Western Society of Naturalists
Program

Vancouver, WA
Nov. 10-13, 2011
Registration and Information
Welcome! The registration desk will be open Thurs 1600-2000, Fri-Sat 0730-1800, and Sun 0800-1000. Registration packets will be available at the registration table for those members who have pre-registered. Those who have not pre-registered but wish to attend the meeting can pay for membership and registration (with a $20 late fee) at the registration table. Unfortunately, banquet tickets cannot be sold at the meeting because the hotel requires final counts of attendees well in advance. The Attitude Adjustment Hour (AAH) is included in the registration price, so you will only need to show your badge for admittance. WSN t-shirts and other merchandise can be purchased or picked up at the WSN Student Committee table.

A partial list of restaurants near the Vancouver Hilton can be found at the end of the program.

Continuing This Year!
In addition to all the traditional WSN special events (see the schedule!), the dance immediately following the auction on Saturday night (so probably starting ~11 pm) is back by popular demand! Music will be provided by the Student Committee. A cash bar will be available from 10 PM – 12 AM, and the dance floor will be open until 1 AM.

Thanks to Student Travel Fund Donors
We’d like to thank all of you who made donations to the Student Travel Fund when you registered; those funds are greatly appreciated by our many student members. Thanks to all!
SCHEDULE OF EVENTS

THURSDAY, NOVEMBER 10, 2011
1800  WSN STUDENT WORKSHOP (Hemlock/Oak Theater)
      BROADENING YOUR IMPACTS: HOW TO SUCCESSFULLY ADDRESS THE 'BROADER IMPACTS' OF YOUR RESEARCH
      by Shawn Rowe and Coral Gehrke, Center for Ocean Science Education Excellence (COSEE)-Pacific Partnerships.

2030  WSN STUDENT MIXER
      Atrium Lounge (606 Broadway Street, Vancouver, WA)
      Open to all graduate and undergraduate students; no ticket required.
      See the student desk for directions.

FRIDAY, NOVEMBER 11, 2011
0855-1200 STUDENT SYMPOSIUM (Heritage Ballroom A/B)
      INTERDISCIPLINARY ECOLOGY: INCREASING OUR UNDERSTANDING OF THE NATURAL WORLD BY LOOKING BEYOND IT.
1200-1300 LUNCH
1300-1730 CONTRIBUTED PAPERS
1830-2030 WSN POSTER SESSION (Heritage Ballroom A/B)
1930-2230 ATTITUDE ADJUSTMENT HOUR (AAH) (Heritage Ballroom A/B)

SATURDAY, NOVEMBER 12, 2011
0800-1115 PRESIDENTIAL SYMPOSIUM (Heritage Ballroom A/B)
      SYMPOSIUM TITLE: SOLUTIONS TO THE FISHERIES CRISIS: STORIES OF SUCCESS AND THE WAY FORWARD
1115  AWARDING OF LIFETIME ACHIEVEMENT AWARD (by Fio Micheli)
1130  AWARDING OF NATURALIST OF THE YEAR AWARD
1135  WSN NATURALIST OF THE YEAR (Megan Dethier)
1200-1300 LUNCH
1300-1730 CONTRIBUTED PAPERS
1800-1900 ANNUAL BUSINESS MEETING (Heritage Ballroom C)
1900-2100 PRESIDENTIAL BANQUET (Discovery Ballroom A/B)
2100-0100 WSN AUCTION followed by DANCE (Discovery Ballroom A/B)

SUNDAY, NOVEMBER 13, 2011
0830-1000 CONTRIBUTED PAPERS
FRIDAY, NOVEMBER 11, 2011

STUDENT SYMPOSIUM (0855-1200)  HERITAGE BALLROOM A/B
INTERDISCIPLINARY ECOLOGY: INCREASING OUR UNDERSTANDING OF
THE NATURAL WORLD BY LOOKING BEYOND IT

0855  INTRODUCTION AND ANNOUNCEMENTS (Kristy Kroeker)

0900  Neo Martinez Pacific Ecoinformatics and Computational Ecology Lab
INTERDISCIPLINARY ECOLOGY: USING NETWORKS TO SYNTHESIZE AND INTEGRATE
ECOLOGY WITH COMPUTER SCIENCE AND ECOSYSTEM MANAGEMENT

0930  John Incardona NOAA Fisheries, NWFSC
UNDERSTANDING THE IMPACTS OF CHEMICAL POLLUTION ON BIODIVERSITY
THOUGH CONSERVATION MEDICINE

1000  Anne Guerry Natural Capital Project
AVOIDING THE TOWER OF BABEL: LESSONS ABOUT INTERDISCIPLINARY
COLLABORATIONS FROM THE NATURAL CAPITAL PROJECT

1030  BREAK

1100  Karen McLeod COMPASS
WALKING THE TALK: MARINE CONSERVATION THROUGH THE LENS OF COUPLED
HUMAN-NATURAL SYSTEMS

1130  PANEL DISCUSSION

1200-1300  LUNCH
| Time   | Session 1: HERITAGE C  
Intertidal Ecology I  
Chair: Brian Gaylord | Session 2: HERITAGE D  
Fisheries Ecology I  
Chair: Larry Allen | Session 3: HERITAGE E  
Community Ecology I  
Chair: Rebecca Martone | Session 4: HERITAGE F  
Invasive Species I  
Chair: Sean Craig | Session 5: DISCOVERY D/E  
Applied Ecology I  
Chair: Katie Arkema |
|--------|--------------------------------------------------|------------------|------------------|------------------|------------------|
| 1300   | Hayford, HA  
*NUCELLA OSTRINA ALTERS BEHAVIOR WHEN TIDAL CYCLE SHIFTS MICROCLIMATE* | Fejtek, SM  
MASSIVE DIE-OFF OF RED ABALONE, *H. RUFSCENS*, QUANTIFIED IN MARINE PROTECTED AREAS ALONG THE COAST OF SONOMA COUNTY, CALIFORNIA | Martone, RG  
WHERE’S THE BIOMASS? SEA OTTERS DRIVE REGIONAL DIFFERENCES IN SUBTIDAL ROCKY REEF FOOD WEBS ON VANCOUVER ISLAND | de Rivera, CE  
INTERACTIVE EFFECTS OF TEMPERATURE AND PREDATION ON BEHAVIOR AND RISK FOR AN INVASIVE CRAB | Andrews, KS  
COMBINING MOVEMENT AND BIOENERGETICS MODELING TO CALCULATE PREDATORY IMPACT OF SPINY DOGFISH IN PUGET SOUND |
| 1315   | † Augyte, S  
ALGAL BIODIVERSITY IN NORTHERN CALIFORNIA’S MARINE INTERTIDAL: A FUNCTIONAL GROUP METHOD | † Daly, B  
IN SITU PREDATION AND BEHAVIORAL PLASTICITY OF JUVENILE RED KING CRABS (PARALITHODES CAMTSCHATICUS) | † Lee, LC  
SHIFTING BASELINES IN A BENTHIC ROCKY REEF FOOD WEB: WHY PLACE AND TIME MATTER TO ASSESSING RECOVERY OF NORTHERN ABALONE IN BC | † Kelley, AL  
VARIATION IN THERMOTOLERANCE AND MORPHOLOGY OF THE INVASIVE *CARCINUS MAENAS* ON THE WEST COAST OF NORTH AMERICA | Calvanese, T  
MOVEMENT PATTERNS AND HOME RANGES OF FISHES OF THE REDFISH ROCKS MARINE RESERVE |
| 1330   | † Coyle, TA  
RELATIONSHIPS BETWEEN SALINITY AND VARIATION IN TROPHIC STRUCTURE ON ROCKY SHORES | † Aaito, EA  
ECOLOGICAL OBSTACLES: EVOLUTIONARY TRAJECTORIES AND PREDATOR-PREY INTERACTIONS IN A SIZE-SELECTIVE HARVEST MODEL | † Dolecai, RE  
SIGNALLING SEAWEEDS: CAN HERBIVORE-INDUCED CUES FROM MARINE SEAWEEDS FACILITATE PREDATOR FORAGING? | † Turner, BC  
EXAMINING THE POTENTIAL FOR OVERCOMPENSATION BY THE EUROPEAN GREEN CRAB, *CARCINUS MAENAS*, IN RESPONSE TO CONTROL EFFORTS | † Munday, ES  
EFFECTS OF VENTING AND DECOMPRESSION ON YELLOW TANGS (Z. FLAVESCENS) IN THE WEST HAWAII AQUARIUM FISHERY |
| 1345   | Garza, C  
SCALE DEPENDENCE IN THE DISTRIBUTION AND INTENSITY OF SPECIES DIVERSITY IN INTERTIDAL COMMUNITIES | Traiger, SB  
MULTIPLE APPROACHES TO ASSESSING THE EFFECTIVENESS OF MARINE RESERVES USING THE COMMERCIAL SEA CUCUMBER, *PARASTICHOPUS PARVIMENSIS* | † Whippo, R  
BENTHIC COMMUNITY STRUCTURE MEDIATED BY THE RED SEA URCHIN *STRONGYLOCENTROTUS FRANCISCANUS* IN THE SAN JUAN ARCHIPELAGO | † Wells, EH  
POST-INVASION CHANGES IN PREDATION PREFERENCES OF THE EASTERN OYSTER DRILL (UROSALPINX CINEREA): A BICOASTAL COMPARISON | Keeling, BE  
QUANTIFYING THE MAGNITUDE OF PREDATION ON PACIFIC HERRING (CLUPEA PALLASI) EGG LOSS FOLLOWING ANNUAL SPAWN EVENTS |
| 1400 | † Kordas, RL | EXPERIMENTAL WARMING REDUCES INVERTEBRATE DENSITY AND COMMUNITY RICHNESS ON ROCKY SHORES |
| 1415 | Davis, BM | ECOSYSTEM-LEVEL EFFECTS OF SEA OTTER (ENHYDRA LUTRIS) RECOLONIZATION ON ROCKY INTERTIDAL COMMUNITIES OF BC'S |
| 1430 | Gaylord, B | FUNCTIONAL IMPACTS OF OCEAN ACIDIFICATION IN THE INTERTIDAL FOUNDATION SPECIES, MYTILUS CALIFORNIANUS |
| 1445 | O'Donnell, MJ | EFFECTS OF REDUCED FOOD AND OCEAN ACIDIFICATION ON AN INTERTIDAL LIMPET |
| 1500 | Break | Break | Break | Break | Break |
| Time  | Session 6: HERITAGE C  
| Intertidal Ecology II  
| Chair: Dawn Vaughn | Session 7: HERITAGE D  
| Ecosystem Assessment  
| Chair: Jameal Samhouri | Session 8: HERITAGE E  
| Community Ecology II  
| Chair: Sarah Henkel | Session 9: HERITAGE F  
| Invasive Species II  
| Chair: Jen Ruesink | Session 10: DISCOVERY D/E  
| Applied Ecology II  
| Chair: Michelle Paddack |
| 1530 | † Gruman, CA  
| INVASIVE PREDATORS AND MARINE-TERRESTRIAL TROPHIC CASCADES IN HAIDA GWAII | Samhouri, JF  
| ECOLOGICAL CONSEQUENCES OF TOP PREDATOR DECLINE IN THE CALIFORNIA CURRENT | † Wood, CL  
| FISHING OUT MARINE PARASITES? MARINE RESERVES FACILITATE PARASITE POPULATIONS AMONG EXPLOITED HOST SPECIES OF CENTRAL CHILE | Albins, MA  
| EFFECTS OF INVASIVE PACIFIC RED LIONFISH ON CORAL-REEF FISH COMMUNITIES: A LARGE-SCALE, LONG-TERM EXPERIMENT | Paddack, MJ  
| SPECIES-SPECIFIC VARIATION IN POPULATION SIZE, STRUCTURE, AND HABITAT PREFERENCES OF ROCKFISH WITHIN HOWE SOUND, BC |
| 1545 | † Casper, NJ  
| DO CRABS NEED THEIR GREENS? DETERMINING THE NUTRITIONAL ROLE OF ALGAE IN THE DIET OF FIRST STAGE BRACHYURAN CRAB LARVAE | Sosik, E  
| YOU ARE WHAT YOU EAT? TESTING ASSUMPTIONS IN ISOTOPICALLY-BASED FOOD WEB MODELS | † Eerkes-Medrano, D  
| DIFFERENTIAL EFFECTS OF HYPOXIC CONDITIONS ON SURVIVAL OF PLANKTONIC LARVAE OF ROCKY INTERTIDAL INVERTEBRATES | † Pusack, TJ  
| RELATIVE EFFECTS OF INVASIVE INDO-PACIFIC RED LIONFISH VS. NATIVE GROUPER ON MORTALITY OF BRIDLED Goby IN THE BAHAMAS | † Galloway, AWE  
| FINE PHYLOGENETIC RESOLUTION OF MARINE MACROPHYTE FATTY ACIDS HAS IMPORTANT IMPLICATIONS FOR FOOD WEB STUDIES |
| 1600 | † Jones, E  
| DECREASED PALATABILITY IN THE BROWN SEAWEED SILVETIA COMPRESSA IN RESPONSE TO A MULTI-SPECIES HERBIVORE ASSEMBLAGE | Spitzack, TS  
| AN EMPIRICAL STUDY OF CORAL REEF RESILIENCE IN HAWAII | Henkel, SK  
| SPATIAL AND TEMPORAL PATTERNS IN THE DISTRIBUTION OF INFAUNAL INVERTEBRATES | † Benkwitt, CE  
| DENSITY DEPENDENCE IN INVASIVE LIONFISH (PTEROIS VOLITANS) ON ATLANTIC CORAL REEFS | † Young MA  
| A LANDSCAPE OF POSSIBILITIES: GEOSPATIAL APPROACHES FOR MODELING SPECIES HABITAT ASSOCIATIONS IN CALIFORNIA’S SUBTIDAL ENVIRONMENT |
| 1615 | † Kelly, JA  
| INVESTIGATION OF THE ECOLOGY AND GENETICS OF TWO DISTINCT MORPHS OF THE NUDIBRANCH DIAULULA SANDIEGENSIS | Helyer, JS  
| A SPATIAL FRAMEWORK FOR DESCRIBING CORAL RESPONSES TO A CHANGING CLIMATE IN THE NORTHWEST HAWAIIAN ISLANDS | † Burgess, AK  
| ALGAL TOXIN TRANSFER IN MARINE PLANKTIC FOOD WEBS: A LOOK AT NUTRITIONAL DEFICIENCIES, TOXICITY EFFECTS & TOXIN RESISTANCE | Juanes, F  
| POTENTIAL OF PASSIVE ACOUSTICS TO MONITOR THE INVASION OF THE HUDSON RIVER BY THE FRESHWATER DRUM, APLODINOTUS GRUNNIENS | † Evans, L  
<p>| BIOACCUMULATION OF COPPER AND ZINC BY THE GIANT KELP MACROCYSTIS PYRIFERA |</p>
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<td>Leong, W: Natural Variation and Selective Pressure of Environmental Stressors on Tigrionus Californicus</td>
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<td>Sanford, E: Ocean Acidification Increases the Vulnerability of Native Oysters to Invasive Drill Predation</td>
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<td>Ruesink, JL: Role of Climate and Ocean Chemistry in an Estuarine Invasion</td>
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<td>Rashier, DB: Chemical Warfare on Fijian Reefs: Macroalgae Damage Corals Using Surface-Associated Allelochemicals</td>
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<td>Vaughn, D: Sex-Specific Foraging and Growth in Thermally-Stressed Intertidal Snails</td>
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<td>Choo, CK: BACI Survey of the Impacts of Pier Construction on Tropical Seagrass Biomass and Morphology</td>
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<td>Brown, AL: Flow-Regulated Algal Turf Control of Oxygen Dynamics Within Interactions of Massive Porites Spp. and Algal Turf</td>
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<td>Grason, EW: Influence of Parasites on Patterns of Abundance, Distribution, and Size of Batillaria Attramentaria in Padilla Bay, WA</td>
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<td>Smith, DM: University of Washington Graduate Students in the High School: Who’s Teaching Who?</td>
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<td>Morgan, CB: Do Parents Know Best? Reproductive Plasticity in an Intertidal Gastropod</td>
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<td>Nielsen, KJ: Sand Crab Population Monitoring in MPAs: A Methodological Comparison to Inform Development of Ecosystem Indicators</td>
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<td>Lewis, LS: Functional Diversity of Herbivorous Urchins in the Kahekili Herbivore Fishery Management Area, Maui, HI</td>
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<td>Jeffries, SV: Assessing the Invasiveness of the Non-Native Kelp Undaria Pinnatifida in Monterey Harbor</td>
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<td>Bolton, DK: Caught Between a Rock and a Hard Place: Predation Pressure in Crevice Communities</td>
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<td>Jensen, MM: Do Wave Impact Forces Limit the Size of Intertidal Organisms?</td>
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<td>Elahi, R: A Consumer One-Two Punch: Facilitation and Functional Diversity Prevent Reversals in Community Composition</td>
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<td>Siple, MC: Defining the Ecosystem Engineer: Food Web Contributions of the Invasive Alga Gracilaria Salicornia</td>
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<td>Davidson, TM: Seawater Temperature Mediates the Biological Erosion and Plastic Pollution of a Non-Native Burrowing Crustacean</td>
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SATURDAY, NOVEMBER 12, 2011

PRESIDENTIAL SYMPOSIUM (0800-1115) 
HERITAGE BALLROOM AB 
SOLUTIONS TO THE FISHERIES CRISIS: STORIES OF SUCCESS AND THE WAY FORWARD

0800  INTRODUCTION (Fio Micheli)

0810  Pauly, D  University of British Columbia 
MAJOR TRENDS IN WORLD FISHERIES

0840  Castilla, JC  Universidad Catolica de Chile 
A PATH TO RATIONALIZE FISHERIES: CHILE´S GOVERNANCE, USE RIGHTS AND OCEAN ZONING

0910  Steneck, R  University of Maine 
THE AMERICAN LOBSTER - AMERICA'S GREATEST FISHERIES SUCCESS STORY OR ACCIDENT WAITING TO HAPPEN?

0940  BREAK

1000  Starr, R  Moss Landing Marine Labs  
COLLABORATIVE FISHERIES RESEARCH: A WAY OUT OF THE DATA-POOR FISHERY TRAP

1030  PANEL DISCUSSION

1115  AWARDING OF WSN LIFETIME ACHIEVEMENT AWARD  (by Fio Micheli)

1130  AWARDING OF NATURALIST OF THE YEAR AWARD  (by Fio Micheli)

1135  WSN NATURALIST OF THE YEAR  (Megan Dethier)

1200-1300  LUNCH
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<td>1300</td>
<td>HERITAGE C Intertidal Ecology III</td>
<td>Fisheries Ecology II</td>
<td>Conservation &amp; Ocean Health</td>
<td>Physiological Ecology I</td>
<td>Dispersal &amp; Recruitment I</td>
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<td>Chair: Jen Burnaford</td>
<td>Chair: Scott Hamilton</td>
<td>Chair: Phil Levin</td>
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<td>ARE TROPICAL TIDPOOLS A NURSERY HABITAT FOR JUVENILE REEF FISH? AN INVESTIGATION FROM OAHU, HAWAII</td>
<td>UTILIZING SPATIAL DEMOGRAPHIC AND LIFE HISTORY VARIATION TO OPTIMIZE SUSTAINABLE YIELD OF A TEMPERATE SEX-CHANGING FISH</td>
<td>SALMON ABUNDANCE PREDICTS ANNUAL GROWTH IN RIPARIAN SITKA SPRUCE</td>
<td>THE EFFECTS OF POLLUTION ON GROWTH AND FECUNDITY OF PARALABRAX NEBULIFER (BARRED SAND BASS) IN SOUTHERN CALIFORNIA</td>
<td>THE IMPORTANCE OF EARLY LIFE-HISTORY STAGES IN ECOLOGICAL SUCCESSION</td>
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<td>ORGANOCHLORINE CONTAMINANTS AND BIOCHEMICAL RESPONSES IN SOUTHERN CALIFORNIA STINGRAYS (UROBATUS HALLERI)</td>
<td>METABOLIC COSTS OF LARVAL SETTLEMENT AND METAMORPHOSIS IN THE CORAL SERIATOPORA HYSTRIX UNDER AMBIENT AND ELEVATED PCO2</td>
<td>PARENTAL EFFECTS MAY INFLUENCE RESPONSE OF BROODING CORALS TO CLIMATE CHANGE STRESSORS</td>
<td>SEASONAL ABUNDANCE AND TIDAL-TIMED MIGRATION OF OLYMPIA OYSTER LARVAE IN COOS BAY, OREGON</td>
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AVOIDING THE TOWER OF BABEL; LESSONS ABOUT INTERDISCIPLINARY COLLABORATIONS FROM THE NATURAL CAPITAL PROJECT

Natural Capital Project
Ecosystem services are essential to sustaining and fulfilling human life but their supply is threatened by the intensification of human impacts on the environment. Recently, efforts to value and protect ecosystem services have been promoted as the best hope for making conservation attractive and commonplace worldwide. In theory, if institutions recognize the values of Nature, then we can greatly enhance investments in conservation and foster human well-being at the same time. In practice, scientific and policy communities have not yet developed the scientific basis or the policy and finance mechanisms for integrating natural capital into resource and land-use decisions on a large scale. This gap between theory and practice can only be filled by interdisciplinary work. The Natural Capital project is one interdisciplinary effort aimed at advancing the science and practice of accounting for natural capital in the decisions of individuals, communities, corporations and governments. We began as a team of ecologists and economists, quickly realized that we needed much broader expertise and enlisted oceanographers, hydrologists, coastal engineers, computer scientists, GIS technicians, and communications experts. As we work in real decision contexts we work closely with managers, planners, and other decision-makers. And as we begin to include work on cultural ecosystem services, our circle of collaborators has grown to include anthropologists, philosophers, political scientists, and others. All of these collaborations necessitate careful and clear communication across disciplinary boundaries—no small feat. I will highlight lessons learned from these interdisciplinary collaborations and discuss the essential role they have played in advancing our mission of mainstreaming natural capital into decision-making.

Incardona, J.
UNDERSTANDING THE IMPACTS OF CHEMICAL POLLUTION ON BIODIVERSITY THROUGH CONSERVATION MEDICINE
NOAA Fisheries, NWFSC
Conservation Medicine is a relatively new discipline that was derived from a convergence of veterinary and human medicine, focusing on the need to understand the relationship of emerging infectious diseases to interactions between humans and endangered primates. Yet any medical student knows that a typical Department of Medicine is multidisciplinary, with subdivisions in Cardiology, Nephrology, Endocrinology, Oncology, in addition to Infectious Diseases. Major needs in Conservation Biology are to understand how organismal health influences the conservation and recovery of endangered species, and in turn how the 10s of thousands of chemical compounds that humans release into the environment impact the health of organisms for which we may have very little biological information. Traditional toxicology has focused on the lethal effects of chemicals, but the studies described here demonstrate (1) how we need to anticipate any type of adverse health impact from chemical exposure, and (2) how the sophisticated tools of modern biomedical research can be applied to multiple organisms to discern those impacts. A broader and more integrated Conservation Medicine could make considerable strides in understanding how our continually expanding chemical universe may contribute to a shrinking biodiversity.

Martinez, N.D.
INTERDISCIPLINARY ECOLOGY: USING NETWORKS TO SYNTHESIZE AND INTEGRATE ECOLOGY WITH COMPUTER SCIENCE AND ECOSYSTEM MANAGEMENT.
Pacific Ecoinformatics and Computational Ecology Lab
Science has fundamentally changed in the last decade or two. Several centuries guided primarily by a reductionist paradigm are giving way to a more holistic science guided by broad synthesis and integration. Networks appear to be one of the most basic and widely used intellectual tools helping to
propel this shift greatly aided by advances in computer science that provide critically important technical tools to pursue the new more inclusive concepts. In ecology, networks both help to synthesize subdisciplines such as behavioral, population, community and ecosystem ecology as well as evolution and also help to integrate disciplines including natural and social sciences such as ecology and economics. This presentation will describe this fundamental shift from in vitro and in vivo to in silico and data-enabled science using examples based on ecological networks. Examples will focus on basic concepts such as ecological diversity, complexity, and dynamics and applied concepts such as conservation ecology and ecosystem management. These examples will highlight computational methods including visualization, cloud-based computing and ecoinformatics using the semantic web. Finally, the concepts of interdisciplinarity and new emerging disciplines will be contrasted as different complementary roads to the future of environmental sciences.

