessary iron requirement, and it is estimated that a majority of iron in heterotrophic bacteria is found in pathways involved in the breakdown and processing of organic matter. As such, it is reasonable that these species with significant capacity for breaking down organic matter would also have a significant iron requirement with dedicated cellular machinery for meeting this requirement. The ability of copiotrophic bacteria to scavenge iron from their environment may be key to their ability to dominate the microbial community and play an important role in the cycling of both carbon and iron. This work uses Alteromonas macleodii ATCC 27126 as a model bacterium representing an ecologically significant copiotroph, in order to better understand the molecular mechanisms by which it obtains iron and how this affects and connects both the iron and carbon biogeochemical cycles.

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Ocean-atmosphere enzyme transfer

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Marine enzymes significantly influence seawater chemical composition by rapidly converting large quantities of their target substrates. By shaping the pool of candidate molecules to transfer in sea spray, a major global aerosol, enzymes are also partially controlling sea spray composition. In addition, the enzymes themselves can be found in sea spray. Here I present a first look at enzyme activities in sea water, the surface microlayer, sea spray from four phytoplankton blooms. Relative activities in the three reservoirs are compared to investigate promotion or inhibition of certain enzyme types to transfer from the ocean to the atmosphere in sea spray aerosol.

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Dissolution Rates of Biogenic Carbonate Sediments from the Bermuda Platform

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The contribution of biogenic carbonate sediment dissolution rates to overall net reef accretion/erosion (under both present and future oceanic pCO_2 levels) has been strikingly neglected, despite experimental results indicating that sediment dissolution might be more sensitive to ocean acidification (OA) than calcification. Dissolution of carbonate sediments could impact net reef accretion rates as well as the formation and preservation of valuable marine and terrestrial ecosystems.

Despite many laboratory studies on biogenic carbonate dissolution, a significant disparity still exists between laboratory measurements and field observations. Performing additional controlled, laboratory experiments on natural sediment may help to elucidate the reasons for this disparity.

The bulk sediment dissolution rates of samples from the Bermuda carbonate platform were measured in natural seawater at pCO_2 values ranging from approximately 3500 μatm to 9000 μatm. This range of pCO_2 levels incorporates values currently observed in porewaters on the Bermuda carbonate platform as well as a potential future increase in porewater pCO_2 levels due to OA. Sediment samples from two different stations on the reef platform were analyzed for grain size and mineralogy. Dissolution rates of sediments in the dominant grain size fraction of the platform (500-1000 μm) from both stations ranged between 16.25 and 47.19 ($\pm$ 0.27 to 0.79) μmoles g^{-1} hr^{-1} and are comparable to rates previously obtained from laboratory experiments on other natural carbonate sediments. Sediments of very similar mineralogy, but different grain sizes, exhibited faster dissolution rates of coarse grain sediments when compared to finer grained sediments. This surprising pattern was not explained by total surface area, chemical characteristics, or mineralogy, which suggests an unidentified driver (or inhibitor) of dissolution in natural sediments. Further experiments must be performed to elucidate the reason for this unusual pattern.

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Assessing the Impact of Concordiasi Stratospheric Balloon Dropsondes and RO Observations on Antarctic cyclone forecasting

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We assimilate GPS Radio Occultation observations and dropsondes from the 2010 Concordiasi campaign and assess their impact on Antarctic weather analysis and forecasting. We use this unique data set to assess the impact of this data on weather forecasting using the Weather Research and Forecasting (WRF) model. Data is assimilated into WRF using a local ensemble transform Kalman filter system (LETKF). Results of data assimilation for a case study of Antarctic cyclone forecasting shows a positive impact on the assimilation of dropsondes for cyclone intensity and location. A single-profile test of RO observations shows the largest impact around the 500 mb level. This study directly enhances weather forecasting in the Antarctic by assessing the impact of additional data observation sources on WRF model forecasts through data assimilation.

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Surface slip rate of the Imperial Fault estimated from remote controlled quadcopter photogrammetry

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In recent years, advances in photogrammetry have allowed remote controlled quadcopters to emerge as a useful tool for remote geological surveying. These tools allow pilots to collect photographic data of difficult to reach outcrops and create a three-dimensional model for easy interpretation. However, the geodetic applications of this technique are limited by the poor accuracy of the quadcopter GPS, which introduces distortions into generated 3D models. To minimize such distortions, we couple quadcopter imagery with independent campaign GPS measurements, which serve as ground truths. In 2016 we conducted a campaign-style GPS Survey along the Imperial Fault, occupying monuments adjacent to an intersection between the fault trace and a concrete canal along which surface fault displacement is readily visible. We conducted a concurrent quadcopter survey of these monuments, collecting photographic images of the canal as it crosses the fault trace. We process these images using the Agisoft Photoscan Pro software to create a three dimensional model of the canal. From this model, we measure a displacement in the canal of 88-102 cm. Comparing this displacement estimate to historical measurements made following the October 15, 1979 Imperial Valley earthquake yields a surface slip rate of 7-11 mm/yr, consistent with accepted values.

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An Absolute Self-Calibrating Pressure Recorder for Campaign-Style Detection of Vertical Seafloor Deformation in the Cascadia Subduction Zone

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Seawater pressure can be used to detect vertical seafloor deformation because small changes in seafloor height produce measurable pressure changes. Vertical deformation rates in subduction zones due to secular strain are expected to be less than 1 cm/year, signals that are difficult to measure with pressure gauges because of gauge drift. The Self-Calibrating Pressure Recorder (SCPR) was designed to circumvent the problem of gauge drift by employing a deadweight calibrator, which periodically provides a reference pressure that is used to correct for drift in a continuously recorded pressure record. Alternatively, the SCPR can be used to make campaign-style determinations of true seafloor pressure to support long-term deformation measurements and provide an exact reference for nearby pressure gauges. This Absolute Self-Calibrating Pressure Recorder (ASCPR) requires a metrological assessment of measurement parameters to ensure that its absolute accuracy is sufficient to resolve secular deformation. While on a concrete seafloor benchmark, alternating calibration and seawater observations are made every 10-20 minutes for several hours. The difference between the known reference pressure and the seafloor pressure is observed, which allows the calculation of the true, absolute seafloor pressure. In 2014 and 2015, seven concrete benchmarks were placed on the seafloor in the Cascadia subduction zone off central Oregon along a profile that extends from 20 km to 105 km offshore. We surveyed two benchmarks in 2014, 2015, and 2016, a third one in 2015 and 2016, and four more in 2016. Current measurement repeatability varies from 2 to 5 cm, but several corrections still need to be incorporated. The expected resolution is 1 cm.

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