McLeod, K.
WALKING THE TALK: MARINE CONSERVATION THROUGH THE LENS OF COUPLED HUMAN-NATURAL SYSTEMS
COMPASS
Sustainability in an increasingly human-dominated world requires recognizing that people are integral parts of all of the planet’s ecosystems – even the wet, salty ones. While there is a rich literature focused on coupled human-natural systems, there have been relatively few efforts to put these ideas into practice in the marine realm, particularly at scales larger than individual communities. Conceptualizing of the oceans as “peopled” is relatively simple, but putting these ideas into practice for conservation and policy is much harder. It also requires reconciling (or at least acknowledging tradeoffs among) potentially conflicting perspectives on what success means through social, economic, and ecological lenses. I will explore how the inclusion of people as integral parts of marine ecosystems affects how we define and evaluate conservation and management success. To illustrate a way forward, and a few of the bumps along the way, I will describe a new, interdisciplinary effort to define and measure ocean health through the flow of social benefits, now and in the future. Policy statements teem with phrases like “healthy, resilient, productive ecosystems” with no clear articulation of what healthy means. Integrating knowledge from ecology, fisheries, oceanography, economics, and other social sciences, the Ocean Health Index will enable users to consider how specific actions are likely to affect the ability of the ocean to provide benefits. The Index is designed to inform regional and national policy dialogue, catalyze efforts to more sustainably use and manage ocean resources, and raise public awareness.
Castilla, J.C.†
A PATH TO RATIONALIZE FISHERIES: CHILE´S GOVERNANCE, TERRITORIAL USE RIGHTS AND OCEAN ZONING
Facultad de Ciencias Biológicas, P. Universidad Catolica de Chile
Fishery-management policies based on the allocation of temporal exclusive rights for fisheries, territorial user rights, and sea zoning are recurrent tools to achieve fishery sustainability. The Chilean Fishery Law (1991) included those tools for the rational management of coastal benthic and pelagic resources. The law reformed the right to fish between artisan small boats/vessels (up to 18 m) and industrial fleets (vessels over 18 m). Space based sea zoning was decreed at two levels. (a) A 5 nautical miles macro-zone (total area of ca. 30.000 Km$^2$) along the coast between ca. 18° S to 41° S, and around Chilean oceanic islands was decreed; with exclusive fishery rights (all fisheries) for the artisan fleet. Industrial as well as artisan fleet can operate offshore outside the 5 miles macro-zone. (b) Inner inshore territorial user rights for fisheries (TURFs) were allocated to well establish small-scale fisher communities for the exclusive exploitation of benthic resources, based on a co-management scheme (mostly for divers). Twenty years after the application of this regulation overall fishery landings in Chile are more stable (around 4 million tons/year) and evenly shared between the artisan and industrial fleets. Further, industrial fleet vessel holding capacity (particularly for the industrial purse-seine fleet) had decreased in ca. 40-50%. The paper addresses successes, failures and difficulties in the application of above policies, jointly with the establishment of a quota systems for resources declared fully exploited. Overall, it is concluded that important steps have done in Chile to tackle the “race for fish” and to rationalize fishery activities. Nevertheless, there is still a along way to go.

Pauly, D.
MAJOR TRENDS IN WORLD FISHERIES
University of British Columbia
The three decades following World War II were a period of rapidly increasing fishing effort and landings, but also of spectacular collapses. Underreporting, ignoring scientific advice and blaming the environment emerged as standard response to ongoing fisheries collapses, which became increasingly more frequent, finally engulfing major fisheries North Atlantic, the North Pacific and elsewhere. The response to the depletion of traditional fishing grounds was an expansion of northern hemisphere fisheries in three dimensions: southward, into deeper waters and into new taxa, i.e., catching and marketing species of fish and invertebrates previously spurned, and usually lower in the food web. These expansions, which continued after the 1980s, but were unable to generate higher catches, and indeed to halt the now prevailing decline of global fisheries, provided new opportunities for mislabeling seafood unfamiliar to North Americans and Europeans, and misleading consumers, thus reducing the impact of seafood guides and similar effort toward sustainability. With fisheries catches declining, and aquaculture-despite all public relation efforts-not being able to pick up the slack, and rapidly increasing fuel prices, structural changes are to be expected in both the fishing industry and the scientific disciplines that study it and influences its governance. Notably, fisheries biology, now predominantly concerned with the welfare of the fishing industry, will have to be converted into fisheries conservation science, whose goal will be to resolve the maintain the marine biodiversity and ecosystems that provide existential services to fisheries. Similarly, fisheries economists will have to get past their obsession with privatising fisheries resources, as their stated goal of providing the proper incentives to fishers can be achieved without giving away what are, after all, public resources. Overall, the crisis that fisheries are now going through can be seen as an opportunity to renew both their structure-away from fuel-intensive large scale fisheries-and their governance, and to renew the disciplines which study fisheries, creating a fisheries conservation science in the process.
Starr, R.
COLLABORATIVE FISHERIES RESEARCH: A WAY OUT OF THE DATA-POOR FISHERY TRAP
Moss Landing Marine Laboratories
Fisheries in the U.S. are regulated by a complex system of federal fishery management councils and state agencies that strive to prevent overfishing while achieving an optimum yield from each fishery. An expensive system of data collection over large areas is used to drive stock assessments that provide estimates of allowable catch to achieve fishery goals. The complexity and cost of this data-intensive system result in few species being assessed and management units that span large areas of the coastline. We know that meta-populations or sub-stocks of fishes occur in much smaller areas, however, causing the current system of management to allow overfishing of some sub-stocks while underutilizing others. Also, when managers close areas to protect weak stocks, fishery-dependent information available to assess fish populations is diminished. Poor economic times exacerbate the problem of reduced information collection. A solution to this data-poor situation is to engage the fishing community in collaborative fisheries research. By working with fleets along the coast, we are able to gain finer-scale information, collect data in closed areas, and engender an increased stewardship ethic at a reduced cost. The result is better information at an ecologically relevant scale that can lead to improved conservation, reduced costs of management, and increased co-management and stewardship of fish populations.

Steneck, R.S.
THE AMERICAN LOBSTER - AMERICA'S GREATEST FISHERIES SUCCESS STORY OR ACCIDENT WAITING TO HAPPEN?
Darling Marine Center, University of Maine
The American lobster is perhaps the only fishery targeted for over 150 years but is doing better today than ever before. Today, lobsters comprise over 80% of Maine's harvested marine resource value. Inflation-corrected income from lobsters has steadily increased nearly 400% since 1985. This “success story” results from several factors. It is a “slot” fishery taking only intermediate-sized lobsters. Egg-bearing females cannot be landed and their tail is notched keeping them out of the fishery while the notch persists. The strong conservation ethic of lobstermen enforces regulations and punishes transgressors. These positive collective actions have been widely praised and were highlighted by Nobel Prize winning economist Elinor Ostrom. However, management successes, biogeography and centuries of overfishing predators have resulted in a hyperabundance of lobsters and remarkably low regional biologic and economic diversity. The social dependency on this lucrative monoculture is unprecedented. In southern New England, disease and stresses related to elevated ocean temperatures resulted in a > 70% lobster decline, prompting managers to propose closing the fishery. A similar collapse in Maine would fundamentally disrupt the social and economic foundation its coastal zone. Maine’s successful lobster fishery is a “gilded trap”. This is a type of social trap in which collective actions resulting from economically attractive opportunities outweigh concerns over associated risks or consequences. Avoiding or escaping gilded traps requires managing for increased biological and economic diversity. The challenge is to shift from single species management to multi-species, social-ecological approaches that diversify local ecosystems, societies, and economies.
Contributed Talks

† Aalto, E.A.
ECOLOGICAL OBSTACLES: EVOLUTIONARY TRAJECTORIES AND PREDATOR-PREY INTERACTIONS IN A SIZE-SELECTIVE HARVEST MODEL
University of California Davis
Fishery harvest affects target species through mechanisms besides simple population loss. Heavy mortality can exert strong evolutionary pressure through unequal impact on species demographics. Size-specific harvest has been shown to produce rapid changes in growth rate and size at maturity in both models and observations. The effect of species interactions on this evolutionary response is less well understood. The presence of other species may constrain the evolutionary trajectory through predation or competition while, reciprocally, the strength of those interactions may be altered by the ongoing trait change in the target species. Marine predators are often gape-limited, and a smaller prey adult size would be expected to increase the effects of predation by increasing the proportion of the population vulnerable to attack. I use a two-species quantitative genetics model to examine how optimal size under harvest changes with the addition of a gape-limited predator. I compare results for a generalist predator with those for an obligate Nicholson-Bailey predator to determine which forms of predation exert the greatest selective pressure. In general, the model suggests that the evolutionary effects of fishing can intensify the negative effects of gape-limited predation and lead to extinction under lighter harvest levels than single-species models would indicate. Although the target species may be capable of evolving in response to strong directional selection from harvest, the niche space it is evolving toward must be able to support it if increased predation or competition make coexistence impossible, then it will be forced into extinction.

Adreani, M.S.*, Steele, M.A.
ESTIMATING FECUNDITY, SPAWNING FREQUENCY, SEASON LENGTH OF TEMPERATE REEF FISH; A COMPARISON OF NATURAL AND ARTIFICIAL REEFS
California State University Northridge
The reproductive output of fishes is often used as a measure of the health and productivity of a given population. This measure may be of particular importance when habitat is altered in some way. Artificial reefs may provide new space for fishes to inhabit, but it is unclear whether fishes reproduce at the same rate on natural and artificial reefs. We tested whether the overall reproductive output on a large artificial reef was similar to nearby natural reefs using three of the most abundant species on rocky reefs in the Southern California Bight (California sheephead, kelp bass and senorita). Fish were collected during their reproductive season and we measured a range of reproductive parameters, including batch fecundity, spawning frequency and the length of the spawning season using visual assessments, gonad histology and egg counts. While there was some variation in the specific measures, our estimates of reproductive output for each of the three species were similar across all of the reefs. These results, along with additional estimates of overall reef productivity, suggest that artificial reefs have the potential to mitigate damages incurred to natural reefs and give us additional insight into the reproductive ecology of these ecologically important species.

† Ahmadia, G.N.
MICROHABITAT USE OF CRYPTOBENTHIC FISHES ACROSS THE CORAL REEF – SEAGRASS CONTINUUM
Texas A&M Corpus Christi
Cryptobenthic fishes have a significant influence on coral reef ecosystem dynamics; however, they have received considerably less attention than their larger, more conspicuous counterparts. In the zones adjacent to coral reefs, there is little or no information about cryptobenthic fishes even for basic parameters such as density and distribution, although smaller organisms are often thought to have some of the largest effects on ecosystem processes. This study investigated cryptobenthic fish distribution and microhabitat use in the coral reef –seagrass continuum. Data collection took place in the Wakatobi Marine National Park located in SE Sulawesi, Indonesia. Cryptobenthic fishes were sampled from predominant microhabitats in three parallel zones- reef flat, bommie flats and seagrass beds. Cryptobenthic fishes occurred in high densities and diversity with a total of 548 fishes collected
encompassing 52 species from 14 different families. There were no clear differences between fish microhabitat use and community structure across zone and of the few differences observed, those were limited to one or two of the metrics analyzed for particular microhabitat types. This suggests microhabitat availability is the key determinant of cryptobenthic fish distribution throughout the coral reef seagrass continuum despite the changes in biological and physical conditions among the zones.

Albins, M.A.*, Hixon, M.A.
EFFECTS OF INVASIVE PACIFIC RED LIONFISH ON CORAL-REEF FISH COMMUNITIES: A LARGE-SCALE, LONG-TERM EXPERIMENT
Oregon State University, Department of Zoology
Previous experiments examining the effects of invasive Pacific red lionfish (Pterois volitans) on tropical Western Atlantic and Caribbean coral-reef fish communities have been limited to small patch reefs (several square meters) and short time periods (two months or less). Although these experiments have shown that single small lionfish are capable of reducing net recruitment (by up to 94%) and species richness (by 4.6 species) of native fishes on smaller reefs, broader-scale impacts remain suggestive. I initiated a large-scale, long-term field experiment designed to assess the effects of lionfish on native reef-fish communities at spatial and temporal scales directly relevant to management and conservation efforts. Subsequent to baseline surveys, high- and low-density lionfish treatments were established on 10 large (1400 to 4000 m²) isolated coral reefs. After initiation of treatments, quarterly surveys of the native reef-fish communities were conducted for approximately 14 months. Lionfish caused significant reductions (mean ± SEM) in density (up to 3.22 ± 0.95 fish m⁻²), biomass (3.26 ± 1.10 g m⁻²), and species richness (4.92 ± 2.09 species) of small (<10 cm total length) native fishes. However, these negative effects on prey-sized fish had not yet translated into declines in a larger size class (10 to 20 cm total length) during the first 14 months of this experiment. These results corroborate and greatly extend those of earlier small-scale, short-term experiments, and provide quantitative estimates of the effects of lionfish on a scale directly relevant to coral-reef management.

Allen, L.G.¹*, Andrews, A.H.²
BOMB RADIOCARBON DATING AND ESTIMATED LONGEVITY OF GIANT SEA BASS (STEREOLEPIS GIGAS)
1 - California State University Northridge 2 - Pacific Islands Fisheries Science Center, NOAA
In January 2010, a massive giant sea bass (500 lbs, 227 kg; near maximum reported size of 557 lbs, 253 kg) was captured off Santa Cruz Island by commercial gill-netters. This specimen presented a unique opportunity for a first-time estimation and validation of longevity for the largest nearshore teleost of the northeastern Pacific. A transverse section of the sagittal otolith produced consistent counts of 62 opaque annuli along two different axes of the ventral sulcus region, translating into an estimated birth year of 1948. This age estimate was supported by measurements of radiocarbon (¹⁴C) in the other sagittal otolith core (within the first year of growth), relative to ∆¹⁴C reference records used for bomb radiocarbon dating. Two otolith core samples produced ∆¹⁴C values that were classified as pre-bomb (prior to ~1958-59), indicating a minimum lifespan of 51 years. It is possible that giant sea bass can normally live more than 60 or 70 years, but a previous estimate of up to 100 years remains unfounded.

† Anderson, L.M.*, Martone, P.T.
HARMFUL OR HELPFUL? BENEFITS RELAYED BY THE BROWN ALGAL EPIPHYTE, SORANTHERA ULVOIDEA, TO ITS RED ALGAL HOST, ODONTHALIA FLOCOSA
University of British Columbia
Aquatic algal epiphytes are often considered deleterious to host species. By growing on algae, marine epiphytes may inhibit photosynthesis, compete for nutrients, as well as increase drag and dislodgement risk of hosts. This ecological interaction is, thus, generally thought to negatively impact the growth and survival of host species. But is algal epiphytism always detrimental? Soranthera ulvoidea is a saccate brown epiphyte that commonly grows on the branched red alga, Odonthalia flocossa, in the intertidal zone of North America including the Gulf Islands in British Columbia, Canada. In this setting, I explored putative benefits, namely desiccation resistance and herbivore avoidance,
provided by epiphytic *S. ulvoidea* to its host. *S. ulvoidea* significantly delayed host desiccation during simulated low tides; unepiphytized hosts desiccated to 50% of their original wetness within only 15 minutes of exposure while epiphytized hosts retained that amount of water for twice as long. Feeding assays showed that three local and common herbivorous invertebrates preferred *S. ulvoidea* over the host, suggesting epiphytized hosts may experience less herbivory and may live longer than non-epiphytized hosts. Contrary to the assumption that epiphytes generally impact host species negatively, this study demonstrates that epiphytic relationships are rather intricate and complex; epiphytes may actually benefit their hosts by mitigating biotic and abiotic intertidal stressors, such as herbivory and desiccation.

**Anderson, S.S.**

**THE CONTEXT FOR OUR SCIENCE: UNDERSTANDING HOW THE PUBLIC VIEW COASTAL RESOURCES IN SOUTHERN CALIFORNIA**

*California State University Channel Islands*

Fostering a healthy coastal zone is arguably one of the most difficult challenges faced by the modern resource manager. California is at the epicenter of the long-term global trend of ever more populous coastal strands with increasingly disparate and complex resource demands and development pressures. In such a situation, understanding the public’s perceptions and valuation of various resources is key to shaping effective policy, conducting truly community-based conservation efforts, and effectively targeting scarce public dollars. My students and I have been sampling such public perceptions for the past six years (700 – 1,500 polls conducted each September) via with polling to better understand where the public currently stands on various issues and to provide a long-term baseline with which to compare the efficacy of various future management efforts. As with most such efforts to take the pulse of the general population, this ongoing effort shows a multifaceted populace. We very much enjoy our coastal resources, engaging in both consumptive and non-consumptive uses of them. We are aware of many high profile or contentious management efforts (such as the Deepwater Horizon blowout), but generally not the main entities or agencies engaged in that management. A robust and holistic understanding of the state of those resources being managed is lacking. Coastal resources are understood to have degraded over time and most dissatisfied with the current trajectory of our stewardship.


**NON-NATIVE *LITTORINA LITTOREA* IN BRITISH COLUMBIA: DISTRIBUTION, POTENTIAL IMPACTS, AND PROBABILITY OF SUCCESSFUL ESTABLISHMENT.**

1 - Bamfield Marine Sciences Centre, University of British Columbia 2 - University of British Columbia

Increased globalization of human societies has resulted in an unprecedented occurrence of exotic species in ecosystems the world over. The presence of these exotics can have wildly varying effects on the local biota: everything from a nearly benign addition to whole ecosystem disruption. In January 2010, we found non-native *Littorina littorea* at Ferguson Point, Stanley Park, Vancouver. An important herbivore on both sides of the Atlantic Ocean, *L. littorea* is thought to have invaded the Northeastern United States and Canada from Europe in the 1800’s, greatly altering intertidal community structure. Using measurements of abiotic tolerance and feeding preference assays, we assessed the potential distribution and impacts *L. littorea* could have if able to establish itself in British Columbia. We also discuss the potential for local predators to serve as a source of biotic resistance against successful establishment. We found that should *L. littorea* successfully establish a population here in British Columbia it would compete directly with native herbivore *Chlorostoma funebralis* for the consumption of ephemeral algae. We however expect establishment to be limited to areas with low predator density as feeding trials and escape response assessments showed *L. littorea* to be extremely susceptible to predation by both *Pisaster ochraceus* and *Pycnopodia helianthoides*. 
Andrews, K.S.*, Harvey, C.J.
COMBINING MOVEMENT AND BIOENERGETICS MODELING TO CALCULATE PREDATORY IMPACT OF SPINY DOGFISH IN PUGET SOUND.
Northwest Fisheries Science Center
The impact of predators in an ecosystem is directly related to how much time they spend in specific habitats and the manner in which they move throughout the environment. In order to investigate the predatory impact of spiny dogfish in Puget Sound, we combined acoustic telemetry with bioenergetics modeling. We used large-scale arrays of passive acoustic receivers in Puget Sound and along the US West Coast to monitor the movement patterns of 17 spiny dogfish Squalus suckleyi for up to four years. Spiny dogfish consistently entered Puget Sound in early summer, remained until late autumn, migrated through the Strait of Juan de Fuca and inhabited coastal waters (as far south as Long Beach, CA) the remainder of the year before returning to Puget Sound the subsequent summer. We then constructed a bioenergetics model to calculate predatory impact based on consumption rates of spiny dogfish in each month of the year in Puget Sound. We compared models with and without the patterns of movement detected by acoustic monitoring. Incorporating movement showed a distinct seasonal pattern of predatory impact whereas the model without movement overestimates predatory impact during winter and spring. This analysis shows the importance of including movement patterns into any ecosystem-level modeling.

YOU BETTER BELIZE IT: USING ECOSYSTEM SERVICES TO INFORM MARINE SPATIAL PLANNING IN BELIZE
1 - Natural Capital Project, Stanford University 2 - Belize Coastal Zone Management Authority and Institute 3 - World Wildlife Fund
Belize is home to a rich diversity of ocean life, coastal habitats and the longest barrier reef in the western hemisphere. It is also home to people inextricably linked to the marine environment as a source of sustenance, inspiration, economic prosperity and cultural heritage. Yet rapid coastal development, over-fishing and population growth threaten local marine ecosystems. In response, the Coastal Zone Management Authority and Institute (CZMAI) is charged with identifying new marine protected areas, locations suitable for coastal development, and strategies to support effective implementation of a coastal zone management plan. Over the last year CZMAI has been partnering with the Natural Capital Project to use Marine InVEST (an ecosystem services assessment tool) to forecast how alternative options of marine spatial plans will influence future uses of the marine environment and the delivery and value of benefits to the Belizean people. We will demonstrate how we developed alternative configurations of spatial plans (based on stakeholder input and the current distribution of marine uses) and used outputs from a suite of ecosystem service models (e.g., lobster fishing, recreation and tourism, protection by mangroves and corals from storms) to evaluate these options. By providing a platform for stakeholder and agency discussions about trade-offs and win-win situations, ecosystem service quantification and valuation is moving the planning process beyond sector-specific issues to inform a defensible marine spatial plan.

† Augyte, S.*, Shaughnessy, F. J.
ALGAL BIODIVERSITY IN NORTHERN CALIFORNIA’S MARINE INTERTIDAL: A FUNCTIONAL GROUP METHOD
Humboldt State University
Marine macrophytes form the foundation of many near-shore food-webs and are important in ecosystem function as they provide habitat for various marine organisms. Given their significance, we created a comprehensive list describing the rocky intertidal macrophyte community composition of northern California and southern Oregon. The flora for this region, based on historical and current findings, is composed of a total of 322 taxa of macroalgae found between the Cape Mendocino and Cape Blanco. These results indicate a relatively high area of biodiversity of 134 species per degree latitude. Furthermore, we examined patterns of algal diversity spanning the shores of the two Capes based on macrophyte composition as well as functional grouping. Hierarchical clustering based on a presence/absence matrix for each species alone revealed that algal communities formed a latitudinal
gradient of similarity along the coastline. On the other hand, the functional group analysis, based on Steneck and Dethier’s (1994) classification of anatomy and morphology, confirms that exposed coastal headlands cluster together based on group similarity. This designation can be indicative of oceanographic conditions such as nutrient inputs from upwelling at the exposed Capes compared to the nutrient limited sites in between the two Capes. Our study gives further insight into the intertidal macrophyte community structure on the remote coastline of northern California and southern Oregon.

† Barner, A.K.*, Pfister, C.P. 2, Wootton, J.T. 2
FEW COSTS TO SELFING? LESSONS ON INBREEDING FROM AN INTERTIDAL KELP, POSTELIA PALMAEFORMIS
1 - Hatfield Marine Science Center, Oregon State University, Department of Zoology 2 - University of Chicago, Department of Ecology and Evolution

Naturally isolated populations have conflicting selection pressures for successful reproduction and inbreeding avoidance. These species with limited seasonal reproductive opportunities may use selfing as a means of reproductive assurance. We quantified the frequency of selfing and the fitness consequences for inbred versus outcrossed progeny of an annual kelp, the sea palm (Postelisa palmaeformis). Using experimentally established populations and microsatellite markers to assess the extent of selfing in progeny from six founding parents, we found the frequency of selfing was higher than expected in every population, and few fitness costs were detected in selfed offspring. Despite a decline in heterozygosity of 30% in the first generation of selfing, self-fertilization did not affect individual size or reproduction, and correlated only with a marginally significant decline in survival. Our results suggest both that purging of deleterious recessive alleles may have already occurred and that selfing may be key to reproductive assurance in this species with limited dispersal. Postelsia has an alteration of a free-living diploid and haploid stage, where the haploid stage may provide increased efficiency for purging the genetic load. This life history is shared by many seaweeds and may thus be an important component of mating system evolution in the sea.

† Basilio, A.J.*†, Laurel, B.J. 2
SUBSTRATE PREFERENCE AND DELAY IN SETTLEMENT OF LARVAL NORTHERN ROCK SOLE
1 - Hatfield Marine Science Center, California State University Monterey Bay 2 - Hatfield Marine Science Center, NOAA Alaska Fisheries Science Center

Northern rock sole (Lepidopsetta polyxystra) is a commercially important flatfish species common throughout the North Pacific, which undergo a transitional period from a pelagic to benthic lifestyle known as settlement. The timing and location of settlement dictate the population dynamics of the species, as dispersal potential is limited significantly after settlement. Little data has been collected about the larval stage of this species, which is a critical point in development during which settlement takes place. This project examines whether habitat selection at settlement is behaviorally controlled. Rock sole larvae were placed in arenas with multiple substrates and observed for habitat preference. Other larvae were placed in arenas with only one substrate to examine whether undesirable habitat delayed settlement. The habitat association experiment found a preference for finer substrates across all sizes regardless of pre-testing condition (pelagic or settled). The second experiment found a significant delay in settlement when larvae were exposed to coarse substrate. The data collected show the possibility of a behavioral control for larval settlement. However other factors removed from the lab experiments, such as predator presence, may affect where larvae settle in the field and require testing.

† Benkwitt, C.E.*†, Hixon, M.A.
DENSITY DEPENDENCE IN INVASIVE LIONFISH (PTEROIS VOLITANS) ON ATLANTIC CORAL REEFS
Oregon State University
Pacific red lionfish (Pterois volitans) are invasive predators that have the potential to seriously alter coral-reef ecosystems throughout the tropical western Atlantic and Caribbean region. The rapid spread and exponential increase of invasive lionfish indicate that density dependence is not yet limiting their populations. To determine the threshold at which invasive lionfish will experience density dependence,
I experimentally manipulated juvenile lionfish densities on small patch reefs to encompass a range of both naturally occurring and inflated densities (1 fish/m² to 12 fish/m²). I then measured lionfish recruitment, persistence, and growth over an 8-week period, as well as the recruitment of native fishes to determine the effect of different lionfish densities on native fish populations. Differences in lionfish recruitment and persistence among reefs were not related to lionfish density. However, lionfish growth decreased linearly with increasing density (p<0.001). Lionfish on the highest density reefs grew approximately 1.6 mm/week (95% CI 0.9 to 2.3) slower than lionfish on the lowest density reefs. The net recruitment of native fishes also declined linearly as lionfish density increased (p=0.01). For each additional lionfish on a reef, the number of native fish recruits decreased by approximately 6 (95% CI 1.9 to 10.2). Density-dependent growth indicates that invasive lionfish are approaching population limits, yet at extreme cost to native fish populations. Negative effects on the recruitment of native fishes suggest that targeted removals that lower lionfish densities may be beneficial to native fish populations.

Bingham, B.L. †*, Dimond, J. †, Muller-Parker, G. 2
Symbiosis, growth, fission and sexual reproduction in Anthopleura eleganissima
1 - Shannon Point Marine Center, Western Washington University 2 - Shannon Point Marine Center, National Science Foundation

Anemones in the genus Anthopleura are unique among cnidarians in hosting photosymbionts from two phyla with very different growth rates and physiologies, features that potentially affect the quantity and quality of photosynthate transferred from the symbiont to the host. To test the fitness consequences of hosting different symbionts, individuals of Anthopleura eleganissima in different symbiotic states were maintained under identical conditions in an outdoor, flow-through tank with simulated tidal exchanges for 8–10 months under three light levels. The anemones were held under high (85% ambient irradiance), reduced (43% ambient irradiance) or highly reduced (2% ambient irradiance). Growth, asexual reproduction and gonad development of the anemones were used to relate fitness to symbiotic state and light treatment. Among the anemones that did not substantially change in symbiont density over time, allocation of energy to growth and reproduction varied by symbiotic state. Asymbiotic individuals (hosting few symbionts) lost body mass and showed little asexual reproduction, investing energy instead in development of gonads. Zooxanthellate anemones (hosting the dinophyte Symbiodinium muscatinei) maintained body mass better, showed higher rates of asexual reproduction, but had little gonad development. Zoochlorellate anemones (hosting the chlorophytes Elliptochloris marina) lost weight and developed little gonad tissue, but showed more asexual reproduction. The magnitude of the effects was related to the light environment of the individual anemones. The interplay of symbiotic state and light environment influences growth, reproduction and fission in A. eleganissima, highlighting the role symbiosis plays in the ecology of this important intertidal species.

† Bolton, D.K. †*, Clark, G.F. †, Coleman, M. 2, Johnston, E.L. †
Caught between a rock and a hard place: predation pressure in crevice communities
1 - Evolution and Ecology Research Centre, UNSW, University of New South Wales 2 - NSW Marine Parks Authority

Many communities are shaped by predation and levels of predation in marine ecosystems can be modified both by natural physical variables and through human activities. Predators are constrained on small scales by physical restrictions such as exposure and crevice width, while human harvesting of higher level predators can modify predation processes on a larger scale. By modifying predation pressure, human interference will directly and indirectly modify ecosystems. In a factorial experiment, caging was used to look at the effect of predation on sessile invertebrate communities developing in a range of artificial crevices. Caging reduced predation pressure on communities (as quantified by underwater videos). However, predation and crevice width interacted such that communities in small crevices (3 cm) were similar regardless of caging treatment. While the difference between caged and non-caged or cage control communities were driven predominately by the medium and large crevice communities (10–30 cm). These results confirm that habitat complexity can create variability in
predation pressure on small scales. Identifying how sessile invertebrate communities will respond to altered levels of predation will enhance conservation efforts in areas of high modification. For example, environments with varied and complex structure may reduce the effect of predation in structuring sessile invertebrate communities. Therefore it may be beneficial to constrain anthropogenic activities known to modify predation pressure to more complex environments in the hope of conserving biodiversity.

Brown, D.J.†, Edmunds P.J.
EFFECTS OF ELEVATED PCO$_2$ AND TEMPERATURE ON THE GROWTH OF THREE CALCIFYING CNIDARIANS
California State University Northridge
Calcifying organisms that create architecturally complex habitats are threatened by increasing atmospheric CO$_2$, which decreases ocean pH (i.e., ocean acidification, OA), and increasing temperature, which diminishes coral productivity at the highest values (typically ≥30°C). This study tested the hypothesis that calcifying cnidarians - both scleractinian (Anthozoa) and milleporine (Hydrozoa) corals--respond differently to pCO$_2$ and temperature. The hypothesis was motivated by the contrasting origins of the taxa, with scleractinians evolving in high saturation state ($\Omega_{\text{arag}}$) seawater, and milleporines in low $\Omega_{\text{arag}}$ seawater. Three calcifying cnidarians from the shallow lagoon (2-6m) of Moorea, French Polynesia were placed in orthogonal combinations of temperature (28.0°C & 30.0°C) and pCO$_2$ (380, 700 & 1000µatm) in a 12-tank mesocosm for 19 days; in this design, tanks (n=2) were nested within the fixed effects of pCO$_2$ and temperature. Calcification was significantly affected by a pCO$_2$ × temperature interaction for both scleractinians, decreasing 33% at 900 vs. 408µatm and increasing 28% at 30.0°C vs. 28.0°C for Pocillopora meandrina, while decreasing 14% at 900 vs. 408 µatm and decreasing 10% at 30.0°C vs. 28.0°C for massive Porites spp. Calcification of Millepora platyphylla was unaffected by pCO$_2$, but it decreased 49% at 30.0°C vs. 28.0°C. The decrease in calcification at high pCO$_2$ for the scleractinians and the absence of a pCO$_2$ effect for the milleporine suggests these taxa will respond differently to OA. The possibility that this outcome reflects different calcification mechanisms related to the origins of these taxa in seas with differing DIC chemistry warrants further study.

† Brown, A.L., Carpenter, R.C.
FLOW-REGULATED ALGAL TURF CONTROL OF OXYGEN DYNAMICS WITHIN INTERACTIONS OF MASSIVE PORITES SPP. AND ALGAL TURF
Gump Station, Moorea, French Polynesia, California State University Northridge
Extreme oxygen concentrations, both hypoxia and hyperoxia, can lead to coral tissue necrosis. In this study we examined how water flow and coral and algal metabolism influence oxygen concentrations within the zone of interaction between massive Porites spp. and algal turf. We exposed coral-macroalgal interactions to three flow speeds (0, 7, 14 cm/s) and measured the thickness of the diffusive boundary layer (DBL) in light (to evaluate hyperoxia, O$_2$ concentrations > 100% ambient O$_2$) and dark (to evaluate hypoxia, or oxygen concentrations < 100%) above the surfaces of the coral, the algal turf and the zone of interaction between the two. Our results indicate that with increasing water flow, the thickness of the DBL decreases, but remains thicker above algal turf and the zone interaction (<500 – 2500µm) compared to above corals. Within the DBL, <1mm above the zone of interaction, the highest O$_2$ concentrations in light and lowest O$_2$ in dark were similar to the highest and lowest O$_2$ concentrations measured above algal turf. To assess the influence of microbes on oxygen conditions within zones of interaction, antibiotic (50µg/ml ampicillin) was added to massive Porites spp.- algal turf interactions; the results suggest that microbes play a diminutive role in oxygen concentration dynamics. As the metabolic byproducts of algal turf appear to affect oxygen conditions within the zone of interaction (dependent on flow), we suggest that future studies should explore the role of oxygen extremes on the outcome of coral-algal interactions.
† Bulach, B.E.*, Edwards, M.S.
INSTANTANEOUS AND SHORT-TERM ACCLIMATION EFFECTS OF OCEAN ACIDIFICATION ON SOUTHERN CALIFORNIA CORALLINE ALGAE
Coastal Marine Institute and Laboratory, San Diego State University
Studies have demonstrated potential negative effects of high pCO₂ on calcifying organisms and some positive effects on photosynthesizing organisms, but less is known about organisms that undergo both of these processes. Coralline algae are some of the most prominent calcifiers in the nearshore ecosystems of temperate to sub-polar regions and represent a significant carbon reservoir. In this study, photosynthesis versus irradiance curves were created for three Southern California species of coralline algae under ambient conditions (pCO₂ of ~380 ppm) and under elevated pCO₂ (~1000 ppm). In all species there was a reduction in the photosynthetic quotient and a decrease in calcification rates. These species were also allowed to acclimate to a pCO₂ of 1000 ppm for two weeks, after which photosynthesis and calcification were measured for comparison to ambient conditions. These results suggest strong negative impacts of ocean acidification on coralline algae, with potential larger consequences for kelp forest ecosystems.

† Burgess, A.K.*, Sulkin, S.
ALGAL TOxin TRANSFER IN MARINE PLANKTONIC FOOD WEBS: A LOOK AT NUTRITIONAL DEFICIENCIES, TOXICITY EFFECTS & TOXIN RESISTANCE
1 - Oregon Institute of Marine Biology, University of Oregon 2 - Shannon Point Marine Center, Western Washington University
Larval crabs are an important component of the plankton in coastal systems and can ingest harmful algal bloom (HAB) species directly or indirectly by ingesting smaller zooplankton that themselves feed on the toxic algae. This research determined whether the reduction in larval crab survival and delay in development reported on the toxic algal fed rotifer diet is a function of algal toxin transfer or a consequence of reduced nutritional value of the rotifer and whether larvae that had previously been exposed to the nutritional/toxic stress are more resistant to exposure in subsequent larval stages than those not previously exposed. Two rotifer diets were created, one fed toxic alga; the other nontoxic alga. To distinguish between toxic and nutritional effects, groups of larvae were fed on various combinations of the two rotifer types. Toxin resistance was determined by switching larvae diets after the second stage. Treatments were applied to larvae of three crab species. Effects of treatments were compared and found that the decrease in larval survival and increase in molt duration of larvae fed ‘toxic’ rotifers was due to a nutritional deficiency of the rotifer. Larvae showed no toxin resistance through experiments. While a nutritional deficiency of the ‘toxic’ rotifers is suspected to be the major reason crab larvae experience higher mortality rates and delayed development, toxin transfer cannot be eliminated entirely and a combination of the two factors is likely causing these effects.

† Callander, D.C.*, Schiel, D.R.
A TALE OF TWO SPECIES: PHYSIOLOGICAL ADAPTATIONS OF MUSSELS TO ENVIRONMENTAL STRESS
University of Canterbury, Christchurch, New Zealand
How organisms adapt to localised changes in the marine environment is crucial to understanding longer term biogeographic patterns and persistence of species in certain locations. These coping mechanisms can come about through behavioural modifications as well as physiological responses to stressful conditions. The physiological stress response of two species of mussel found in New Zealand, Mytilus galloprovincialis and Perna canaliculus, was measured using quantitative PCR. Several heat shock proteins and other stress markers were used in these analyses. M. galloprovincialis and P. canaliculus dominate the mid and low intertidal respectively. Comparing the capacity of these two species to respond to stressful conditions will enable predictions and comparisons for how resilient their populations may be as the climate warms. A series of field and lab experiments were carried out on these species to test the physiological effects of geographic location, tidal height, size and acute thermal challenges. It was generally found that over the course of the summer, stress markers were upregulated consistently at the more extreme sites and in the more harsh conditions. These studies quantify part of the physiological response of ecologically important
organisms to environmental stress and will help predict the vulnerability of species to changing climactic conditions.

Calvanese, T.
MOVEMENT PATTERNS AND HOME RANGES OF FISHES OF THE REDFISH ROCKS MARINE RESERVE
Oregon State University
Marine reserves can be a viable component of conservation and fisheries management strategies aimed at restoring biodiversity and functioning ecosystems, and rebuilding fish stocks. There is evidence of increased biomass within reserves, and spillover to surrounding areas. However, these effects depend on the degree of protection provided, a function of reserve size and the spatial extent of movements. My goal is to understand the movement patterns of fishes of Redfish Rocks to help determine optimal reserve size needed to balance protection with spillover. I am using acoustic telemetry to evaluate movement patterns of six species; the China Rockfish Sebastes nebulosus, Quillback Rockfish S. maliger, Canary Rockfish S. pinniger, Copper Rockfish S. caurinus, Black Rockfish S. melanops, and Cabezon Scorpaenichthys marmoratus. Surgically implanted acoustic tags transmit coded signals identifying each fish and its depth, which are recorded when the fish swims within range of an acoustic receiver. An array of receivers provides coverage of the study area, and collects data used to test three hypotheses; (1) The no-take marine reserve provides different degrees of protection to different fishes due to species-specific differences in home range size and movement patterns. (2) The rate of movement between Redfish Rocks and Island Rock, similar habitat outside the reserve, is species-dependent. (3) Habitat associations within the reserve are species-specific. By elucidating these spatial relationships, this work will provide information essential to the effective management of a network of marine reserves in Oregon, and a larger network of protected areas extending from California to Washington.

Caselle, J.E.*, Hamilton, S.L.*, Readdie, M., Kushner, D.
HABITAT AND FISHING EXPLAIN GRADIENTS OF FISH DENSITY ACROSS THE BOUNDARIES OF FOUR MARINE RESERVES IN THE CHANNEL ISLANDS, CA
1 - Marine Science Institute, University of California Santa Barbara 2 - Moss Landing Marine Laboratories 3 - Landels-Hill Big Creek Reserve, University of California Santa Cruz 4 - Channel Islands National Park, National Park Service
Marine protected areas (MPAs) are frequently implemented as fisheries management tools. Previous studies of MPAs have demonstrated higher biomass, density, and size structure for many organisms inside closed areas relative to areas open to fishing. Most studies are limited to ‘inside’ vs. ‘outside’ comparisons. At four target reserves in the Channel Islands, CA, we assessed these parameters at multiple sites ranging from the center of the reserves to areas up to several kilometers away. Using SCUBA surveys of rocky reef fishes and habitat, we found that fish density and biomass tended to be greatest at the core of the reserves, and declined with distance from the core. These patterns were most evident for species that are the targets of fishing outside reserves. However, the shape of the decline across the reserve boundaries varied among the four reserves and the importance of habitat vs. fishing in creating the observed patterns also varied spatially. Interpreting abundance patterns across MPA boundaries has implications for calculating the magnitude of spillover, one important purported fisheries benefit of MPAs.

† Casper, N.J.*, Sulkin, S.D.
DO CRABS NEED THEIR GREENS? DETERMINING THE NUTRITIONAL ROLE OF ALGAE IN THE DIET OF FIRST STAGE BRACHYURAN CRAB LARVAE
Shannon Point Marine Center, Western Washington University
The survival and distribution of benthic invertebrate larvae have important implications for adult population dynamics. Nutrition and food availability have been considered among the primary determinants of larval survival. The feeding strategy of brachyuran larval crabs, a combination of omnivory and selectivity, is complex and not yet completely understood. Although gut analyses of zoeae collected from the field have identified microalgae in the diet, and laboratory studies have
confirmed that brachyuran zoeae will ingest a variety of microalgae, diets consisting solely of microalgae are generally not sufficient to sustain development under laboratory conditions. This study examined the role ingesting phytoplankton plays in the nutrition of first stage larval crabs by simulating conditions in which ingestion of algal prey might increase survival or accelerate development. Experiments included initial starvation treatments as well as patchy prey diet experiments. Larvae of black clawed crabs (*Lophopanopeus bellus*) and Dungeness crabs (*Metacarcinus magister*) were exposed to combinations of control zooplankton treatments, an experimental brown microalga *Isochrysis* treatment, and starvation. Results showed that in both initial starvation experiments and patchy prey experiments larval survival decreased and development was delayed in comparison to the fed control; however, no difference in survival and development was detected between unfed and algal diet treatments. Results suggest that algae do not function to provision larvae with nutrients or energy during periods of no zooplankton prey, and do not increase survival or accelerate development. Ingesting algae may be a neutral side effect of an opportunistic feeding strategy in an uncertain prey environment.


PROTEIN EXPRESSION OF A DISRUPTED STRESS ENDOCRINE AXIS IN CONTAMINANT EXPOSED SOUTHERN CALIFORNIA WILD FISH

1 - California State University Long Beach 2 - Pacific Coast Environmental Conservancy 3 - Orange County Sanitation District

Recent studies on contaminant exposed wild fish in the Southern California Bight and in San Francisco Bay show that these organisms exhibit a form of endocrine disruption that involves the stress and metabolic hormone, cortisol. This condition is observed as an inability to produce cortisol in response to a stressor, and has been documented in several coastal fish species. Exposures of fish to certain contaminants such as DDT metabolites and petroleum-derived PAHs are significantly correlated with this form of endocrine disruption. Potential molecular targets are beginning to be identified that include specific genes and proteins expressed within the cortisol-producing interrenal organ. Expression of mRNAs of important cortisol biosynthetic enzymes, such as steroidogenesis-activation regulator (SIAR) and P450-11β hydroxylase, were significantly depressed in impacted fish. A proteomics approach has also been employed to discover proteins whose expression is changed with the endocrine disruption. Collectively, results from these studies are pointing to underlying mechanisms by which the stress endocrine system may become disrupted in contaminant exposed fish residing in the urban ocean of California (Supported by NOAA-USC Sea Grant Program).

Cerny-Chipman, E.B.*, Gouhier, T.C., Menge, B.A.

LINKING BARNACLE FECUNDITY AND RECRUITMENT ACROSS TEMPORAL AND SPATIAL SCALES

Oregon State University

Understanding the relationship between larval recruitment and adult abundance is critical for predicting patterns of abundance in marine communities. Past research has focused on the role of oceanographic currents as drivers of recruitment because most marine species produce planktonic larvae with long pelagic durations that decouple larval production from recruitment at local and regional scales. Although larval production may affect recruitment by limiting the size of the larval pool, little is known about the relationship between larval production and recruitment at different spatial and temporal scales. We examined the relationship between adult fecundity, a proxy for larval production, and larval recruitment of barnacles *Balanus glandula* and *Chthamalus dalli* along the Oregon Coast using a multi-year dataset. As predicted by pelagic larval duration, recruitment and adult fecundity are weakly correlated at the local site scale. At larger spatial scales, fecundity and recruitment show significant positive cross-correlations. Fecundity and recruitment were positively correlated at spatial scales of ~50-75 km for *C. dalli* and ~150-175 km for *B. glandula*. These results suggest that larval production is an important factor contributing to patterns of recruitment. Additionally, dispersal of larvae may be more localized than previously thought (<175 km), with larvae returning to nearby sites despite a relatively long pelagic larval duration. Overall, our findings indicate that (i) local conditions affecting larval production can have important implications for patterns of recruitment at regional
scales (<175 km) and (ii) that larval production may be critical to resolving the relationship between recruitment and adult abundance.

Chang, A.L.¹,²*, Deck, A.¹ Malm, P.D.¹, Willits, K.¹, Attoe, S.¹, Fisher, J.L.¹, Morgan, S.G.¹

GREAT PLACE TO LIVE, BUT I DON’T WANT TO RAISE MY KIDS THERE: LINKING HABITAT QUALITY AND POPULATION DYNAMICS OF OLYMPIA OYSTERS

1 - Bodega Marine Lab, University of California, Davis 2 - Smithsonian Environmental Research Center

Identifying high quality habitat is key for effective conservation of species facing changing climate regimes, but Olympia oysters (Ostrea lurida) and other species inhabit dynamic estuarine systems and have a complex life cycle with sessile adults and mobile larvae whose requirements may differ. Freshwater flow is an important determinant of habitat quality in estuarine systems and has been greatly modified in many places by both climate change and water diversions. We investigated O. lurida population dynamics in San Francisco Bay using surveys and growth measurements at 11 sites during varying freshwater flow conditions from 2009 to 2011 and experimentally tested for differences in low salinity tolerance among regions. Oyster abundance and size distribution differed significantly along the salinity gradient; maximum densities occurred in brackish waters in the northern region of the Bay, with over 1000 oysters / m². Juvenile oyster recruitment varied significantly around the Bay, with greatest settlement in upstream areas, coinciding with maximum adult densities. In contrast, growth rates were lowest in the upstream areas and higher downstream, despite apparently greater food availability upstream. Shelled larvae appeared most frequently on the opposite side of the Bay from sites of maximum recruitment, although fecundity was generally low. Meanwhile, tolerance to simulated low salinity events was lower for an upstream population compared to downstream populations, suggesting that these upstream populations may be more susceptible to these events despite high recruitment and abundance, resulting in large interannual population fluctuations. Populations in different regions of the Bay thus appear to contribute in varying ways to the persistence of O. lurida.

Cheng, B.S.*, Grosholz, E.D.

THERMAL PERFORMANCE IN AN INVASIVE PREDATOR AND NATIVE PREY INTERACTION: IMPLICATIONS FOR CLIMATE CHANGE

Bodega Marine Laboratory, University of California Davis

Initial climate change studies have typically focused on the abilities of single species to cope with changing environmental conditions. However, it comes as no surprise to ecologists that species responses to climate change will also depend on their interactions with other organisms in the ecosystem (e.g. predators, competitors, facilitators, etc.) Furthermore, climate change has implications for highly invaded systems such as estuaries where native and invasive species often have drastically different evolutionary histories. In west coast estuaries of the United States there has been much interest in restoring depleted populations of the native Olympia oyster (Ostrea lurida). However, one factor inhibiting oyster recovery has been predation by invasive eastern oyster drills (Urosalpinx cinerea) that were introduced as early as 1875 to Tomales Bay, CA from the eastern seaboard. We investigated the thermal performance of this invasive predator and native prey interaction by assessing both lethal (acute) and sub-lethal (chronic) performance in F1 lab raised oyster and whelk recruits. In addition, we measured feeding and metabolic rate (oxygen consumption) as performance metrics to assess the ability of these two species to operate in a warmer climate.

† Choo, C.K.*, Granek, E.

BACI SURVEY OF THE IMPACTS OF PIER CONSTRUCTION ON TROPICAL SEAGRASS BIOMASS AND MORPHOLOGY

Portland State University

This study investigates the impacts of pier construction on tropical seagrasses in the Pulai River Estuary, Malaysia. A Before-After-Control-Impact (BACI) survey was employed on a monthly basis between July and Dec 2010, and then at three-month intervals through June 2011. Significant impacts were observed following pier construction, which took place in Sept 2010. The biomass of Enhalus
E. acoroides declined by three-folds, the below-aboveground ratio shifted from 5.6 to 11.6, leaf lengths declined by 70% while the % broken leaf tips increased by 85%. The rhizome diameter also exhibited bizarre branching form. The smaller and possibly less resistant seagrass, Halophila ovalis vanished at the onset of the construction. In June 2011, however, some signs of recovery were observed. The total biomass for E. acoroides increased to 272.31±85.09 S.E. gm⁻² and the above-belowground biomass, leaf lengths, shoot lengths, number of shoots and leaves, and rhizome diameter had also recovered to conditions comparable to before project implementation. However, H. ovalis remained absent and the seagrass meadow as a whole was reduced by 35%. The possible factors contributing to seagrass deterioration include propeller-induced damage due to increased sea navigation, the lack of buffer areas, increased water turbidity and siltation and the ineffectiveness of silt trap deployment. The study is on-going to gauge the recovery potential of seagrasses in the estuary.

† Close, S.L.*, Chan, F.¹, Nielsen, K.J.², Hacker, S.D.¹, Menge, B.A.¹
LINKING NUTRIENT CONTENT OF INTERTIDAL MACROPHYTES TO AMBIENT NUTRIENT AVAILABILITY ACROSS A LARGE BIOGEOGRAPHIC REGION.
1 - Oregon State University, Department of Zoology 2 - Sonoma State University
In rocky intertidal habitats on the West coast of North America, the diverse macrophyte assemblages are intricately linked to coastal upwelling and nutrient regimes, and play a key role in ecosystem processes and community dynamics. Nutrient content of seaweeds and surfgrass can serve to integrate some of the natural variability in nutrient availability on a biologically-realistic scale, providing information on the nutrient environment encountered by the organism through time. In this study, we investigated patterns in the nutrient content of five species of intertidal macrophytes over a period of 6 years, and across a latitudinal gradient in oceanographic conditions encompassing over 200 km of the Oregon and northern California coast. Investigating the coupling of macroalgal nutrient content to physical variables, particularly nutrient availability, enables us to examine one way in which regional oceanographic processes and patterns observed in rocky intertidal habitats are linked. Across the latitudinal gradient encompassed in this study, nutrient content of macrophytes appears to cohere with nutrient availability at the largest spatial scale (northern vs. southern sites), suggesting that large-scale oceanographic patterns are a major driver of macroalgal nutrient content.

Connor, K.M.¹, Gracey, A.Y.
CYCLES OF GENE EXPRESSION IN MYTILUS CALIFORNIANUS UNDER A SIMULATED ENVIRONMENT
Wrigley Marine Science Center, University of Southern California
The intertidal mussel Mytilus californianus resides in a fluctuating environment due to the rotation of Earth as well as cycles of aerial emergence and aquatic immersion. These forces subject mussels to daily variation in light, temperature, oxygen and nutrients. Few studies have investigated how these environmental cycles are transduced in the transcriptome. While previous studies in this area of research have been limited to field observations, we examined transcriptional response in mussels under a simulated environment in the laboratory. This allowed us to control environmental variables that often appear stochastic in field regimes. We subjected mussels to a tidal regime of 6:6 hour emergence:immersion cycles for three days. On the fourth day we elicited a simulated heating event during low tide. An external light source simulated day and night cycles. Our results revealed unexpected patterns of gene expression. I will discuss these patterns as well as other novel observations of gene expression in M. californianus.

† Coyle, T.A.*, Kordas, R.L., Harley, C.D.G.
RELATIONSHIPS BETWEEN SALINITY AND VARIATION IN TROPHIC STRUCTURE ON ROCKY SHORES
Department of Zoology, University of British Columbia
Spatial variation in salinity in the Strait of Georgia, British Columbia, may affect species directly based on their physiological tolerance or indirectly via changes in inter-specific interactions. Richness and abundance of herbivores was significantly higher in sites with consistently high salinity, and lower at sites near the mouth of the Fraser River where salinity was seasonally variable. We predicted that 1)
the herbivore distributional pattern is determined by hypo-osmotic stress, and 2) salinity driven
variation in herbivore abundance would lead to higher algal abundance at low salinity sites. Laboratory
trials confirmed that salinity conditions at low salinity sites exceeded the tolerance of limpets, despite a
capacity for local adaptation and acclimation. Field based herbivore exclusion experiments at high and
low salinity sites demonstrated that the effect of salinity on Ulva spp. abundance is indirect and driven
by a reduction in herbivory. Our results emphasize the importance of community level interactions in
determining spatial and temporal patterns of distribution and abundance across environmental
gradients.

† Daly, B.1*, Eckert, G.1, Stoner, A.2, White, T.3
IN SITU PREDATION AND BEHAVIORAL PLASTICITY OF JUVENILE RED KING CRABS
(PARALITHODES CAMTSCHATICUS)
1 - University of Alaska Fairbanks 2 - Alaska Fisheries Science Center, National Oceanic and
Atmospheric Administration (NOAA) 3 - University of California Los Angeles
Juvenile predation likely creates a population bottleneck for many marine populations. Gut content
analysis suggests that groundfish prey on juvenile red king crabs (Paralithodes camtschaticus); however,
few observations are available from shallow king crab nursery areas. We tethered recently-
settled red king crabs of different sizes (2.0-3.9 mm carapace width) in the field during July and
September 2011 to explore differences in predation and identify predator species groups. Survival was
not significantly different during July and September or between size classes. Predation was high
(~30% survival), and crabs were consumed by a diverse group of predators including juvenile flatfish,
ronquils, kelp greenling, hermit crabs, and sea stars. Red king crabs have varying behavioral
responses to predators that may change with experience. In laboratory experiments, we evaluated
behavioral plasticity of recently-settled crabs by exposing them to physical and visual cues from fish
predators and used video cameras to observe predator prey interactions. Crabs increased cryptic
behavior and had higher survival when previously exposed to Pacific halibut (Hippoglossus stenolepis)
for 48 h suggesting that crabs can improve predator avoidance behavior with experience. For king
crab stock enhancement, extended hatchery rearing may not increase post-release survival, thus it
may be more efficient to release juveniles soon after settlement. Additionally, short-term conditioning
with predators prior to release may enhance behavioral responses and improve survival. In shallow
nursery areas, recently-settled red king crabs are consumed by a broad range of fishes and
invertebrates and may develop improved predator defenses with experience.

† Davidson, T.M.1*, de Rivera, C.E.
SEAWATER TEMPERATURE MEDIATES THE BIOLOGICAL EROSION AND PLASTIC POLLUTION
OF A NON-NATIVE BURROWING CRUSTACEAN
Portland State University
Increases in ocean temperature associated with global climate change are predicted to elicit drastic
changes to marine ecosystems. Even small changes in seawater temperature (1-2°C) may alter rates
of biological activity, with concomitant impacts to communities and ecosystems. The biological erosion
of marine habitats and structures (hereafter: bioerosion) is a rarely considered, yet important biological
activity that is likely to be influenced by changing ocean temperatures. We conducted an experiment to
test how seawater temperature affects bioerosion by a non-native crustacean (Sphaeroma quoianum).
Closed aerated saltwater aquaria were maintained at one of thirteen different temperatures using
aquarium chillers and heaters (ranging from 7.5°C-25.2°C). In each aquarium, twenty isopods were
encaged with an expanded polystyrene foam block (800ml) and left to burrow. Polystyrene foam, used
as floats under docks, is often damaged by isopods in the field. After two months, isopods created the
longest burrows in the moderate seawater temperatures (13.8°C-18.3°C) with lower burrow lengths
observed for the coldest and warmest seawater treatments. Millions of plastic particles can be created
during the boring process on polystyrene floats; the number of particles created exhibited the same
relationship as the bioerosive impact. These results indicate that increasing seawater temperatures
can exacerbate the bioerosive impacts and plastic pollution caused by a non-native crustacean until a
threshold, after which the impacts diminish. Since ocean temperatures are predicted to increase 1-2°C
in the next 90 years, our data suggest the impacts of this non-native crustacean will increase 5.1-17.1% in some cold central California and Oregon bays.

† Davis, A.C.D., Mueller, C.B., Kvitek, R.G.
A REGIONAL ANALYSIS OF THE DISTRIBUTION OF RIPPLED SCOUR DEPRESSIONS ON THE CALIFORNIA COAST
California State University Monterey Bay
Rippled scour depressions (RSDs) are coarse-grain sediment features found on continental shelves worldwide that are characterized by long period sand waves inside of the depressions (0.4m-1.0m depth). Sonar data from the California Seafloor Mapping Project reveal RSDs as common features on the shelf including within marine protected areas (MPAs). While many studies describe RSDs at specific locations, this study is the first to address the spatial distribution of RSDs at the regional scale. The goals of this study were to: 1) quantify the abundance and patterns of distribution of RSDs along the entire California coast, and 2) determine the percentage of rock reef, sedimentary and RSD habitats within state waters, inside and outside of the MPA network. We developed an algorithm-based tool to identify edges of RSDs and differentiate them from other sediment and rocky reef habitat. We then used GIS spatial analysis to quantify the distribution and abundance of RSDs along the coast and test predicted relationships with proximity to rocky reef, depth, and latitude. RSDs make up 3.4% of the shelf compared to 8.0% for rocky reef. RSD percent cover varies significantly with depth and increase with proximity to rocky reef. Because RSDs are a unique habitat found throughout California’s MPAs their distribution likely affects the composition and abundance of benthic communities. So, determining the patterns of distribution and abundance for RSDs on the continental shelf will provide information valuable to the design, monitoring and assessment of California’s MPA network mandated by the State’s Marine Life Protection Act.

Davis, B.M., Salomon, A.K.
ECOSYSTEM-LEVEL EFFECTS OF SEA OTTER (ENHYDRA LUTRIS) RE-COLONIZATION ON ROCKY INTERTIDAL COMMUNITIES OF BC’S CENTRAL COAST
Simon Fraser University
The effects of sea otter foraging on subtidal benthic community structure are well documented and widely observed. However, their impacts on intertidal communities are less well known. Sea otters were re-introduced to the west coast of Vancouver Island in the 1970’s and the first raft to re-colonize the central coast of British Columbia was sighted in the Goose Group Islands in 1989. Since then the population has been growing at an estimated rate of 11% per year and expanding its range throughout the central coast. We quantified intertidal macroinvertebrate density and kelp biomass at seven sites varying in sea otter occupancy time. To examine the extent to which kelp-derived carbon fuels coastal food webs in areas with and without sea otters, we collected kelp, invertebrates, fish tissue and particulate organic matter from seawater for stable isotope analysis. Broadly, we found that sites with sea otters have fewer macroinvertebrate grazers and higher kelp biomass. However, detecting the indirect effects of sea otters includes reconciling many intricate relationships. For example, while invertebrate grazers are being reduced by sea otters predation, they may also experience a boost in growth; benefitting from increases in kelp biomass. By exerting strong top-down control on benthic communities, the sea otter range expansion in BC has important repercussions ecologically, socio-economically and culturally. All of these aspects of sea otter re-colonization will need to be accounted for in the marine use plan currently under development for this area.

de Rivera, C.E.*, Clarke, I.*, Ruiz, G.M.†
INTERACTIVE EFFECTS OF TEMPERATURE AND PREDATION ON BEHAVIOR AND RISK FOR AN INVASIVE CRAB.
1 - Portland State University 2 - Bodega Marine Laboratory, Philomath public schools 3 - SERC
Understanding factors that affect local to geographic distribution of organisms is central to ecology and can be used to help predict which areas will be impacted by nuisance species. Research has clearly shown that both abiotic and biotic resistance affect distribution of invading species. The interacting roles of these different types of resistance have not been as well studied, however. Here, we examine
how temperature interacts with predation risk of the survival and foraging levels of European green crab, *Carcinus maenas*. We used two predators, separately, in tanks held at a constant temperature from 9-30°C: *Cancer productus*, which overlaps with *C. maenas* along estuaries in the northeast Pacific and *Callinectes sapidus*, the blue crab, which overlaps with *C. maenas* along the northwest Atlantic. We hypothesized that predation pressure would diminish and therefore foraging increase with increasing temperature if the predator is typical of cool temperate water, but predation pressure would increase, with decreased foraging, if the predator were warm-water adapted relative to its prey (at the northern part of its range) relative to the prey. We found that predation by *C. sapidus* was generally higher than that by *C. productus* and occurred from 12-30°C, while *C. productus* only preyed on *C. maenas* at 9°C. *Carcinus maenas* foraging also varied across the combinations of water temperature and predator species. Therefore, impacts of *C. meanas* are expected to vary with changing temperatures, but not linearly, and the effects of warming are expected to interact with predation differently across the coasts.

**Del Giudice-Tuttle, E.*, Johnston, K.K.**

**MAPPING AND ASSESSING INUNDATION AND INFLUENCE ON VEGETATION ZONATION IN AN URBAN COASTAL WETLAND**

*Santa Monica Bay Restoration Commission*

The Ballona Wetland Ecological Reserve (BWER) in Los Angeles, California has been extensively impacted by anthropogenic hydrologic and geomorphic modifications including the channelization of Ballona Creek, dredging of the Marina Del Rey, and subsequent building of roads and levees. All tidal influence to the BWER is mediated by man-made structures, including: culverts, levees, a flap gate, and a self-regulating tide gate (SRTG). These changes have resulted in shifts to the ecological function and biological diversity. Tidal inundation and channel geomorphology data were collected in muted tidal habitats of the BWER. Research questions examined included: 1) what is the current extent, frequency, and duration of tidal inundation at differing tide heights, 2) what are the relationships between the resulting inundation profiles and channel geomorphology, 3) what are the associations between the inundation regime, vegetation cover, and habitat type, 4) what are the implications of the results in the context of ecological restoration, climate change, and sea-level rise? Extent of tidal inundation was assessed by tracing the perimeter of standing water using GPS units at six different tide heights. Channel geomorphology was assessed by taking spot elevations along cross-sectional transects at nine stations. Vegetation was assessed using a stratified random sampling method; species level data and percent cover were collected on transects. Results suggest that inundation extent was greater adjacent to channel sections with gradual slopes and lower banks. Native species cover was higher where inundation was more frequent and of longer duration. Non-native species presence was greater in areas outside of the inundation extent, regardless of habitat association.

**DeMartini, E.E.*, Wren, J.L.K.**, Kobayashi, D.R.*

**RECRUITMENT IN A GUILD OF CORAL-SHELTERING FISHES DURING 21 CONSECUTIVE YEARS AT WEST HAWAII ISLAND**

1 - Pacific Islands Fishery Science Center, National Marine Fisheries Service 2 - Department of Oceanography, University of Hawaii at Manoa

Shallow (1- to 5-m deep) cabbage coral (*Pocillopora meandrina*) habitats were snorkel-surveyed at 7 to 12, semi-wave protected sites along the coastline of North and South Kohala during April 1990-August 2010. Recruit (≤4-cm total length, TL) and larger (>4 cm TL) arceye hawkfish *Paracirrhites arcatus* and five other species (3 hawkfishes, 2 blennies) were tallied by cm-size class. Seven cores sites were monitored for all 21 years; surveys began at another 5 sites in 2000. Surveys were conducted quarterly at the core sites during the 1990s and yearly at all sites during summertime peak recruitment in the 2000s. Arceye hawkfish represented >92% of all recruits tallied and dominated spatial and temporal recruitment patterns. Relative recruitment magnitude was quantified by a “recruitment index” (RI = 100 x [N recruits / N larger]). The most conspicuous patterns were generally higher recruitment at the upcoast (North Kohala) sites and temporally persistent levels of recruitment (either high or low) at many sites. A preliminary exploration of possible links between recruitment
patterns and coastal oceanography will be presented. Implications of recruitment patterns for replenishment of benthic populations along the west Hawaii coast also will be noted.

† Demes, K.W.†, Harley, C.D.G.†, Pruitt, J.N.‡, Carrington, E.‡
SURVIVAL OF THE WEAKEST: INCREASED FROND MECHANICAL STRENGTH IN A WAVE-SWEEP KELP INHIBITS SELF-PRUNING INCREASING MORTALITY
1 - University of British Columbia 2 - University of Pittsburgh 3 - Friday Harbor Labs
Hydrodynamic forces imposed by waves are thought to be the largest selective pressure for seaweeds in high energy near-shore habitats. Over the last few decades interspecific comparative studies have illuminated the importance of tissue strength and flexibility to survival in this mechanically stressful zone. However, whether or not selection acts on mechanical properties remains unknown. In this study, we measured flexibility and strength in 5 fronds of 40 Egregia menziesii individuals whose survival was tracked over a year. Because frond strength and stiffness result in increased drag for the whole plant, we predicted that stronger and/or stiffer plants should have lower survivorship. Logistic regression analyses show that variation in both mechanical properties resulted in differential survivorship of whole plants whereby more flexible individuals were more likely to survive and stronger individuals were more likely to become dislodged. Further analyses revealed that stronger individuals lost fewer fronds throughout the winter, while weaker individuals ‘self-pruned’. Increased survivorship of self-pruned individuals was likely due to decreased size (and therefore decreased drag) during the largest swell events. Results indicate that inter-individual variation in mechanical properties is evolutionary significant and suggest that self-pruning is an important survival strategy in multi-fronded perennial kelp species.

Dimond, J.†, Holzman, B.‡, Bingham, B.L.†
THE ROLE OF THE HOST IN THE PHOTOPHYSIOLOGY OF ELLIPTOCHLORIS MARINA, CHLOROPHYTE SYMBIONT OF ANTHOPLEURA SPP. SEA ANEMONES
1 - Shannon Point Marine Center, Western Washington University 2 - Cascadia Community College
Elliptochloris marina, the chlorophyte symbiont of Anthopleura spp. intertidal sea anemones along the Pacific coast of North America, occurs approximately 6 degrees of latitude farther south and much higher in the intertidal zone in A. xanthogrammica than in A. elegantissima. These host-dependent distribution patterns cannot be attributed to habitat effects or differences in host size. We hypothesized that these patterns might reflect differences in E. marina photophysiology according to host species. To evaluate this hypothesis, both anemone species hosting E. marina were acclimated together in outdoor tanks for three months before collecting data on their photobiology. Throughout diel cycles, quantum yield of photosystem II was consistently higher in A. xanthogrammica symbionts, and rapid light curves (RLCs) of freshly excised anemone tentacles likewise showed higher quantum yields in A. xanthogrammica symbionts. In contrast, for symbionts freshly isolated from host tissues, both RLCs and light-saturated carbon fixation rates showed no host species effect. These results suggest immediate effects of the intact host environment on symbiont photophysiology. Examination of host tissue properties suggests that thicker tissues of A. xanthogrammica may enhance E. marina photophysiology by filtering more light and allowing for thicker layers of symbionts that increase self-shading. Such an environment would favor E. marina, a relatively stress-susceptible symbiont, over Symbiodinium muscatinei, which is more tolerant of high irradiance and is the more prevalent symbiont in A. elegantissima.

Dlouhy, B.L.*, Shanks, A.L
DRIFTING AMONG JUVENILE BIVALVES WITHIN THE COOS BAY ESTUARY
Oregon Institute of Marine Biology, University of Oregon
Larval dispersal is an important aspect of life history in many marine organisms, including bivalves. The dispersal period is usually related to the time the larvae spend in the water column. Bivalve larvae that are planktotrophic spend an extended time in the water column until competent to metamorphose at which time the larvae settle into an appropriate habitat. It was previously thought after initial settlement the dispersal stage was over, however, over the past few decades research has indicated this is not the case. Bivalves have the ability and potential to disperse during post-larval and juvenile
phases by “byssus drifting,” or thread drifting. From August 2009 through July 2011 stratified plankton
tows were taken monthly in the Coos Bay estuary to address the effects of physical oceanographic
factors including tidal cycle, temperature, salinity, lunar periodicity, and current speed. At least five
species of juvenile drifting bivalves, including *Clinocardium nuttalli* and *Mytilus* spp., were collected
throughout the water column, ranging in sizes from 1.0 mm to 4.0 mm. Preliminary results suggest the
effects of tidal cycle are not consistent throughout the year and current speed may play an important
role in the drifting behavior.

† Dolecal, R.E.*, Long, J.D.

**SIGNALING SEAWEEDS: CAN HERBIVORE-INDUCED CUES FROM MARINE SEAWEEDS
FACILITATE PREDATOR FORAGING?**
*Coastal and Marine Institute Laboratory, San Diego State University*

Chemosenstive, carnivorous predators utilize a variety of chemical cues to track and locate their prey.
These cues may originate from the prey themselves, or from behaviors that provide evidence of their
presence. Work in terrestrial systems has demonstrated that when actively grazed, plants will release
herbivore-induced volatile chemicals that arthropod predators can exploit to find their herbivorous prey.
This type of chemically-mediated tritrophic interaction is important in facilitating predator foraging, as
well as acting as an indirect defense mechanism for plants. Despite the critical influence of chemical
cues in interactions between marine organisms, seaweed-predator interactions remain unstudied in
marine systems. To evaluate the importance of seaweed cues to benthic predator foraging, I tested
the attractiveness of two common Southern California seaweed species, *Macrocystis pyrifera* and *Ulva*
sp., when actively grazed. To do this, I used y-maze choice experiments and *in situ* trapping
experiments. Y-maze experiments tested predatory responses of *Pisaster giganteus* to grazed
*Macrocystis* versus ambient seawater, while trapping experiments tested the attractiveness of 1)
grazed *Macrocystis* versus empty traps or ungrazed *Macrocystis*, and 2) grazed *Ulva* versus empty
traps, to a natural suite of predators under natural conditions. In both y-maze and trapping
experiments, actively grazed seaweeds failed to attract higher numbers of predators, suggesting that
cues released by grazed *Macrocystis* and *Ulva* are not utilized by benthic predators during foraging.
Future work will investigate the ubiquity of these seaweed-predator interactions in additional seaweed
species in order to improve our limited understanding of the prevalence of these tritrophic links in
marine communities.

Donovan, M.K.*, Williams, I.D.*, Dierking, J., Friedlander, A.M.

**MULTI-SCALE DEMOGRAPHIC TRENDS IN AN INTRODUCED HAWAIIAN REEF FISH**
*1 - National Oceanic and Atmospheric Administration (NOAA), Coral Reef Ecosystem Division, University of Hawaii at Manoa 2 - Hawaii Cooperative Fishery Research Unit, University of Hawaii at Manoa*

Identifying the appropriate spatial scale to measure ecological mechanisms can be difficult, and this is
arguably a large gap in understanding the population dynamics of coral reef fishes. Multiple factors
operating at different spatial scales affect local populations of reef fish such as ocean current patterns
at a broad scale and competition at a fine scale. This study utilizes a unique opportunity to collect large
sample sizes of a coral reef fish species across the Hawaiian Archipelago. Collections occur as a
result of a grass roots effort to remove an invasive predatory fish, the peacock grouper *Cephalopholis argus*,
which was introduced into Hawaii in the 1950s. Otolith ageing techniques were employed to
describe age and growth, and that information combined with length frequency distributions from
underwater visual surveys was used to estimate population size structure by location. These factors,
measured at different locations, were then compared to assess the individual effects of temperature,
habitat, productivity, latitude, and conspecific density on demographic responses of *C. argus*. This
study highlights the importance of considering variability in demographic parameters in a coral reef fish
for population assessments. Further, this is a step towards understanding the variation of demographic
parameters and how this relates to physical and biological processes that occur on multiple spatial
scales.
Dudgeon, S.R.¹, Rudy, R.A.¹, Rudy, P.A.¹, Krueger, S.A.², Kubler, J.E.¹
TRADE-OFFS OF REPRODUCTIVE MODE REVISITED: ASEXUAL MASTOCARPUS PAPILLATUS HAVE SOME BENEFITS OF SEX WITHOUT THE COST?
1 - California State University Northridge 2 - Marine Biological Station, Roscoff, France, California State University Northridge
Populations of asexual organisms, being clones, should lack genetic diversity relative to their sexual counterparts and inevitably accumulate deleterious mutations leading to limited ecological success and persistence principally in marginal habitats. Patterns of distribution and abundance of asexual Mastocarpus papillatus conflict with theoretical expectation: asexual fronds are more abundant and distributed more widely than sexual fronds across tidal elevations in California, through both favorable and marginal habitats. We examined whether asexual M. papillatus consisted of haploid lineages with little genetic diversity relative to their sexual counterparts, using both microsatellite markers and C-values of different life cycle stages from images of DAPI-stained nuclei obtained by confocal microscopy. In contrast to what is assumed in the literature, asexual fronds of M. papillatus are diploid, as in M. stellatus. Heterozygous genotypes at several microsatellite loci confirmed diploidy in asexual fronds of M. papillatus. Genetic diversity in asexual lineages of M. papillatus is comparable to that in the sexually reproducing lineage at microsatellite loci tested thus far. The occurrence of greater than expected genetic diversity of asexual fronds (associated both with diploidy and multiple origins from sexual lineages) without incurring the cost of sex provides a basis to explain the ecological success of the asexual life cycle of M. papillatus.

† Dufault, A.M.¹, Cumbo, V.R.¹, Fan, T.Y.², Edmunds, P.J.¹
THE IMPORTANCE OF LIGHT IN MEDIATING THE EFFECTS OF OCEAN ACIDIFICATION ON CORAL RECRUITS.
1 - California State University Northridge 2 - National Museum of Marine Biology and Aquarium, Taiwan
Light is of fundamental importance to reef-building corals, driving photosynthesis by their symbiotic algae Symbiodinium, and helping them dominate benthic ecosystems in shallow tropical seas. The influence of light on coral calcification is well understood, however the effect of light has been absent from work investigating effects of ocean acidification (OA) on coral calcification. In this study, we tested the effect of light and increased pCO₂ on calcification and survival of 2 day old Pocillopora damicornis recruits. Recruits were incubated in 1 of 5 light treatments (226, 122, 70, 41, 31 µmol photons m⁻²s⁻¹) under ambient (493µatm) or high pCO₂ (878µatm) for 5 days. Calcification was significantly affected by pCO₂ and the interaction of pCO₂ x light, and in ambient pCO₂ the response resembled a hyperbolic tangent function against light intensity. Recruits in high pCO₂ displayed a contrasting relationship to light relative to ambient pCO₂, resulting in large differences in calcification between ambient and high pCO₂ at intermediate light intensities but similar rates at the highest and lowest light intensities. Survivorship of spat was significantly affected by both light and pCO₂, and was highest at 122 µmol photos m⁻²s⁻¹ in both pCO₂ treatments; survivorship was not correlated with calcification. This work demonstrates that the effects of OA on the calcification of coral recruits is light-dependent and suggests that the interactive effects of pCO₂ and light on calcification may be an important means to resolve some of the contrasting results that have been reported for the effects of OA on corals.

Eckert, G.L.¹, Okamoto, D.K.²
RECRUITMENT AND COLONIZATION ON ARTIFICIAL REEFS IN SOUTHEAST ALASKA
1 - University of Alaska Fairbanks 2 - University of California Santa Barbara
Artificial reefs are commonly used to enhance fisheries in tropical regions and recently have been used as mitigation in a variety of habitats, including estuaries, bays, harbors, and kelp forests. To investigate the utility for mitigation of artificial reefs in high latitude temperate kelp forests in Alaska, we studied colonization potential and community succession on two small artificial reefs in Southeast Alaska that were constructed in December 2007. The artificial reefs were composed of natural rock roughly 0.5-1.0 m in diameter, 1-3 rock layers deep, for approximate reef dimensions of 30m x 10m x 2m at 5-8 m depth below MLLW. We surveyed permanent transects on these artificial reefs and
nearby natural reefs each summer from 2008-2011. Two of three kelp species (Saccharina bongardiana f. subsimplex and Laminaria yeoensis) rapidly recruited to the artificial reefs and within 18 months matched or exceeded the adult densities on natural reefs. In contrast, the third kelp species (Agarum clathratum) did not recruit at all on the artificial reefs within the first two years, and its adult stipe density on artificial reefs still remains near zero. The most common macroinvertebrate species, including Pycnopodia helianthoides, Evasterias troscheli, Parastichopus californicus, and Strongylocentrotus droebachiensis, had variable densities on natural and artificial reefs over time. On average, algal and invertebrate biodiversity was higher on natural reefs opposed to artificial reefs, while fish biodiversity was not different between reef types. In conclusion artificial reefs can serve as an effective habitat restoration tool in high latitude kelp forests.

Edmunds, P.J.*, Cumbo, V.*, Fan, T.-Y.
METABOLIC COSTS OF LARVAL SETTLEMENT AND METAMORPHOSIS IN THE CORAL SERIATOPORA HYSTRIX UNDER AMBIENT AND ELEVATED PCO₂
1 - California State University Northridge 2 - National Museum of Marine Biology and Aquarium, Institute of Marine Biodiversity and Evolution, National Dong Hwa University
For stony corals, the transition from pelagic larva to benthic polyp marks a major shift in body design, yet little is known of the metabolic consequences of this reorganization. In this study, we designed a system to incubate newly settled corals under high rates of seawater flow, and used it to test the effects of elevated pCO₂ on the respiration and growth of Seriatopora hystrix over the first 4 d of benthic existence. In March 2011, larvae were harvested from S. hystrix collected from Nanwan Bay, Taiwan, and settled at a density of 11-20 spat in small (3.2 mL) glass vials. Spat were incubated for up to 4 d at 24.0°C and ~ 250 μmol quanta m⁻² s⁻¹, and received seawater (at 1.4 mL s⁻¹) equilibrated with 489 μatm or 859 μatm pCO₂. Spat respiration ranged from 0.056 to 0.095 nmol O₂ spat⁻¹ min⁻¹ at 489 μatm pCO₂, it increased over time and peaked ~ 48 h after settlement, and was 1.9 to 3.3-fold greater than larval respiration. Elevated pCO₂ slightly depressed respiration in Experiment 2, but had no effect on coralite area; high pCO₂ was, however, associated with weaker adhesion to the settlement surface and lower biomass. Together, these results reveal the metabolic cost of settlement and metamorphosis in a brooding coral, and suggest that the effects of high pCO₂ in the first few days of settlement may be eclipsed by intrinsic metabolic demands.

† Edwards, C.B.
A GLOBAL ASSESSMENT OF CORAL REEF HERBIVORES: EVIDENCE FOR FISHING EFFECTS ON THE BIOMASS OF DIFFERENT FUNCTIONAL GROUPS
Scripps Institute of Oceanography, Scripps Institution of Oceanography, UCSD
Resilience and restoration strategies for threatened and degraded coral reefs will be most useful if realistic management targets are accurately determined. Evidence suggests herbivores may be a useful mechanism for maintaining or rebuilding reef resilience. However, little is known about how fishing alters herbivore biomass or community structure. We conducted a global meta-analysis on the variability in biomass of key taxonomic and functional groups and examined variation between fished and unfished locations at global and regional scales. An exhaustive search of peer reviewed literature and collaboration between SIO and US governmental monitoring programs was used to create a dataset including over 800 estimates of biomass from 130 locations around the globe. Herbivore biomass at unfished and fished sites was 46.2±6.3 and 16.1±1.1 g/m², respectively, and independent of regional effects. Functional group analysis shows significantly greater biomass of the scraper/excavator sub-guild at unfished sites relative to fished sites (25.5±6.3 and 16.1±1.1 g/m², respectively), also independent of regional effects. Results suggest over-exploitation of fish resources has large impacts on herbivorous fish assemblages and disproportionately effects the scraper/excavator sub-guild. Evidence suggests scraping and excavating species are especially important in maintaining low fleshy algal abundance and promoting crustose coralline algae and coral recruitment, supporting the view that restoration strategies must maintain subgroups in proper ratios. Given the important role that herbivores play in maintaining the balance between algal and coral cover these results have significant implications for the development of management strategies to improve the resilience and restoration of the world’s coral reefs.
† Eerkes-Medrano, D.¹, Menge, B.¹, Langdon, C.², Sislak, C.³
DIFFERENTIAL EFFECTS OF HYPOXIC CONDITIONS ON SURVIVAL OF PLANKTONIC LARVAE OF ROCKY INTERTIDAL INVERTEBRATES
1 - Oregon State University 2 - Hatfield Marine Science Center 3 - Portland State University
Coastal ocean hypoxia is increasing worldwide with detrimental effects in many species. In the Pacific Northwest, an unprecedented rise in seasonal hypoxic and anoxic events has resulted in mass mortalities of fish and benthic invertebrates, but the effects on planktonic organisms are not well understood. We investigated the mortality of planktonic larval invertebrates exposed to low oxygen conditions in controlled laboratory experiments. Hypoxic conditions were generated by bubbling seawater with nitrogen gas to expose larvae to dissolved oxygen concentrations representative of the near shore environment of the Oregon coast. Results revealed a wide range of tolerances, from species with little tolerance to hypoxia (e.g. the shore crab Hemigrapsus oregonensis) to species with high tolerance (e.g. the California mussel Mytilus californianus). These differential responses amongst intertidal taxa suggest that chronic hypoxia or anoxia potentially could affect their recruitment success and consequently, the structure and species composition of intertidal communities.

† Elahi, R.*, Sebens, K.P.
A CONSUMER ONE-TWO PUNCH: FACILITATION AND FUNCTIONAL DIVERSITY PREVENT REVERSALS IN COMMUNITY COMPOSITION
Friday Harbor Labs, University of Washington
Declines in global biodiversity have prompted ecologists to question the relative importance of diversity and identity in the context of species loss. We tested the effects of consumer functional diversity and identity on subtidal rock wall epifauna using two field experiments in the San Juan Islands, WA. In the first, we added urchins to walls every two weeks for three months and demonstrated that urchins control the structure of this community by grazing on sessile taxa, exposing algal crusts and bare rock (together considered ‘space’), and facilitating chitons and other consumers. In the context of diet analyses, we conclude that urchins create space by consuming macroalgae and invertebrate colonies, while chitons maintain available space by grazing primarily on microalgae and diatoms. In the second experiment, we conducted a factorial removal of urchins and chitons from walls every two weeks for one year. The removal of each functional group in isolation had no effect on the epifaunal community, but the removal of both consumers caused a decrease in space and an increase in the cover of clonal ascidians. Together, these experiments suggest that urchins and chitons can be considered functionally redundant in the maintenance of space, but not the creation of space. Facilitation and redundancy among consumers may contribute to the resiliency of urchin-mediated ‘barrens’, even if urchins do not persist.

† Evans, L.*, Edwards, M.S.
BIOACCUMULATION OF COPPER AND ZINC BY THE GIANT KELP MACROCYSTIS PYRIFERA
Coastal and Marine Institute Laboratory, San Diego State University
The bioaccumulation of copper (Cu) and zinc (Zn) by the giant kelp, Macrocystis pyrifera, was examined by exposing meristematic kelp tissue to elevated metal concentrations in seawater. Two different experiments examined metal uptake: 1) under a single ecologically relevant elevated level of each metal (i.e. 30ppb Cu and 100ppb Zn), and 2) between varying metal levels (i.e. 15 to 480ppb Cu, and 50 to 600ppb Zn). Both experiments were designed to contrast the uptake of the metals in isolation, and in combination. Following three days of exposure, M. pyrifera tissues were collected and analyzed using an Inductively Coupled Plasma Atomic Emissions Spectroscopy. Our results indicate that M. pyrifera bioaccumulated Cu in all treatments regardless of whether Zn concentrations were increased. Yet M. pyrifera only bioaccumulated Zn in treatments when Zn was increased alone. This suggests that elevated Cu concentrations inhibit the uptake of Zn, but not vice versa. Following this, a second experiment was done to examine the relationships between varying seawater Cu and Zn concentrations and their bioaccumulation by M. pyrifera. Here, our results indicate that as metal concentrations in the seawater increase, the uptake of Cu and Zn by M. pyrifera tissue also increases. As with the first experiment, the presence of elevated Zn did not appear to impact Cu uptake at any concentration examined. However a trend was observed in which the presence of elevated Cu
appeared to inhibit Zn uptake. This study suggests that *M. pyrifera* may be used as a bio-indicator species to monitor heavy metal pollution in the coastal environment.

MASSIVE DIE-OFF OF RED ABALONE, *H. RUFESCENS*, QUANTIFIED IN MARINE PROTECTED AREAS ALONG THE COAST OF SONOMA COUNTY, CALIFORNIA
University of California Santa Cruz
In late August of 2011 a die-off of several invertebrate species, including sea urchins (*Strongylocentrotus purpuratus* and *franciscanus*), species of chitons (most notably the gumboot chiton, *Cryptochiton stelleri*), and especially the red abalone (*Haliotis rufescens*) was observed along the Sonoma Coast. The California Fish and Game Commission subsequently voted unanimously to close the recreational abalone fishery throughout Sonoma County. Surveys of the recently established marine protected areas (MPAs) in the North Central Study Region of the MPA network conducted before (2010) and just after the event (2011) allowed quantitative estimates of the magnitude and spatial extent of the die-off. Although it appears that the die-off was restricted to only a small stretch of coastline, mortality as high as 96% was observed in *H. rufescens* within shallow waters (less than 6.5m). No dead *H. rufescens* were observed deeper than 6.5m and the smallest dead *H. rufescens* observed was 12cm. Along this stretch of coastline, *H. rufescens* is a particularly abundant herbivorous detritivore in shallow depths (<10m) while *S. franciscanus* and *S. purpuratus* are predominant herbivores in deeper depths (20m). A mixture of the two herbivores occurs in middle depths. The study provides one example of how monitoring studies of marine protected areas can identify environmental events and help inform management responses.

Fernandez-Silva, I.*, Whitney, J., Wainwright, B., Bird, C, Toonen, R., Bowen, B.
NEXT GENERATION SEQUENCING APPLICATIONS FOR THE STUDY OF BIODIVERSITY
Hawaii Institute of Marine Biology, University of Hawaii
The emergence of Next Generation Sequencing (NGS) technologies makes genomic information fast and affordable in non-model species and opens new horizons for hypothesis testing in evolutionary studies. Here we will present some new methodologies based on NGS for the development of large panels of markers in non-model species and review some recent large-scale population genetic and molecular phylogenetic studies.

Fierst, J.L.*
A HISTORY OF PHENOTYPIC PLASTICITY ACCELERATES ADAPTATION TO A NEW ENVIRONMENT
University of Oregon
Theoretical studies suggest that phenotypic plasticity may result in increased adaptation. Plastic organisms produce multiple phenotypes, one of which may better fit the environment, or may adapt quickly through genetic assimilation. An alternative is that the fluctuating environments that result in phenotypic plasticity may produce evolvable genetic architectures. I modeled a phenotypic character in one population with phenotypic plasticity, and one population in a constant environment. A history of phenotypic plasticity increased the rate of adaptation in the new environment and this increase was consistent over long periods of adaptation in the new environment. Invasive species have been reported to adapt rapidly to new environments in the absence of genetic variation. If phenotypic plasticity results in segregating phenotypic variation that permits persistence in new environments and evolvable genetic architectures, invasion dynamics may be dominated by plastic species.

Fisher, J.L.*, Peterson, W.T. 2, Morgan, C.A. 1, Peterson, J. 1, Bi, H. 3, Rykaczewski, R. 1
THE PACIFIC DEcadAL OSCILLATION AND THE SOURCE WATERS FEEDING THE NORTHERN CALIFORNIA CURRENT DETERMINE FOOD WEB STRUCTURE
1 - Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, Oregon State University 2 - NOAA, Northwest Fisheries Science Center, Hatfield Marine Science Center, Oregon State University 3 - Chesapeake Bay Biological Laboratory, University of Maryland
Here we explore the relative effects of local upwelling vs. basin-scale changes in advection, on
copepod community structure in the Oregon upwelling zone over the past 15 years. Hydrographic and zooplankton data collected every two weeks has shown that variations in sea surface temperature, salinity, copepod biodiversity, species richness, and community structure are correlated with the Pacific Decadal Oscillation (PDO). When the PDO is in a negative phase (as in 1999-2002 and 2008), cold Subarctic waters from the Gulf of Alaska feed the northern California Current (NCC), transporting large, lipid-rich copepods to the shelf waters of the NCC; when the PDO is positive (as in 1996-1998, 2003-2007, and 2009), warm subtropical waters from offshore and south of Oregon feed the NCC, transporting small, oceanic lipid-poor copepods to the coastal upwelling zone. This suggests that large-scale transport processes control zooplankton species composition in the coastal upwelling zone off Oregon, whereas upwelling itself may control only local productivity. These changes in food chain structure correlate with (and predict) salmon returns to the Columbia River basin.

† Fox, C.H.*, Reimchen, T.E.
SALMON ABUNDANCE PREDICTS ANNUAL GROWTH IN RIPARIAN SITKA SPRUCE
University of Victoria
Anadromous salmon (Oncorhynchus spp.) provide what is considered to be the dominant marine subsidy to terrestrial ecosystems of the Pacific Northwest. Salmon nutrients, primarily transferred into riparian zones by bears (Ursus spp.), have been shown to broadly influence terrestrial ecosystems, including nitrogen sequestering by plants. Studies of conifers suggest that tree rings provide a proxy for historical salmon abundance but fine-scale, within-watershed knowledge of the contribution of salmon to tree growth is limited. 39 tree cores were collected from riparian Sitka spruce in Bag Harbour, Haida Gwaii, a site where salmon carcass distribution has been extensively documented. Tree ring widths were measured, cross-dated and detrended for age effects. A series of GLMMs were constructed and ranked using AIC. Predictor variables included >50 years of annual salmon abundance, precipitation and maximum monthly temperature in addition to the spatial predictors distance from stream and distance upstream. Our analysis found that the highest ranked model included salmon abundance, in addition to environmental and spatial predictors. A second series of ranked GLMMs suggests that the role of salmon is temporally variable; over certain time periods salmon abundance is the strongest single predictor of tree growth while in others, environmental predictors are also major contributors. Unexpectedly, no interactions between salmon abundance and spatial predictors were detected, suggesting that the influence of salmon is more widespread than previously known. Our study highlights the importance of salmon to terrestrial forests and provides additional evidence that as salmon populations decline, their role in terrestrial ecosystems is diminished.

† Fox, M.D.*
INVESTING IN POTENTIAL: MECHANISMS FOR RECOVERY FROM BIOMASS LOSS IN MACROCystis PYRIFERA
Moss Landing Marine Laboratories
The exceptional morphologic and physiologic plasticity within giant kelp, Macrocystis pyriforma, has allowed it to become the most globally successful kelp species. Despite extensive knowledge of Macrocystis biology few studies have examined the physiological mechanisms for recovery from disturbance within this species. Climate models suggest an intensification of North Pacific winter storms and a concomitant increase in significant wave heights, both of which are sources of considerable biomass loss and mortality within Macrocystis populations in California. A biomass removal experiment was conducted to model the impacts of winter wave damage on giant kelp plants in order to elucidate the mechanisms for recovery. Preliminary results suggest recovery is driven by the initiation of new fronds rather than by elongation of existing fronds. The presence and number of active meristems in the canopy and plant biomass appear to constrain the initiation rates and subsequently recover. As such, the intensity and frequency of winter storms could play a prominent role in structuring giant kelp forest systems in the future.
DEVELOPING AN AUTOMATED DETECTION ALGORITHM TO QUANTIFY SURFACE SWARMS OF AURELIA SPP. AND CHRYSAORA FUCESCENS
1 - California State University Monterey Bay 2 - Moss Landing Marine Laboratories 3 - National Oceanic and Atmospheric Administration (NOAA)

We developed an automated detection algorithm to quantify aggregations of moon jellies, Aurelia spp., and brown sea nettles, Chrysaora fuscescens, from the sea surface to approximately 1 m depth from aerial photographs. Photographs were acquired during aerial line-transect surveys to assess distribution and abundance of the critically endangered leatherback turtle, Dermochelys coriacea, along the central coast of California. Following existing protocols, jellies observed within the strip-transect under the plane were recorded using a categorical density index: none, few (0-30), moderate (31-300), or dense (>300). Jellies were manually counted in several photographs of each density category using a point feature in ArcGIS. An automated detection algorithm (MATLAB) produced a second density estimate for the same photographs by using pixel color to determine the proportion of surface area represented by jellies and then dividing that total jelly surface area by the mean surface area of jellies in that photograph (n=100). A significant, positive relationship between the manual and automated detection algorithm density estimates indicates that the algorithm is a useful tool to estimate density of surface swarms of jellies (moon jellies: $y=0.654x + 22.339$, $r^2=0.964$, $p<<0.001$, $n=15$, brown sea nettles: $y = 0.700x + 45.739$, $r^2=0.73$, $p<<0.001$, $n = 15$) despite a slight downward bias for moderate to dense jelly aggregations. The efficiency of the automated detection algorithm provides important and timely information for leatherback turtle prey studies and critical habitat assessments.

† Galloway, A.W.E.*, Britton-Simmons, K.H.*, Gabrielson, P.W.*, Brett, M.T.*
FINE PHYLOGENETIC RESOLUTION OF MARINE MACROPHYTE FATTY ACIDS HAS IMPORTANT IMPLICATIONS FOR FOOD WEB STUDIES
1 - Friday Harbor Labs, University of Washington 2 - University of North Carolina Botanical Garden, University of North Carolina

Temperate rocky marine macrophyte communities are among the most productive ecosystems on earth and contain a diverse assemblage of species. This diversity confounds attempts to ascertain food web linkages using mixing models based upon stable isotope biomarkers. Fatty acids (FA), in particular essential FA (EFA) may address this problem because EFA are only synthesized by primary producers and as such are conservative trophic biomarkers. We tested the hypothesis that marine macrophyte have different FA signatures by conducting a phylogenetic survey of FA content of 40 subtidal and intertidal marine macrophytes representing 36 families, 21 orders, and 4 phyla (seagrasses, Anthophyta; brown algae, Ochrophyta; green algae, Chlorophyta; red algae, Rhodophyta) in the San Juan Archipelago (SJA), WA, USA. We use multivariate statistics to show that there is a clear relationship between FA signature and marine macrophyte group. FA composition differs significantly among phyla, orders, and families using all 44 FA identified as well as a subset of seven w-3 and w-6 EFA. We found the same statistically significant taxonomic pattern and resolution by testing published EFA data of 123 additional macrophyte species representing the same four phyla. The FA signatures of seagrasses and green algae were distinct, despite the close evolutionary relationship of these lineages. The variability in macrophyte FA content differs among phyla, with species of red algae showing greater diversity compared to other phyla. The taxonomic resolution of macrophyte EFA has considerable implications for resolving fundamental ecological questions about the importance of different basal resources to marine food webs.

Garza, C.*
SCALE DEPENDENCE IN THE DISTRIBUTION AND INTENSITY OF SPECIES DIVERSITY IN INTERTIDAL COMMUNITIES.
California State University Monterey Bay

The processes that drive the distribution and intensity of species diversity in rocky intertidal communities are some of the most intensively studied phenomena in the ecological literature. In this study I examined the effect of scale dependence on the relationship between physical forcing factors...
and the location and intensity of species diversity along rocky shores on the U.S. West coast. Using a hierarchical sampling design, at Point Lobos State Reserve in California, estimates were made of quantitative changes in the strength of the relationship between species diversity and the physical environment as a function of scale. The results of this study reveal that the relationship between physical factors, such as wave energy, and the location and intensity of species diversity are also related to the complexity of the habitat across which diversity is measured. These findings also suggest that the distribution and intensity of species diversity are driven by complex spatially structured processes whose relational strength is sensitive to changes in the scale over which it is observed.

Gaylord, B.1*, Hill, T.M.1, Sanford, E.1, Lenz, E.A.1, Jacobs, L.A.1, Sato, K.N.1, Russell, A.D.2, Hettinger, A.1

FUNCTIONAL IMPACTS OF OCEAN ACIDIFICATION IN THE INTERTIDAL FOUNDATION SPECIES, MYTILUS CALIFORNIANUS

1 - Bodega Marine Laboratory, University of California Davis 2 - Dept. of Geology, University of California Davis

Human-produced carbon dioxide (CO₂) is reducing the pH and altering the carbonate chemistry of seawater, with broad implications for marine organisms and ecosystems. Current research suggests that calcification will decrease in many species, but compelling evidence of impaired functional performance of calcium carbonate structures is sparse. Here we demonstrate that ocean acidification markedly degrades the mechanical integrity of larval shells in the mussel Mytilus californianus, a critical community member on rocky shores throughout the northeastern Pacific. Larvae cultured in seawater containing CO₂ concentrations expected by the year 2100 (540 or 970 ppm) precipitated weaker, thinner, and smaller shells than individuals raised under present-day seawater conditions (380 ppm), and also exhibited lower tissue mass. Under a scenario where mussel larvae exposed to different CO₂ levels develop at similar rates, these trends suggest a suite of potential consequences, including an exacerbated vulnerability of new settlers to crushing and drilling attacks by predators, poorer larval condition causing increased energetic stress during metamorphosis, and greater risks from desiccation at low tide due to shifts in shell area/body mass ratios. Under an alternative scenario where responses derive from slowed development, with impacted individuals reaching identical milestones in shell strength and size by settlement, a lengthened larval phase could increase exposure to high planktonic mortality rates. In either case, because early life stages operate as population bottlenecks driving general patterns of distribution and abundance, the ecological success of this vital species may be tied to how ocean acidification proceeds in coming decades.

† Gooding, R.A.1*, Ingram, T.H.2, Harley, C.D.G1

MULTIPLE CLIMATE VARIABLES MAY INDIRECTLY REDUCE MUSSEL POPULATIONS VIA INCREASED GROWTH AND FEEDING OF A KEYSTONE PREDATOR

1 - University of British Columbia 2 - Harvard University

Recent studies have demonstrated that responses to multiple climate variables are varied and often species-specific. The indirect consequences of these differing responses via altered species interactions are poorly understood. Field studies manipulating climate variables at population and community levels can be difficult or impossible; mathematical models incorporating results of laboratory studies on interacting species can help predict these responses. Using previously published and newly collected data on effects of ocean warming and acidification on sea stars and mussels, we developed a predator-prey model to predict population-level responses. We found the abundance and size distributions of the mussel Mytilus trossulus will likely decrease with future climate change, even under scenarios where M. trossulus is not directly affected by climate change. In contrast, modeled populations of P. ochraceus remained relatively unaffected under most scenarios. This could drastically alter diversity patterns on temperate rocky shores. More broadly, our findings suggest that predictions of responses to climate change should consider not only species-specific responses, but also indirect effects via altered species interactions.
† Gowan, J.*, Carpenter, R.
DO FINE-SCALE SPATIAL DIFFERENCES IN SEDIMENTATION AFFECT CORAL-ALGAL INTERACTION OUTCOMES: DOES IT MATTER WHERE YOU GET DIRTY?
California State University Northridge
The outcomes of interactions between scleractinian corals and benthic algae are important in structuring coral reef communities and may be influenced by various abiotic factors such as sedimentation, a process often underlying reef degradation. Previous studies revealed that gradients in coral-algal interaction frequency and benthic composition correlate with gradients in sedimentation, suggesting that sediment loading may play an important role in determining the outcomes of coral-algal interactions. Additionally, field surveys indicate that sediment accumulation is significantly greater along interaction margins compared to the adjacent non-interacting coral and algal surfaces. This finding leads us to hypothesize that this may be an additional important mechanism by which sediments influence coral-algal interactions. We quantified the relative effects of sediment accumulation along interaction boundaries, on the surface of coral and algal tissue not in direct competition, and all possible location combinations. Our results revealed that the greatest damage to coral tissue occurred in treatments where sediments were present along the interaction margin. This outcome suggests that sediment accumulation at the coral-algal interface has the greatest effect on the competitive outcome of the interaction. Knowledge of how fine-scale patterns of sediment deposition may affect the competitive outcome of coral-algal interactions has large implications for the study of coral and algal dynamics as well as increasing our understanding of the relative importance of the phenomenon known as sediment trapping by algal turf.

Graham, M.H.*, Muth, A.
PHYLOGENETIC RELATEDNESS CONSTRAINS THE EFFECT OF INCREASED TEMPERATURE ON KELP RECRUITMENT
Moss Landing Marine Laboratories
Kelp recruitment success is generally considered to decrease with rising water temperatures making kelp populations vulnerable to impending climate change. The response of kelp systems to climate change at a global scale may vary, however, due to regional differences in temperature variability, acclimation, and differential responses of kelp taxonomic clades to rising temperatures. Culture experiments were conducted on 19 kelp taxa from 4 families with collection sites from British Columbia, central California, southern California, and southern Chile to test the effects of temperature and nutrients on recruitment success. Cultures were grown under three nutrient levels (1, 5, and 10 µmol nitrate) and two temperatures (12°C and 18°C) at saturating irradiance and monitored weekly for sporophyte production. For all taxa from all locations, sporophytes were always present in the 12°C treatment, under all nutrient levels tested. Regardless of taxon, however, sporophytes were never observed in the 18°C treatments from British Columbia and southern Chile. Sporophytes were observed in the 18°C treatments in increasing frequency from central California to southern California, but not for taxa from the cold-water family Alariaceae. These results indicate that the ability of kelps to acclimate recruitment success to rising temperatures is restricted to specific clades, suggesting that the response of kelp systems to climate change will vary at a global scale depending on phylogeography.

† Grason, E.W.*
INFLUENCE OF PARASITES ON PATTERNS OF ABUNDANCE, DISTRIBUTION, AND SIZE OF BATILLARIA ATTRAMENTARIA IN PADILLA BAY, WA.
University of Washington
One factor that is often cited as important in allowing introduced species to become abundant in novel habitats is a release from natural enemies. When invasive species do co-occur with their natural enemies, it provides investigators with an opportunity to learn about the context dependence of species interactions. In Padilla Bay, WA, a highly abundant, invasive, mud snail, Batillaria attramentaria, is infected with a co-evolved parasite, the castrating trematode Cercaria batillariae. The parasite reduces snail fecundity, and, in native habitats, has been reported to cause gigantism and migration of snails to lower tidal elevations. The population of Batillaria in Padilla Bay is notable for a
high prevalence of parasitized individuals: 86% versus 4-14% at other sites in the introduced range, and 40-50% in the native range. With field observations and a simple stage-structured matrix model, I explore how parasites might influence the abundance, size, and distribution of the snail populations across several sites. Initial field observations in Padilla Bay show an increase in snail size at lower tidal heights, consistent with parasite-induced changes in the growth and movement, with notable exceptions. These data are reconciled with patterns of parasite prevalence in Padilla Bay and compared to patterns in the native range. The matrix model is used to generate expectations about how infection rate and fecundity can affect snail size distribution and parasite prevalence, and compare expectations across several sites.

† Gravem, S.A.*, Morgan, S.G.
ABIOTIC IMPACTS ON SPECIES DISTRIBUTIONS AROUND INTERTIDAL BOULDERS FOR FORECASTING RESPONSES TO CLIMATE CHANGE
Bodega Marine Laboratory, University of California Davis
Our ability to predict the responses of species to climate change is based on abiotic controls on species distributions. We measured gradients of insolation, temperature, water motion, and desiccation around replicate intertidal boulders to determine their effects on species distributions and interactions in rocky intertidal communities. Temperature loggers reported highest rock temperatures on south and east boulder faces during morning low tides in summer, and temperatures increased with shore level and on horizontal surfaces. We also identified a mathematical relationship between rock temperatures and body temperatures of solitary biomimetic “robomussels,” suggesting that rock surface temperature can be used to estimate body temperatures. Water motion was greatest on low seaward southwestern faces regardless of aspect. Desiccation was greatest on sunny low tides during strong, prevailing northwesterly winds. Different exposures to temperature and water motion synergistically affected species interactions and community composition around boulders, and may be used to forecast the impact of climate change on rocky intertidal communities across species’ ranges.

† Groesbeck, A.S.*, Salomon, A.K.*, Lepofsky, D.S.*, Rowell, K.*
ANCIENT CLAM MARICULTURE ON BC’S COASTLINE: AN EXPERIMENTAL EXAMINATION
1 - REM, Simon Fraser University 2 - University of Washington
Our project brings together archaeological, ecological, and traditional ecological knowledge to provide evidence for the historical ecological role of clam gardens, which offer insights for contemporary shoreline conservation strategies in the Pacific Northwest. The re-discovery and documentation of ancient clam gardens in British Columbia has prompted many questions about this ancient mariculture technique. It is widely assumed that clam gardens served to increase secondary production of clam beaches managed by coastal First Nations. Our study empirically tests this assumption through contemporary surveys and ecological experiments. We’ve both conducted surveys comparing non-walled and clam garden beaches, to understand the physical and ecological characteristics of clam gardens; and have completed experimentally testing if clam gardens have higher secondary productivity than beaches without garden walls. Our experiments take advantage of the comparable replicates of “classic” clam gardens built by First Nations’ people on Quadra Island, BC. We out-planted native little neck clams (Prototheca staminea) in 6 clam gardens and 5 non-walled beaches during their 2011 growing season and have preliminary data comparing growth rates between the two types of habitats. Other factors such as temperature, submergence time, and larval recruitment success were also measured for each experimental site and compared between garden and non-walled beaches. Preliminary surveys of these beaches indicate that clam gardens have distinct physical and ecological characteristics, such as extending clam habitat far beyond the natural slope of these modified beaches. Flattened slopes of clam gardens appear to be optimum habitat for staple foods of native shellfish.
† Gruman, C.A.1, Salomon, A.K.1, Price, E.2, Bergman, C.M.2

INVASIVE PREDATORS AND MARINE-TERRESTRIAL TROPHIC CASCADES IN HAIDA GWAI
1 - School of Resource and Environmental Management, Simon Fraser University 2 - Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site

Several islands in the remote archipelago protected within Gwaii Haanas National Park Reserve, National Marine Conservation Area Reserve and Haida Heritage Site off British Columbia’s North coast have been colonized by invasive Norway rats (Rattus norvegicus). On other island archipelagos, Norway rat invasions have been shown to provoke a terrestrial-marine trophic cascade that drastically alters the structure of intertidal communities. Invasive rats prey heavily on seabirds that forage on rocky shores, resulting in the proliferation of invertebrate grazers (snails and limpets) and subsequent declines of macroalgae. This cross-system trophic cascade drastically alters the structure of the intertidal community. We sought to quantify the magnitude of these indirect effects in Gwaii Haanas and also to determine the extent to which other environmental factors may mediate the strength of the cascade. We compared the abundance of algal species, sessile invertebrates and grazers on islands with and without rats along a gradient of wave action. Our data will inform managers of Gwaii Haanas, who are eager to learn how Norway rats may have impacted intertidal ecosystem integrity in the past and whether it might be restored following a Norway rat management program currently underway.

† Hall, A.M.

SPECIES OF CONCERN CUSK AND RIVER HERRING
University of Alaska Fairbanks

A declining trend has been evident since the 1980s for populations of river herring (Alosa pseudoharengus and Alosa aestivalis) and cusk (Brosme brosme) along the northeastern seaboard. Landings and survey indices have decreased considerably for cusk. An increase in the ratio of landings to survey biomass estimates since 1986 implies an increase in exploitation over this time period. River herring populations have declined throughout much of their range, prompting the establishment of moratoriums on taking and possessing river herring in Connecticut, Rhode Island, Massachusetts, Delaware and North Carolina. Recorded numbers of river herring entering these rivers suggest population collapses. The National Marine Fisheries Service (NMFS) has listed both river herring and cusk as “species of concern.” NMFS is responsible to promote conservation efforts for species for which NMFS has concerns regarding population status and threats (e.g., river herring) and for those for which information is insufficient to determine whether listing under the Endangered Species Act is warranted (e.g., cusk). The goal of this project was to review available information on these species, including potential risks and environmental threats, to develop a list of proactive conservation activities that NMFS should consider undertaking. The combined effects of overfishing, bycatch and habitat degradation have had drastic long-term impacts on river herring and cusk. These threats make it difficult for these species to reproduce successfully to sustain their populations over time. Identification of proactive efforts that can be taken to conserve such species of concern helps NMFS ameliorate current and future threats to these species.

Hallenbeck, T.R., Kvitek, R. G, Lindholm, J

RIPPLED SCOUR DEPRESSIONS ADD ECOLOGICALLY SIGNIFICANT HETEROGENEITY TO SOFT BOTTOM HABITATS ON THE CONTINENTAL SHELF
California State University Monterey Bay

Comprehensive high-resolution seafloor mapping of California’s state waters have revealed rippled scour depressions (RSD) to be one of the most abundant and widespread habitats of the inner continental shelf. These sharply delineated elongate features range in size from 100’s to 1000’s of m² in areal extent, are characterized by 30 to 50 cm deep depressions of coarser sediments and longer period bedforms than found on the surrounding seabed, and are known to persist where they are found for decades. Although RSDs have been identified on many of the world’s continental margins, previous studies focused on their geomorphology and dynamics, leaving the ecological influence and associated biological communities of RSDs unexplored. A small remotely operated vehicle (ROV) was used to survey twenty RSDs in three depth zones (<15 m, 15 to 30 m, >30 m) within Monterey Bay, California. Density and richness of benthic communities and habitat characteristics including substrate,
bedform type, and depth were determined from the recorded video imagery. As predicted from known species/grain size relationships, mean density and richness of trophic groups was lower inside RSDs than outside. Surprisingly, RSDs did contain significantly more young of the year (YOY) rockfish (especially ESA threatened canary rockfish, *Sebastes pinniger*) and small flatfish than adjacent fine sediments, suggesting a possible nursery function for these otherwise depauperate coarse-grained habitats. These results indicate RSDs can add a significant and previously undescribed level of ecological patchiness to nearshore soft sediment communities, which may be further amplified by the dynamic nature of RSD bedforms.

**Hamilton, S.L.**, **Wilson, J.R.**, **Ben-Horin, T.**, **Caselle, J.E.**

**UTILIZING SPATIAL DEMOGRAPHIC AND LIFE HISTORY VARIATION TO OPTIMIZE SUSTAINABLE YIELD OF A TEMPERATE SEX-CHANGING FISH**

1 - Moss Landing Marine Laboratories 2 - Bren School of Environmental Science and Management, University of California Santa Barbara 3 - Marine Science Institute, University of California Santa Barbara

Fish populations vary geographically in demography and life history due to environmental and ecological processes and in response to exploitation. However, fisheries models rarely explicitly incorporate spatial variation to inform management decisions. Here, we describe extensive geographic variation in several demographic and life history characteristics (size structure, growth, survivorship, maturation, and sex change) of California sheephead (*Semicossyphus pulcher*), a temperate reef fish targeted by recreational and commercial fisheries. We developed a dynamic size and age-structured model to assess the potential cost or benefit in terms of fisheries yield and conservation objectives of changing minimum size limits and/or fishing mortality rates. Results indicate that managing populations individually, with location-specific regulations, could increase yield by over 26% while maintaining conservative levels of spawning biomass. While this local management approach would be challenging to implement in practice, we found statistically similar increases in yield by dividing southern California into two separate management regions. To maximize yield, size limits should be increased by 90 mm in the north and held at current levels in the south. We also found that managing the fishery as one single stock (the status quo), but with a size limit 50 mm greater than the current regulations, could increase fishery yield by 15%. Increases in size limits may also have important ecological consequences for the predatory role of sheephead in kelp forests. This framework for incorporating demographic variation into fisheries models can be exported generally to other species and may aid in identifying the appropriate spatial scales for management.

† **Hamman, E.A.**, **Zill, J.A.**

**SNAILS AND SEDIMENT: THE EFFECT OF MULTIPLE STRESSORS ON CORAL GROWTH**

**Richard B. Gump South Pacific Research Station, University of Florida**

Corals are affected by a variety of stressors, and the effects of multiple stressors are often not predicted merely by combinations of single stressors. In addition to environmental stressors such as changes in salinity, temperature, and sedimentation, corals are also subject to stress imposed by predators. Field and laboratory experiments have shown guard crabs (*Trapezia spp.*) alleviate the effects of single stressors such as sedimentation and predation on *Pocillopora* corals. However, the effects of multiple stressors have not been explored. To understand the effect of multiple stressors on *Pocillopora*, we conducted a field experiment in the lagoon of Moorea, French Polynesia. Forty small *Pocillopora verrucosa* colonies with resident pairs of *Trapezia spp.* crabs were deployed in the field. Corals were randomly assigned treatments in a 2 by 2 factorial design of increased sedimentation or predation by *Drupella cornus*. Coral skeletal growth was calculated via the buoyant mass technique and the area of feeding scars left by *Drupella* was measured. Both stressors demonstrated a negative effect, but no interaction, on skeletal growth. However, *Drupella* feeding scars were significantly reduced in the presence of increased sedimentation. These results could potentially be the result of cleaning and defense behaviors by *Trapezia*, or a direct effect of sedimentation on *Drupella* feeding behavior. This study provides an example of how abiotic stressors can be an important consideration in studies of species interactions, particularly corallivory.
Hata, T., Denny, M.W.
NOWHERE TO HIDE: SMALL-SCALE FLOW IN THE INTERTIDAL ZONE
Hopkins Marine Station, Stanford University
The hydrodynamic forces generated by breaking waves are one of the greatest environmental stressors experienced by organisms residing in the rocky intertidal zone of wave-swept shores. Although past studies have developed methods to measure water velocity in the field on the scale of centimeters—a scale relevant to relatively large organisms such as barnacles and limpets—measuring at finer scale has not been possible because the delicate laboratory instrumentation usually used for this purpose is unfit for the extreme physical conditions of the intertidal zone. Flow at sub-millimeter scales is important to characterize, however, as it affects the distribution of small benthic organisms as well as larvae and spores seeking to settle on new surfaces. We have designed a pressure block able to continuously measure flow 250 microns above the substrate through the course of several tidal cycles. Preliminary measurements in the field have shown that flow across a flat plate at this height can routinely exceed two meters per second, suggesting that in these conditions, organisms of this size range can not find shelter from hydrodynamic forces by residing in the boundary layer.

Haupt, A.J.*†, Micheli, F., Palumbi, S.R.
CONCORDANT PHYLOGEOGRAPHIC PATTERNS ASSOCIATED WITH THE MAJOR HEADLAND OF CAPE MENDOCINO IN NORTHERN CALIFORNIA
Natural Resources Agency, CA
Coastal geographic features are important determinants of dispersal for marine larvae. We consider the role that Cape Mendocino may play in limiting larval dispersal along the coast of northern California. Though Cape Mendocino is a prominent headland, it has been largely ignored in the eastern Pacific phylogeographic literature, which focuses instead on Point Conception in southern California. We review and synthesize phylogeographic studies that include sampling sites north and south of Cape Mendocino and discuss the oceanography and topography of the cape as potential mechanistic drivers of larval dispersal patterns. Slightly more than half (24 out of 46) of the species that span Cape Mendocino showed significant genetic structure around this headland. This result suggests that, for some species, Cape Mendocino may provide a barrier to population connectivity via larval dispersal. This concordant phylogeographic break is coincident with a large persistent upwelling jet, an offshore cyclonic eddy, poleward-moving water in the south, and a large stretch of sandy habitat to the north, which may combine to reduce the ability of larvae to disperse across the cape. If Cape Mendocino represents a barrier to dispersal for half of the surveyed species and thereby limits connectivity among marine reserves in this region, it could reduce the efficacy of the marine reserve network established under California’s Marine Life Protection Act. If populations north of Cape Mendocino have higher connectivity with populations in Oregon than with those in southern California, marine spatial planning must occur at a multi-state scale to reach marine conservation goals.

Hayford, H.A.¹, Gilman, S.E.², Carrington, E.¹
NUCELLA OSTRINA ALTERS BEHAVIOR WHEN TIDAL CYCLE SHIFTS MICROCLIMATE
1 - Friday Harbor Labs, University of Washington 2 - Claremont Colleges
The capacity of an organism to regulate temperature through behavior is often overlooked when predicting the effects of climate change. Ectotherms in the littoral zone cope with regular temperature shifts through behavioral changes, physiological tolerance, and phenological timing. Nucella ostrina, a common predatory snail of the Eastern Pacific, must risk aerial exposure to feed on its preferred prey, the barnacle, Balanus glandula. We hypothesized that N.ostrina foraging in the San Juan Islands, Washington, would be constrained by a combination of temperature and timing of summer low tides. We added N. ostrina to artificial concrete islands in the intertidal and forced snails to choose between barnacle prey placed on western or eastern faces of blocks on each island. Snail behavior and barnacle consumption were monitored daily during July and August of 2011. N. ostrina exhibited feeding peaks during the neap tide weeks, when aerial exposure time and/or aerial temperature were minimized. The percentage of snails foraging on one substrate face or the other coincided with timing of the low tide; snails fed on the cooler western faces when low tides occurred in the morning, and on eastern faces during afternoon low tides. Barnacle consumption rates mirrored this spatiotemporal
foraging behavior. These results suggest that *N. ostrina* alters its behavior to capitalize on relatively small-scale differences in microclimate, maintaining a foraging pattern that consistently minimizes its exposure to hot aerial temperatures. If temperatures increase, mobility may give this predator an advantage over its sessile prey.

† Helyer, J.S.
A SPATIAL FRAMEWORK FOR DESCRIBING CORAL RESPONSES TO A CHANGING CLIMATE IN THE NORTHWEST HAWAIIAN ISLANDS
*University of Washington*

The Northwest Hawaiian Islands (NWHIs) are a model system for investigating coral response in a changing climate since many of the anthropogenic stressors which can confound results are absent. However, variable distribution patterns and non-random sampling of coral populations in the NWHI may be constraining our understanding of the ecology of this reef system and therefore our ability to predict and test hypotheses about coral responses to climate change. To overcome these limitations, I use a regional data set which utilized probability sampling to describe the distribution of corals at seven major reefs in the NWHI. Using a spatial framework which accounts for reefs, geomorphic zones (backreef, forereef, lagoon), and exposure (northwest, southeast) I present both relative and absolute estimates of percent cover for the main coral species across the NWHI and describe how this framework can be used to help interpret results from previous bleaching events as well help develop working hypotheses for future responses.

Henderson, J.S.*, Hacker, S.D.
The EFFECTIVENESS OF CLONAL GROWTH VERSUS SEEDLING RECRUITMENT FOR AN INVASIVE EELGRASS ACROSS A GRADIENT OF DISTURBANCE
*Oregon State University, Department of Zoology*

A gradient of disturbance severity may have the ability to impact life history strategies through a balancing of tradeoffs and natural selection. If this results in selection for life history strategies that alter the odds of dispersal and colonization events, then disturbance may have the ability to ultimately affect the metapopulation dynamics of a species. Populations of a non-native seagrass species that has invaded the estuaries of the Pacific Northwest are capable of colonizing and persisting in areas that are prone to sediment disturbance by burrowing shrimp and wind-driven waves. Examining the effectiveness of reproduction by clonal growth versus reproduction by seeds across the gradient of disturbance that this species experiences could help to shed light on the factors that govern its short and long term persistence. Observational studies from Coos bay, Oregon, indicate that seed production varies between populations, and that populations display consistent trends in timing and magnitude of seed production between years. A continuation of that research in Yaquina Bay, Oregon, seeks to examine the effectiveness of reproduction by seeds and reproduction by clonal growth across a gradient of sediment disturbance regimes. Experiments in progress are presented, along with data from one year of observational studies in Yaquina Bay.

Henkel, S.K.*, Politano, K.K.
SPATIAL AND TEMPORAL PATTERNS IN THE DISTRIBUTION OF INFANUAL INVERTEBRATES
*Hatfield Marine Science Center, Oregon State University*

The Oregon coast has become a target for offshore renewable energy due to its energetic wave and wind climate and existing electrical infrastructure on the coast. Most of the devices proposed for wave or wind energy capture in this setting are to be placed on the continental shelf or slope, in relatively flat, sandy substrates, moored to substantial concrete anchors. Concerns have been raised about the effects to benthic habitat and organisms by the installation of devices and complex mooring systems. However, little is known about natural species-habitat relationships and community processes in this zone, as it is rather understudied relative to other benthic habitats. This study explores patterns of infaunal invertebrate distributions and abundances across Oregon and Washington sampled in summer 2010 and over time at the site off Newport, Oregon with repeated sampling from June 2010 to August 2011. Infaunal invertebrates were sampled with a 0.1 m² box core, sieved on 1 mm mesh, and identified to species when possible. Variability in assemblages was observed among the four sites,
driven more by depth and grain size than a latitudinal gradient. At the Newport site, densities of some infaunal organisms (polychaetes, crustaceans) were remarkably consistent over time while densities of molluscs fluctuated greatly and densities of echinoderms steadily declined from June to October 2010. However, the general assemblage of species did not vary over time. Factors influencing individual species distributions and correlations with overall diversity will be presented.

Idjadi, J.A.*
CORAL COMPETITIVE INTERACTIONS: CAN RESPONSES TO COMPETITORS VARY ON SMALL SCALES?
Eastern Connecticut State University
Coral reef communities are among the most species rich despite intense competition and asymmetry in the competitive abilities of neighboring corals. There is evidence that the spatial arrangement of competitors can be important for the success of weak competitors. In this study, we hypothesized that small colonies of *Porites* spp can vary their responses to spatially variable competitive environments over small spatial scales. We measured a number of anatomical and physiological traits including skeletal density, nematocyst density, symbiont mitotic index, and photosynthetic efficiency to determine the scale on which corals can adjust their reactions to their competitive neighborhood. Preliminary analysis suggests that many of these traits vary depending on whether or not the coral colonies are exposed to competition. However, corals do not appear to be able to effectively adjust to different competitive circumstances occurring around the perimeter of a single colony.

Iglesias, I.S.*
ARE TROPICAL TIDEPOOLS A NURSERY HABITAT FOR JUVENILE REEF FISH? AN INVESTIGATION FROM OAHU, HAWAII.
University of Hawaii at Manoa
Coastal ecosystems are often essential nursery habitats for marine fishes. In tropical ecosystems, juvenile reef fishes depend on coastal nursery habitats such as mangroves, seagrass beds and estuaries for refuge from predation and locally enhanced growth rates. In the Hawaiian Islands, there is a paucity of putative nursery habitats because mangroves are non-indigenous and the native seagrass does not form extensive beds nearshore. This raises the question: which habitats are important for the early life history stages of coastal fish species in Hawaii? My research explores the distribution and abundance of juvenile reef fish in rocky intertidal pools, a potentially overlooked nursery habitat on the island of Oahu. To determine the spatial and temporal distribution of reef fish in tidepools, I conducted monthly visual surveys of juvenile fish from randomly selected tidepools at four locations. Further, I assessed whether there was a windward, leeward effect of currents on recruiting fish to ascertain whether recruits endemic to the Hawaiian Islands were dispersing similarly to recruits with Indo-Pacific ranges. The contemporaneous decline in coastal fish populations and increase in human pressure on coastal ecosystems predict an uncertain future for many of Hawaii’s resource species, four of which are common in tidepools as juveniles. Improving the knowledge of habitat requirements for recruiting/juvenile fishes will better inform future management decisions and hopefully promote future research on the under-studied intertidal habitat of Hawaii.

† Ingeman, K.E., Webster, M. S., Hixon, M.A.
INVASIVE LIONFISH ALTER DENSITY DEPENDENCE IN REEF FISH POPULATIONS ON BAHAMIAN CORAL REEFS
Perry Institute for Marine Science, Oregon State University
The invasive Indo-Pacific lionfish (*Pterois volitans*) is a new and voracious mesopredator that has altered the population dynamics of native coral-reef fishes of the tropical Western Atlantic and Caribbean. The fairy basslet (*Gramma loreto*) is a common prey of lionfish, and the mechanisms regulating population dynamics of this small reef fish were well studied prior to the invasion. Previous research demonstrated temporal demographic density dependence that resulted in tight population regulation. The primary mechanism was mortality due to predation, perhaps making fairy basslet particularly sensitive to the addition of a novel predator. We examined 16 previously studied basslet populations in the Bahamas, providing an unprecedented before-after comparison for detecting the
effects of the invasion. Compared to pre-invasion levels, the mean density of fairy basslet has decreased significantly from 8.2 to 4.9 fish/m² and reductions showed a positive spatial correlation with local lionfish abundance. We replicated a field experiment, previously conducted prior to the arrival of lionfish, to compare demographic rates between unmanipulated basslet populations and populations with artificially increased recruitment levels. Over the course of experiment, per capita loss of fairy basslet was driven primarily by predation and was 5.4 times higher in populations with inflated recruitment than in unmanipulated populations, indicating a similar density-dependant relationship to that observed prior to the invasion. However, overall basslet loss was nearly twice that observed prior to the arrival of lionfish. Thus, lionfish predation represents a substantial density-independent increase in fairy basslet mortality, with grave implications for population stability and local persistence.

† Jeffries, S.V.
ASSESSING THE INVASIVENESS OF THE NON-NATIVE KELP UNDARIA PINNATIFIDA IN MONTEREY HARBOR
Moss Landing Marine Laboratories
The annual subtidal alga Undaria pinnatifida has been federally declared an invasive species and has spread rapidly across the globe from its native range in northern Asia. The ability of this alga to complete its life cycle determines its success in a particular location, and several abiotic factors have been found to be important in determining reproductive success in kelps. Laboratory zoospore culture experiments were conducted monthly to test the effects of temperature and nitrate concentrations on microscopic stage production throughout a year. Cultures were grown under two temperatures (12, 18º C) monthly and three nitrate concentrations (1,5,10 µmol) three months during the year. Each month sporophytes were produced in both temperatures, and densities were either higher in the 18ºC treatment or there was no difference between temperatures. Sporophytes were also produced in all nitrate treatments, but there was no consistent nitrate effect observed. Finally, field measurements and sporophyll punches were obtained to test the relationship between zoospore output and the physical features sporophyll size and blade length for U. pinnatifida in Monterey Harbor. These results revealed a non-linear relationship for individual plants, and a linear relationship at a population (average) level. Similar culture experiments have been conducted on other native central California kelp species, a majority of which were unable to produce sporophytes in all treatments. This suggests that U. pinnatifida is a condition-flexible alga whose reproductive physiology allows it to enter and thrive in new areas.

† Jenewein, B.T., Gosselin, L.A.
WEATHERING DROUGHT: IS JUVENILE MORTALITY IN THE MUSSEL MYTILUS TROSSULUS INFLUENCED BY HUMIDITY CONDITIONS AT LOW TIDE?
Bamfield Marine Sciences Centre, Thompson Rivers University
Populations of marine intertidal invertebrates vary substantially in abundance from year to year and from one location to another. It has been suggested that these differences might be partly due to variations in survival through the first days of life as a juvenile, where most cohorts experience 60 – 99% mortality. However, the causes of this mortality, including the role of weather conditions experienced during low tide, are not well understood. Vulnerability to weather conditions could constitute a direct link between early juvenile mortality and climate change. The goals of this study were (1) to determine the vulnerability of newly settled mussels (Mytilus trossulus) to the range of relative humidity (RH) conditions experienced in the field, and (2) to examine ontogeny of vulnerability to low RH conditions and thus determine how much growth is needed to become tolerant of low RH conditions in the field. Laboratory experiments were conducted to test the vulnerability of mussels to various RH conditions, and field measurements of weather parameters were made throughout the summers of 2010 and 2011 using a weather station and intertidal data loggers. We found that newly settled mussels experience a threshold of tolerance between 50% and 75% RH. Vulnerability at this threshold greatly decreased when the mussels reached a size of 3-4mm shell length. Weather conditions monitored in the field reveal that lethal RH conditions do occur each summer.
Biogeographical Variation in Trophic Interactions on Temperate Reefs of the Southern California Bight

San Diego State University and University of California Davis

In many aquatic systems, top predators strongly influence primary production and community structure by reducing herbivore abundance. However, the trophic role of individual predator species often varies within similar habitat over geographic space. Sea urchins are the primary grazer of temperate subtidal reefs worldwide and in the absence of predators are capable of creating barrens devoid of macroalgae. Within subtidal reefs of the Southern California Bight (SCB), predators such as sunflower stars (*Pycnopodia helianthoides*), California spiny lobster (*Panulirus interruptus*), and the labrid fish sheephead (*Semicossyphus pulchur*) may control sea urchin populations, but studies testing for strong top-down control of urchins are lacking at broad spatial scales. We conducted surveys and tethering experiments at 19 sites spanning over 1700 km in the SCB to assess the generality, mechanisms, and strength of potential trophic cascades induced by these predators. We found a significant negative correlation between the abundance of predators and urchins across all study sites. However, this relationship appears to be site specific, with many sites harboring high densities both of predators and urchins. Tethering experiments suggest that predation rates depend primarily on urchin behavior, rather than predator abundance. These results elucidate the complexities of species interactions in these systems and caution against oversimplifying the role predators play in these subtidal communities. We hypothesize that the mechanisms leading to latitudinal variation in species interaction strength and type within the SCB involve site-specific levels of predator abundance, species composition, the sizes of predator and prey species, and variation in oceanographic conditions.

Do Wave Impact Forces Limit the Size of Intertidal Organisms?

Hopkins Marine Station

Although intertidal organisms are generally much smaller than their terrestrial and subtidal counterparts, the biological and physical mechanisms that limit size have not been determined. While hydrodynamic forces due to breaking waves are theorized to limit size, traditional models based on drag and accelerational forces are poor predictors of maximum sizes in the field. However, these models may be incomplete: the sharp, transient force occurring at wave impact - the impingement force - is not well-characterized, and is not included in current size-prediction models. Impingement may limit organism size through differing scaling exponents: organism tenacity is generally proportional to area, since adhesive strength scales with attachment area (the square of characteristic length). If the largest force experienced by the organism also scales with area, there is no theoretical size limit as the organism grows isometrically. If, however, maximum force is proportional to organism volume, force increases with the cube of characteristic length as the organism increases in size. In this case, force increases at a faster rate than attachment strength, limiting the organism’s size. While the scaling behavior of other hydrodynamic forces is known, whether impingement scales with area or volume has remained unstudied. To test the scaling behavior of impact forces, rectangular prisms of various sizes and aspect ratios were exposed to impingement forces using simulated waves from a gravity-driven water cannon. Preliminary data suggest that impingement scales with area, and is not likely to limit organism size -- leaving size limitation in the surf zone a mystery.

Decreased Palatability in the Brown Seaweed *Silvetia compressa* in Response to a Multi-Species Herbivore Assemblage

1 - San Diego State University and University of California Davis 2 - San Diego State University

Herbivores play a dominant role in structuring marine communities, influencing both seaweed characteristics and community composition. In order to resist high levels of consumption, seaweeds have developed a suite of traits to deter herbivores, including inducible defenses. Although inducible defenses are believed to be common in marine producers, most work has focused on single herbivore effects, even though diverse herbivore assemblages often exist in the field. Because seaweed
responses can vary with herbivore species, there is a need to incorporate multiple herbivores into these experiments. In this study, we investigated whether grazing by an herbivore assemblage altered palatability of the brown seaweed Silvetia compressa, relative to ungrazed individuals. Silvetia thalli were grown with and without herbivores for 10 and 21 days, and then we performed paired-choice assays between grazed and ungrazed tissues. We found that seaweeds that had not been exposed to herbivores were preferred over grazer-damaged ones. In order to test whether this response was due to a preference for the tissues removed by herbivory, we scraped off outer tissue layers to mimic grazing damage. Herbivores consumed more scraped seaweed than unmanipulated tissue, ruling out a preference for outer tissues and suggesting that damage alone does not decrease seaweed palatability. In addition, we investigated whether changes in palatability were due to direct grazing and/or waterborne cues, but found no effect of herbivore cues on Silvetia palatability. These experiments suggest that a multi-species herbivore assemblage can induce deterrent responses in Silvetia, which may, in turn, impact community and ecosystem-level functioning.

† Jorve, J.P.*, Harley, C.D.G.
INTERACTIVE EFFECTS OF SHORE LEVEL AND EXPERIMENTAL WARMING ON ADULT AND JUVENILE INTERTIDAL KELP
University of British Columbia
Predicted increases in temperature associated with global warming could have deleterious effects on intertidal organisms, the severity of which could depend on their vertical intertidal location. Saccharina sessilis is a dominant, intertidal, brown alga forming a consistent canopy in the low to mid intertidal zone. Forty permanent plots were manipulated to achieve levels of high (5 adult plants) and low (single adult plant) canopy densities. Half of the canopy manipulations were also experimentally warmed during one low tide per month to raise ambient temperatures roughly 10° C. Results for both juvenile recruitment and adult canopy cover indicated a weak positive effect of increasing intertidal height in the low zone, and a strong negative effect of increasing intertidal height in the high zone (p<0.001, p=0.036). Additionally, there was a significant Canopy Cover x Heat x Zonation interaction (p=0.019) on juveniles, indicating that heating negatively affected recruitment in the high zone but only in low canopy cover plots. In this case, the effects of global warming were contextual, dependent upon both environmental (i.e. intertidal height) and biological (i.e. canopy cover) constraints.

Juanes, F.*, Rountree, R.A.
POTENTIAL OF PASSIVE ACOUSTICS TO MONITOR THE INVASION OF THE HUDSON RIVER BY THE FRESHWATER DRUM, APLODINOTUS GRUNNIENS
University of Victoria
The freshwater drum, Aplodinotus grunniens, has recently become established in the Hudson River presumably by entrance through the Erie Canal. However, even basic information on the current distribution of adult freshwater drum in the Hudson River is not currently available. In addition the role of the New York State Barge Canal System (NYSBCS) as a vector for drum introduction into the Hudson River and other associated bodies of water is uncertain. We describe the sound characteristics of freshwater drum based on recordings in native populations in the Missouri River (Missouri), Dale Hollow Lake (Tennessee), and Lake Champlain (New York). Based on these data we confirmed that previously unidentified sounds recorded in the Hudson River were produced by freshwater drum. A preliminary passive acoustic survey of the Champlain Canal suggests that drum are now seasonal residents throughout the canal system. It is probable that formerly isolated populations in the Great Lakes and Lake Champlain are now mixing in the newly established Hudson River population via free movements through the NYSBCS. The widespread occurrence of native populations just a short distance from the Hudson River obscures the fact that the species was formerly geologically excluded from the nearby east coast drainage. As a result the invasion has received little attention from the scientific and management communities. We propose that passive acoustics technologies offer a powerful method to monitor the invasion and spread of the species through the Hudson River and other water bodies connected by the New York Stage Canal System.
Kane, C.N.∗
PATTERNS OF BIODIVERSITY IN MESOPHOTIC CORAL ECOSYSTEMS OF THE
NORTHWESTERN HAWAIIAN ISLANDS
Washington State University Vancouver
The diversity of coral reef ecosystems and their contributions are well established and far-reaching in
both scientific and public literature. However, the study and understanding of these ecosystems has
largely been limited to shallow waters less than 30 meters in depth. Deep coral reefs, often referred to
as “twilight zone” reefs or Mesophotic Coral Ecosystems, are direct extensions of these well-studied
shallow reefs yet have been almost entirely overlooked until recently. Initial observations of reef fish at
mesophotic depths (50-90 meters) in the Northwestern Hawaiian Islands reveal 45% endemism,
nearly twice that recorded in shallow waters of the same region, or in any other shallow coral reef
ecosystem. Levels of endemism for reef fishes appear to increase along a latitudinal gradient, with
fish assemblages at the northernmost atolls having significantly higher levels of endemism than more
southerly islands. These results support the notion that mesophotic systems harbor
unique and
potentially important communities, and thus warrant further investigation into their significance and
potential contributions to coral reef ecosystems as a whole.

Keeling, B.E.∗†, Salomon, A.K.†, Hessing-Lewis, M.L.‡, Dick, S.J.†, Housty, C.¶
QUANTIFYING THE MAGNITUDE OF PREDATION ON PACIFIC HERRING (CLUPEA PALLASI)
EGG LOSS FOLLOWING ANNUAL SPAWN EVENTS
1 - Coastal Marine Ecology and Conservation Lab, Simon Fraser University 2 - Lubchenco/Menge
Lab, University of Oregon 3 - Shurin Lab, University of British Columbia 4 - Gladstone Reconciliation
Pacific herring (Clupea pallasi) are an integral component of marine ecosystems from Southeast
Alaska to Northern California, providing a key source of food for marine predators, and supporting
commercial and subsistence fisheries for coastal communities. Despite annual fishing closures,
herring catch in British Columbia has undergone major declines over the past 50 years. There exists a
very limited understanding and quantification of herring egg loss rates post spawn events, a key
source of uncertainty in current stock assessment models. We conducted a multi factorial exclusion
experiment near Bella Bella, British Columbia, to quantify the effects of benthic and pelagic predation
on herring egg loss rates. We based our experimental design on the traditional native Spawn on Kelp
(SOK) fishery and suspended standardized pieces of roe on kelp, enclosed in predator exclusion
cages varying in mesh size, at three different depths throughout the water column. We monitored
weight and percent egg cover over a two-week period and observed that predation had a significant
effect on the quantity and rate of egg loss through time. Uncaged samples experienced an average
percent egg cover loss rate of 32% day−1, while those protected from all predators decayed by 0.3%
day−1. Samples in the benthic environment were found to have a more dramatic average egg loss rate
(35% day−1) than those at the surface (1% day−1). The importance of herring spawn events in altering
and providing a seasonal pulse of resources to nearshore environments should be considered when
managing current populations.

† Kelley, A.L.∗, deRivera, C.E., Buckley, B.A.
VARIATION IN THERMOTOLERANCE AND MORPHOLOGY OF THE INVASIVE CARCINUS
MAENAS ON THE WEST COAST OF NORTH AMERICA
Portland State University
Physiological studies of native marine species have long been utilized to understand the role of abiotic
conditions in the maintenance and distribution of species within native communities. However, this
approach is rarely used for the assessment of invasive organisms within the context of novel
environments and is largely absent from the scientific literature. For the invasive decapod Carcinus
maenas, temperature has been implicated as the main predictor of establishment success across
temperate regions. Recent studies have identified variations in upper thermal tolerance thresholds of
adult Carcinus maenas sampled from the northern, cold acclimated, cold adapted (Vancouver Island,
British Columbia, Canada-BC) and southern, warm acclimated, warm adapted (Sea Drift Lagoon,
Stinson Beach, California-CA) near the edges of their recipient range on the west coast of North
America. Crabs sampled from BC had a significantly lower upper thermal tolerance (critical thermal
maxima) and Hsp 70 expression after lab acclimation of 6°C when compared to the CA population. These results highlight the ability of the BC population to modulate its upper organismal and cellular thermotolerance to reflect the colder environment that it now inhabits, mirroring native ectotherms that have had millennia to make adaptive changes to their genome. Additionally, I am interested in how these variations in ambient temperature across its invasive range may generate clinal differences in the overall adult size in this species.

† Kelly, J.A.*, Mackie, J.A.², Craig, S.F.¹

INVESTIGATION OF THE ECOLOGY AND GENETICS OF TWO DISTINCT MORPHS OF THE NUDIBRANCH DIAULULA SANDIEGENSIS

1 - Humboldt State University 2 - San Jose State University

The nudibranch taxonomic species Diaulula sandiegensis (Cooper, 1862) shows phenotypic variation in dorsal spotting pattern throughout its range along the Pacific coast, from Alaska to Mexico, yet the biological significance of this variation is not understood. Testing the possibility of cryptic (unrecognized) species, we conducted a series of experiments. In growth experiments, individuals raised on the same sponge food in aquaria maintained spot morphology. Mating studies revealed resounding assortative mating among the spot morphs—during 332 hours of time-lapse photography, 64 out of 65 mating events occurred between like-morph pairs. We are currently investigating the population genetics of these two different morphs of D. sandiegensis using DNA. Comparisons using COI (mitochondrial) indicated a 6% divergence in nucleotide sequence of the two morphs, collected in the same area, Humboldt Bay, California. Consequently, we argue that D. sandiegensis consists of at least two different Biological species. Factors allowing species to remain isolated despite sympatric occurrence in some areas are being examined. The D. sandiegensis experiments sum to a rigorous test of the possibility for cryptic species to occur in the E. Pacific region despite relatively good marine biological attention. Such cases support a general reinvestigation of species diversity using a range of in-depth approaches.

† Kennedy, E.M.*, Martone, P.T.

A CURIOUS SYMBIOSIS: EXPLORING THE PHYSIOLOGICAL BENEFITS AND COSTS OF THE REVERSE LICHEN, PRASIOLA BOREALIS AND ITS MYCOBIONT

University of British Columbia

Symbioses are complex and dynamic associations, ranging from parasitism to mutualism. A unique reverse-lichen symbiosis between the chlorophyte Prasiola borealis (Reed) and its inhabiting mycobiont is found in supralittoral zones along the west coast of Vancouver Island. Currently, the nature of this symbiosis is unresolved. This study explores the position and stability of P. borealis on the symbiotic continuum and investigates whether environmental factors can cause shifts towards either mutualism or parasitism. Comparative physiological experiments were performed on P. borealis and a non-lichenized Prasiola species to test whether the presence of a mycobiont ameliorates UV tolerance due to UV-absorbing, fungal mycosporines. Baseline physiological differences were observed, indicating that P. borealis photosynthesizes less efficiently and achieves lower photosynthetic rates than non-lichenized Prasiola. Despite exhibiting a lower baseline photosynthetic capacity, P. borealis was not affected by extended exposure to UV radiation. Photosynthetic activity was maintained at control levels, whereas non-lichenized Prasiola exhibited higher stress and lower photosynthetic output after UV stress. The UV tolerance observed in P. borealis may be an indication of a mutualistic interaction between the alga and its mycobiont. However, the results did not correspond to mycosporine absorption by the fungus. Therefore, further research is required to distinguish the physiological processes involved in UV tolerance, as well as resistance to other abiotic stressors. Understanding the unique interaction between P. borealis and its mycobiont will bring clarity to the costs and benefits associated with this reverse lichenization process.
† Kindinger, T.L.; Hixon, M.A.
CAN TERRITORIAL DAMSELFISH CONTROL LOCAL DENSITIES OF INVASIVE LIONFISH ON CARIBBEAN CORAL REEFS?
Oregon State University, Department of Zoology
Invasive Indo-Pacific lionfish (*Pterois volitans*) have spread rapidly throughout coral reefs of the tropical western Atlantic and Caribbean. Lionfish are highly efficient predators known to greatly reduce recruitment of native coral-reef fishes, including the juveniles of species known to be important for reef resilience and fisheries. Thus far, there is little evidence of native large predators effectively controlling lionfish populations. We investigated another possible source of biotic resistance to the invasion: territorial aggression by the native three-spot damselfish (*Stegastes planifrons*). The level of territorial defense that three-spots exhibit toward other reef fishes is species-specific, with species posing a greater potential threat to defended resources eliciting more aggressive responses at larger distances from the center of the guarded territory. Three-spot territories are also known refugia for new recruits of some reef fishes. In the Bahamas and Cayman Islands, we used a model-bottle study design to compare the behavioral responses of three-spots towards invasive lionfish with responses towards native reef fishes (ocean surgeonfish, grunts, and coney grouper) and an empty bottle control. Despite a few cases of three-spots nipping the pectoral fins of lionfish, both mean frequency of aggressive responses and mean distance from the center of the territory where three-spots first attacked were not significantly different from the empty bottle control. These results suggest that territorial damselfish currently do not control local lionfish densities on invaded reefs, and therefore, are unlikely to provide potential refuges from lionfish predation for new recruits of native reef fishes.

† Kordas, R.L.; Harley, C.D.G.
EXPERIMENTAL WARMING REDUCES INVERTEBRATE DENSITY AND COMMUNITY RICHNESS ON ROCKY SHORES
University of British Columbia
The importance of temperature is currently being addressed with renewed vigor as anthropogenic climate change begins to drive global temperatures beyond historical bounds. Climate change scenarios suggest the earth will warm by 1.7-4.4 °C by the end of the century, which constitutes extremes in both the maximum temperatures reached and the rate at which interannual change is occurring. The broad-brush effects of warming are already observable across a wide variety of systems and taxa, however specific responses of species or ecosystems of interest are more difficult to predict in part because some species will be affected differently than others. To determine how aerial thermal stress affects population and community patterns in situ, temperature was manipulated by deploying black and white tiles in the Strait of Georgia (British Columbia) rocky intertidal. Temperature sub-lethally affected barnacles by reducing the growth rates of individuals. Additionally, barnacle abundance was lower and declined more rapidly through time on heated tiles. Most algal populations were unaffected, but grazer density declined in warmed treatments. Finally, community richness was lower in heated treatments and exhibited similar patterns over time within each zone. These results extend physiologically-based predictions to the field and show that, although species respond idiosyncratically, the overall effect of warming is negative in this intertidal community.

† Kroeker, K.J.; Micheli, F.; Gambi, M.C.
OCEAN ACIDIFICATION AFFECTS RECRUITMENT AND COMPETITION IN BENTHIC COMMUNITIES SURROUNDING NATURAL CO2 VENTS
1 - Hopkins Marine Station, Stanford University 2 - Stazione Zoologica Anton Dohrn
Ocean acidification is considered a threat to marine ecosystems worldwide. Our current understanding of the ecosystem impacts is based on studies of naturally acidified ecosystems, which have revealed important shifts in community structure and reductions in biodiversity with increasing acidification. In order to forecast how ocean acidification will affect other ecosystems, studies are needed that elucidate the mechanisms for the observed changes in naturally acidified ecosystems. Here, we monitored the development of benthic communities on recruitment tiles for the period of one year in three pH zones caused by natural CO2 vents in the Mediterranean Sea: extreme low pH (pH<7.2), low pH (pH=7.5-7.8), and ambient pH. At the end of one year, we found significant differences in
community structure on the recruitment tiles among pH zones. Analyses indicate calcified taxa did not recruit to the tiles in the extreme low pH zones, where filamentous algae quickly colonized and persisted for a year. In contrast, calcified taxa recruited early and continued to grow in both the low and ambient pH zones. The communities in the low and ambient pH zones diverged in the final stages of succession, when turf and canopy-forming macroalgae grew over calcified taxa in the low pH zones but not in the ambient pH zones. Our results suggest extreme acidification may limit recruitment of calcified species, and near-future ocean acidification may affect the competitive balance between calcified and non-calcified taxa. Together, these changes will promote a shift towards ecosystems dominated by fleshy macroalgae with reduced functional diversity.

Larson, S.E.*, Christiansen, J.
SEATTLE AQUARIUM’S SHIFTING BASELINE STUDY OF ROCKFISH IN THE STRAIT OF JUAN DE FUCA 2005-2011
Seattle Aquarium
The region in and around Cape Flattery and the Strait of Juan de Fuca is noted for its abundance and diversity of temperate marine species. From 1984 to date the Seattle Aquarium has performed annual field diving in this region. Divers participating in this effort have informally observed changes in rockfish (Sebastes sp.) diversity and abundance. These anecdotal observations were not quantified or documented on a formal basis. In an effort to document rockfish in this area in 2005 the Seattle Aquarium began formal annual strip transect video surveys. Video based transects minimally disturbs an area and allows repeatable measurements of fish abundance annually to determine significant changes in species diversity or abundance (termed shifting baselines). Shifting baselines are the chronic, slow, hard to notice changes in ecosystems over time resulting in dramatic shifts in species distribution and abundance. The data gained on shifting baselines in these areas will be an important reference point for monitoring the health of these ecosystems. Since 2005 stability in numbers of adult rockfish in these areas has been evident with no significant changes observed. The only significance found was the young of the year rockfish recruitment event in 2006 and 2008. These spikes in juvenile rockfish recruitment were correlated with lower sea surface temperatures the preceding winter and spring. Juvenile rockfish survival may be linked to these lower sea surface temperatures and thus may be negatively affected by increases in water temperature associated with global warming.

† Lasley-Rasher, R.S.*, Yen, J
PREDATION RISK SUPPRESSES MATING SUCCESS AND OFFSPRING PRODUCTION IN A COASTAL MARINE COPEPOD
Georgia Institute of Technology
The threat of predation can have significant impacts on prey foraging, locomotion, and mating behavior. These non-consumptive effects of predators may cascade to affect the population growth rates of their prey and the subsequent flow of energy throughout natural food webs. Because birth rates of sexually reproducing zooplankton species are controlled by female fecundity and mating success, understanding the effects of predation on plankton mating behavior is critical. Yet, relationships between predation risk and prey mating behavior, and prey birth rates remain unclear in marine plankton. In this study, we investigated the effects of a common mysid predator, Neomysis americana on the mating success of a coastal marine copepod Eurytemora herdmani. We show that the presence of a mysid predator, or only a predator cue, reduces copulation frequency and spermatophore transfer of E. herdmani, and leads to a 38-61% decrease in E. herdmani nauplii production. These results suggest that mysid predators can constrain copepod population growth through non-consumptive processes such as reducing the frequency and success of mating events. This work highlights the need to look beyond population-level demographic factors (i.e. sex ratio and population density) and consider community-level ecological factors (such as predation risk) when modeling population growth rates of prey species important to food webs supporting commercially-important species.
† Lavelle, K.A.*, Shirley, T.C.
ECOLOGY OF THE BRISINGID SEA-STAR NOVODINIA ANTILLENSIS IN DEEP-WATERS OF ROATAN, HONDURAS
Texas A&M Corpus Christi

The brisingid sea-star Novodinia antillensis is a common suspension feeder in the deep-sea but little is known about its distribution or ecology. Using the 3-man submersible Idabel we surveyed deep-water coral communities to depths of 650 m at six sites off Roatan, Honduras. Transects were from deep to shallow and recorded on high-def video; still images were taken with an SLR synchronized with exterior strobe lights. Novodinia antillensis was conspicuous and abundant at all sites; no other brisingids were observed. Individuals were found within a depth range of 335 – 624 m, with corresponding temperatures of 14 – 11°C. Predation events were evident from regenerating arms; only a few small brisingids were observed, suggesting infrequent recruitment or rapid growth. Brisingids were most frequently observed on deep-water corals, sponges, and boulders, with all arms fully extended into the water column. Preliminary analyses indicate a preference for octocorals or hard substrate. N. antillensis co-occurred with galatheoid crabs, crinoids, and ophiuroids on corals. Novodinia antillensis may have an important role as an abundant suspension feeder in the food webs of deep-water communities.

† Le Corre, N.*, Martel, A., Guichard, F., Johnson, L.E.
CHARACTERIZATION OF LARVAL PHASE (PII MORPHOMETRY) AND SETTLEMENT (PRIMARY VS. SECONDARY) IN BLUE MUSSELS FROM A SUBARCTIC AREA
1 - Department of Biology, Université Laval 2 - Museum of Nature, Ottawa 3 - Department of Biology, McGill University

Benthic marine communities are strongly influenced by recruitment processes, especially since the life cycle of many benthic invertebrates includes a dispersive planktonic phase. A weekly (2008) and biweekly (2008 & 2009) assessment of settlement of the marine mussel Mytilus spp. was conducted. Settlers were collected and counted, and postlarval total shell sizes were then used to estimate primary vs. secondary settlement rates (post-settlement movements). In 2008, continuous settlement occurred over two months with two major peaks of primary settlement during mid-July and mid-August. As expected, secondary settlement happened throughout the season but generally increased over time after the two peaks. As the growth and developmental history of planktonic bivalve larvae are recorded in the larval shell, we performed a morphometric analysis on the prodissocochn II shells, and estimate that the planktonic larval period is 28-55 days. These data suggest a main spawning event in late-June, a larval phase of at least five weeks, a first settlement (metamorphosis) in mid-August, and then an exploratory phase of secondary settlers.

† Lee, T.S.*, Henkel, S.K.
VARIANCES OF ASTEROID ECHINODERMS DENSITIES ACROSS SUBSTRATA, DEPTH, AND TEMPERATURE
Hatfield Marine Science Center, Oregon State University

The outer continental shelf waters of the Pacific Northwest encompass a diverse spectrum of habitats and benthic macroinvertebrates. One of the most familiar groups of macroinvertebrates is Asteroid Echinoderms, commonly known as sea stars. With varying morphology, diet, and habitat preference, sea stars can exert influence in altering species composition of sessile and mobile benthic communities. Despite their familiarity, little research has characterized patterns of sea star distributions across varying habitats in continental shelf margins. Based on the results of Correspondence Analysis of all invertebrates and habitat types collected from historic manned submersible Delta dives, we selected four common sea stars to evaluate their density differences based on substrata, depth, and temperature. The Sand Star Luidia foliolata had highest densities in primarily mud habitats and at depths 90-110 meters. The Blood Star Henricia spp. had highest densities in higher relief habitats and at depths <130 meters. The Vermillion Red Star Mediaster aequalis was abundant across habitats of various grain size and relief, and was most commonly distributed at depths <90 meters. The Sun Star Solaster spp. was distributed mainly in mud habitats and at depths >150 meters. The sea star species found in deeper depths were also correlated with lower temperatures. These results indicate that
substratum, temperature, and depth are reliable indicators for density variations across continental shelf habitats. Using Canonical Correspondence Analysis, we examined relationships between each sea star densities and overall macroinvertebrate composition after accounting for depth and temperature.

† Lee, L.C.*, Salomon, A.K.
SHIFTING BASELINES IN A BENTHIC ROCKY REEF FOOD WEB: WHY PLACE AND TIME MATTER TO ASSESSING RECOVERY OF NORTHERN ABALONE IN BC
Coastal Marine Ecology and Conservation Lab, Simon Fraser University

Shifting baselines can elicit vexing conservation challenges when society comes to value attributes of an altered ecosystem state and perceives it as “normal”. Such is the case with northern abalone on temperate rocky reefs in BC where sea otters, important abalone predators, were extirpated by the industrial fur trade a century ago. In the absence of otters, the abundance and size of their benthic macroinvertebrate prey, including abalone, increased dramatically, facilitating development of shellfisheries. Poor fisheries management led to a precipitous decline in abalone populations, listing of northern abalone as a threatened species, and recent uplisting of its status to endangered. Re-introduction and range expansion of sea otters in recent decades is again shifting the abundance and distribution of macroinvertebrates and kelp. Setting conservation targets and management objectives for abalone and sea otters becomes complex given that both are listed as species at risk in Canada, and that the hyper-abundance of abalone following otter extirpation currently informs reference points for recovery. Improved understanding of historical conditions and trajectories of change will be important for informing conservation and management decisions, including ramifications for achieving recovery targets. I use a combination of historical knowledge and observational data across gradients of sea otter occupation in two regions of BC to understand how recovery of sea otters is impacting benthic rocky reef food webs and recovery of northern abalone. While poaching remains a threat, my assessment of abalone recovery in an ecosystem context challenges the view that northern abalone are endangered.

Lees, D.C.*
"MULTICULTURAL" CONDOMINIUMS CONSTRUCTED BY BURROWING SHRIMP IN CLEAN AND CONTAMINATED SEDIMENTS THROUGHOUT SAN DIEGO BAY.
Littoral Ecological & Environmental Services

While involved in remediation projects related to contaminated sediments in San Diego Bay, I became aware of burrowing shrimp assemblages living in the bay floor. Dense populations lived in sediments contaminated with >25,000 ppm copper ore and >1,600 ppm PCBs. In the latter case, Convair Lagoon, a proposed remediation option was capping 5.7 acres of intertidal and shallow subtidal sediments with a 2-foot thick layer of sand. Based on my experience working on soft sediments, I had two concerns: 1) that the shrimp currently living in these sediments could be able to burrow back to the surface of the newly constructed cap, and 2) that new shrimp could colonize the sand cap and then burrow down into the contaminants. Both activities would reconnect the contaminants with the bay ecosystem. To evaluate these risks, we conducted studies of the burrowing shrimp living in bay sediments. We injected dye into burrow systems to assess linear extent of the burrows. We also injected epoxy resin into them to form castings for assessing depth of penetration and burrow complexity. During these studies, we found the burrow systems were complex, comprising “multicultural” condominiums constructed by five different species of burrowing shrimp. These interconnected systems extended more than 2 m linearly and more than 1 m in depth. We then conducted lab studies to identify grades and a minimum thickness of gravel that could be used to prevent penetration into the cap by shrimp. As a result, a gravel barrier was incorporated into the cap design.
Leong, W.∗
NATURAL VARIATION AND SELECTIVE PRESSURE OF ENVIRONMENTAL STRESSORS ON TIGRIOpus CALIFORNICUS
University of Southern California

Tigriopus californicus is a benthic harpacticoid marine copepod that lives in supralittoral splash pools along the west coast of North America. In its natural habitat, T. californicus experiences extreme differences in environmental conditions both temporally and spatially—among individual pools at each location and along latitudes between Alaska and Mexico. It is therefore an excellent model for the study of how organisms adapt to their environment and how the environment drives evolution in populations of animals. Although T. californicus has been tested for tolerance to extreme temperatures in the laboratory, there are limited field data for the challenges they face in the wild. In summer 2011, pools on Catalina Island in California were monitored at 3h intervals over 3 daily cycles. Data show extreme variations in daily temperatures and salinities between tidal influxes. 20 copepods were collected for measurement of HSP70 expression by RT-qPCR at each timepoint. Copepods exhibit variable expression of HSP70 in response to environmental stressors. A balanced 4-factor experimental design was used to investigate the effects of salinity, starvation, light stress, and substrate availability on the survivorship of Tigriopus californicus. Results show multiple stressors interact to affect the survivorship of copepods.

Levin, P.S.∗†, Azose, Joel¹, Anderson, Sean²
ECOLABELING OF BIBLICAL PROPORTIONS: ENVIRONMENTAL CONSEQUENCES OF EATING KOSHER SEAFOOD
1 - NOAA Fisheries, NWFSC 2 - California State University Channel Islands, Environmental Science and Resource Management Program

As a response to widespread concern about the state of marine ecosystems, and the perceived failure of existing policies, many organizations are developing market-based instruments that promote sustainability. Eco-standards such as shopping guides, eco-labels and stewardship certifications are now commonplace. However, in many cultures dietary guidelines have existed for thousands of years, and anthropologists have argued that such dietary rules emerged to reduce environmental impacts by encouraging exploitation of productive species, increasing ecological efficiency, or decreasing harvest of apex predators. Here, we explore the environmental consequences for marine systems of one of the more familiar ancient dietary traditions—keeping kosher. CSUCI students sampled nearly 4,500 seafood items from 68 supermarkets and 112 restaurants. We separated kosher and nonkosher species and estimated the mean trophic level of kosher vs. nonkosher seafood as well as food miles and carbon footprint. In general, diversity of kosher seafood available was greater than nonkosher species. Trophic level of kosher species was substantial higher than nonkosher items. The carbon footprint of consuming nonkosher seafood was greater than consuming only kosher species—there is a 67% probability that a randomly selected kosher species will have a lower carbon footprint than a nonkosher species, and a 60% that it will be less than a totally randomly selected species. This difference is eliminated if only Seafood Watch best choices are consumed. Thus, the naïve kosher consumer will have less climate impact than nonkosher consumers, but may encourage high trophic level fisheries.

† Lewis, L.S.∗, Smith, J.E.
FUNCTIONAL DIVERSITY OF HERBIVOROUS URCHINS IN THE KAHEKILI HERBIVORE FISHERY MANAGEMENT AREA, MAUI, HI
Scripps Institution of Oceanography, UCSD

Grazing by herbivorous urchins is known to be important to the health and persistence of coral reef ecosystems. However, much of what we understand about urchin-reef interactions has been derived by studying few urchin species in a limited number of marine ecosystems. Here, we explored the functional diversity of herbivorous urchins in a near-shore coral ecosystem (Kahekili Herbivore Fishery Management Area) in Maui, Hawaii. First, we used field-based grazing assays to compare dietary preferences and grazing rates among five urchin taxa common to reefs along leeward Maui. urchins were offered six algal types including: Turbinaria ornata (brown macroalga), Ulva fasciata (green
macroalga), *Acanthophora specifera* (red macroalga; invasive), *Amansia glommerata* (red macroalga; native), mixed turf (fleshy algae < 1cm on carbonate), and CCA (crustose coralline algae on carbonate). Second, we deployed a long-term caging experiment on reef isolates to examine the functional roles of 3 urchin species common to the area (Heterocentrotus mammillatus, *Echinothrix calamaris*, and *Tripneustes gratilla*). Isolates were caged using 3 cm black plastic mesh and urchins added at densities of 2 urchins per m^2^ in both monocultures and all possible 2-sp. combinations. Changes in the % cover, density, and composition of benthic organisms were compared among urchin treatments and to full exclosures and open plots to explore any differential impacts among urchin taxa (and combinations) on benthic communities. Results of this work will be used to explore functional diversity among Hawaii’s urchins, and the relative importance of each species to the functioning of Hawaii’s coral reefs.

Lipski, D.M.*, Katz, S.

DEEP SEA CORAL HABITAT IN THE CHANNEL ISLANDS NATIONAL MARINE SANCTUARY: ARE CORALS CHALLENGED BY CARBONATE UNDERSATURATION?

*Channel Islands National Marine Sanctuary*

This study examined water column chemistry in and around known deep sea coral habitats in the Channel Islands National Marine Sanctuary. Deep sea corals are thought to be important habitat for fish and other invertebrates but much remains unknown about their physical environment in addition to their biology and ecology. Worldwide, corals may be vulnerable to many threats including ocean acidification which is an issue of increasing concern for calcifying organisms such as corals. However, perceptions of the magnitude of threats are often based on extending inferences from laboratory observations and focal locations to other areas in the absence of detailed monitoring data. During a NOAA-supported cruise to study deep sea corals in June-July 2010 we collected water samples to characterize the physical and chemical environment as part of a larger survey to evaluate deep water coral distribution and habitat. Additional samples were collected in November 2010 to look at seasonal variability. Parameters measured continuously with a CTD included temperature, salinity, dissolved oxygen, and pH; discrete samples were also taken for the measurement of nutrients and carbonate saturation state. The aragonite saturation depth (Ω), a physiologically relevant index of acidification status, was between 50 to approximately 100m for most sampled stations indicating that corals at depth (300-900m) are experiencing under-saturated conditions. Knowledge of the physical environment that deep water corals experience is an important step toward understanding their distribution and ecology, and to understand what conservation efforts are needed and could be most effective.

Lonhart, S.*, Figurski, J., Freiwald, J., Storlazzi, C.

BIOLOGICAL RESPONSES TO BURIAL AND EXHUMATION OF BEDROCK REEFS IN CENTRAL CALIFORNIA

1 - NOAA’s Monterey Bay National Marine Sanctuary 2 - Long Marine Laboratory, University of California Santa Cruz 3 - Pacific Coastal and Marine Science Center, US Geological Survey

Benthic marine habitats and associated fishes, invertebrates and algae can be predicted from seafloor maps generated from acoustic multi-beam surveys. Key attributes of habitat, such as substrate and reef morphology, can change rapidly and extensively in energetic environments where sediment transport contributes to burial and exhumation of the seafloor. In northern Monterey Bay, up to 30% of rocky habitat is buried or exhumed seasonally. We categorized areas of the seafloor that were stable or dynamic (i.e. chronically buried and exhumed) using acoustic surveys spanning five years, and we compared the communities of sessile and mobile organisms between those areas. Species richness and diversity of mobile and sessile organisms were significantly lower in dynamic areas than in adjacent, stable, reef habitat. Sessile communities in dynamic areas were dominated by diatoms that colonize rapidly and by sponges that survive scour and burial. Potentially sensitive species such as small anemones, cup corals, and bryozoans were reduced or absent. Most mobile species (e.g., sea stars and urchins) were more abundant in stable areas than in dynamic areas, however a few species thrived in dynamic habitats (e.g., anemones). These results demonstrate that substrate dynamics operating at intra-annual time scales can structure marine communities. Efforts to map the

HABITAT AND BATHYMETRY INFLUENCE THE LANDSCAPE-SCALE DISTRIBUTION AND ABUNDANCE OF DRIFT MACROPHYTES AND ASSOCIATED INVERTEBRATES

1 - Friday Harbor Labs, University of Washington
2 - Washington Department of Fish and Wildlife

We used a remotely operated vehicle (ROV) to investigate landscape-scale patterns of subtidal drift material and invertebrates within the San Juan Channel in Washington State. Specifically, we quantified the distribution and abundance of drift macrophytes (seaweed and seagrass) and four macro-invertebrate species across depth and habitat type to depths of 170 m. Drift macrophytes were ubiquitous in the deep subtidal zone, present on 97% of all video segments deeper than 30 m, with large drift piles particularly associated with low angle habitats at depths exceeding 70 m. Two harvested species (Strongylocentrotus franciscanus, Pandalus platyceros) that feed directly on drift material appear to be distributed in space (depth and substrate type) so as to maximize access to drift macrophyte food resources, according to their respective feeding modes. Overall, our data suggest that basin shape and habitat drive the landscape-scale distribution of drift material, and indirectly the consumers that feed on it. The export of large amounts of detritus derived from nearshore macrophyte production into deep water habitats likely fuels extensive secondary production in these aphotic zones.

† Lyons, K.*, Goodmanlowe, G.*, Lavado, R.*, Schlenk, D.*, Lowe, C.G.*

ORGANOCHLORINE CONTAMINANTS AND BIOCHEMICAL RESPONSES IN SOUTHERN CALIFORNIA STINGRAYS (UROBATIS HALLERI)

1 - California State University Long Beach
2 - University of California Riverside

While contaminant concentrations have been reported for elasmobranchs around the world, very few have monitored levels for southern Californian species despite the high volume of industrial and residential inputs into the coastal environment. The round stingray (Urobatis halleri) is a local benthic species that forages near areas of high organochlorine contamination and is a good model to monitor contaminant accumulation and effects in elasmobranchs. PCBs, DDT (and metabolites), and chlordanes were measured in adult and juvenile stingrays from area in southern California. Juveniles and adults were found to have higher concentrations of PCBs (1,100±357 ng/g, ww) than chlordanes (92.23±49.78 ng/g, ww), or DDE (38.25±31.96 ng/g, ww). Preliminary data did not show significant differences in contaminant concentrations between juveniles and adults for any of the contaminants; however, there was high variability in contaminant concentrations among individuals, which may be influenced by the round stingray’s migratory patterns. Potential toxicity effects correlated to PCB exposure were explored through Western blotting and EROD activity assays of cytochrome P450 (CYP1A1) and compared to stingrays from a reference site (Santa Catalina Island). Stingrays collected from Seal Beach showed a higher expression of CYP1A1 than Catalina Island rays. Our preliminary results show that contaminant exposure from compounds such as PCBs may be inducing a biochemical response in stingrays. Since round stingrays feed at lower trophic levels, they represent a suitable model for monitoring contaminant concentrations in local benthic elasmobranchs and use in future research exploring the physiological impacts of these contaminants.

† Lyons, P.J.*

THE EVOLUTION OF MUTUALISM BETWEEN ALPHEID SHRIMPS AND GOBIID FISHES: A BALANCE BETWEEN COSTS AND BENEFITS

Perry Institute for Marine Science, Stony Brook University

I describe several assays designed to examine how costs and benefits interact in the development of mutualisms between species. A mutualism occurs between alpheid shrimp and gobiid fishes. These shrimp have poor vision but good burrowing ability. Individual shrimp share their burrows with a goby that, with good vision but no burrowing ability, acts as a watch-out warning shrimp when predators approach. In the Caribbean, a single species, Nes longus, which has been described as a mutualist, follows these behaviors. Others, such as Ctenogobius saepepallens, casually use shrimp burrows,
rarely warn shrimp of danger, and are better described as commensalists. I found that *N. longus* more effectively avoids predators while using shrimp burrows than *C. saepepallens*. Thus, tight mutualism with shrimp is advantageous, especially in areas where shrimp burrows are abundant. I have quantified several behaviors that likely allow *N. longus* to use burrows more effectively. Why then would *C. saepepallens* not evolve such behaviors and become a strict mutualist if strict mutualism is advantageous? For gobies, there is likely a cost associated with mutualism with shrimp. To warn shrimp, gobies must remain at a burrow entrances and restrict foraging to that small area. I found that on the same restricted diet, *C. saepepallens* lost more weight than *N. longus*. Thus, *C. saepepallens* may be constrained to a casual association with shrimp due to foraging requirements. This story indicates that strict mutualism may evolve infrequently because few species can overcome the inherent costs of mutualism.

Mackie, J.A.*, Buncic, M.¹, D'Andrea, A.², Parr, Leslee, A.¹, Dumbauld, B. R.³
SPATIAL AND TEMPORAL GENETIC INVESTIGATION OF THE PLANKTONIC LARVAL POOL OF THE US-PACIFIC ESTUARY GHOST SHRIMP, *NEOTRYPAEA CALIFORNIENSIS*
1 - San Jose State University 2 - College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Orego 3 - US Department of Agriculture, Agricultural Research Service
The burrowing ghost shrimp, *Neotrypaea californiensis*, has a 6-8 week dispersing larval phase, providing a useful model for examining the contribution of ocean current variability to population structure. Larvae were collected on the Oregon and Washington shelf in 2005 and 2006 over a 450-km transect to measure spatial genetic variation, between-year genetic variation and seasonal-period (within-year) variation—using cytochrome oxidase 1 (COI) nucleotide diversities. We examined three spatial-temporal hypotheses: there may be a year-dependent genetic pattern (H1) with the larval pool differing between years; a spatially-driven pattern (H2), with genetic pattern indicating an uneven intensity of larval input from different sources; or a seasonally-driven pattern (H3) with genetic variation altering within a year, perhaps reflecting different current regimes. We found support for between-year with heterogeneity hypothesis (H1): haplotype patterns differed between years, while remaining contiguous over the oceanic area within each of the years. There was however genetic discontinuity when comparing larvae collected off shore and those collected within an estuary, suggesting the importance of near-shore scale transport processes in effectively defining spatial genetic variation of adult populations. We compared the genetic diversity of larvae from the plankton with spatially aggregated adult samples from Yaquina Bay Estuary, Oregon. COI variation was lower in adult samples (mean \( \pi = 0.010 \)) than in larval samples (mean \( \pi = 0.034 \)). Accordingly, we suggest effective recruitment into estuaries is temporally constrained, with rare events contributing disproportionately to demography.

† Mahoney, B.*
TEMPORAL AND SPATIAL VARIABILITY IN ALGAL-INVERTEBRATE ASSOCIATIONS IN KELP FOREST COMMUNITIES, MONTEREY BAY, CA.
*Long Marine Laboratory, University of California Santa Cruz*
Mechanisms that operate across spatial and temporal scales regulate distribution and abundance of available habitat and can influence abundance and diversity of associated fauna. Understory algae in a kelp forest is primarily red algae which provide important habitat to diverse communities of small, mobile invertebrates that are, in turn, important food sources for kelp forest fishes. To understand spatial variability in red algae and how this translates to variability in associated invertebrates, I conducted benthic surveys in kelp forests in Monterey, CA every month from July-October 2011. Percent cover of red algae was quantified using UPC along transects. Morphological complexity of algae can influence the composition and abundance of associated fauna. To determine abundance and composition of associated invertebrates at each site and for varying morphological complexities, I collected 5 species of red algae (simple to complex morphologies). Associated invertebrates were removed and enumerated. Red algal coverage as well as abundance of the 5 algal species were compared among sites and over time. The invertebrate composition associated with algal species and sites were analyzed using multivariate approaches in PRIMER. I found considerable spatial variability in both algal and invertebrate communities. In addition, the relationship between algal substrate and
Malm, P.D.*, Nielsen, K.J.
THE ROLE OF GRAIN SIZE AND WRACK COMPOSITION IN STRUCTURING TALITRID AMPHIPOD POPULATIONS ON NORTHERN CALIFORNIA BEACHES
Sonoma State University

Sandy beaches are characterized by low levels of in situ primary productivity and are subsidized by inputs from adjacent marine habitats including kelp forests, wetlands and rocky intertidal zones. Inputs of wrack derived organic nutrients support associated invertebrates that in turn provide food for shorebirds and other higher order consumers. These ecosystems have been surprisingly understudied (in northern California in particular) given their ecological importance, connectivity to other ecosystems and considerable overlap with human activities. We observed substantial variation among 4 beaches within 10 km of Bodega Head in the abundance and taxonomic composition of wrack and talitrid amphipods. We found talitrid amphipods were 2 orders of magnitude more abundant (>30,000 vs. < 500 m$^{-1}$ of shoreline) on beaches dominated by cover of eelgrass (Zostera spp.) wrack and relatively fine sand than on beaches dominated by brown algal wrack and coarser sand. Zostera wrack was ~3000 % more abundant on Dillon and Doran Beaches compared to Salmon Creek and Miwok Beaches while in contrast kelp wrack was 6 % more abundant on the latter beaches than the former. Based on prior research in Southern California we hypothesized that beaches with higher brown algal wrack input rates should support larger talitrid amphipod populations. However in a lab experiment we found amphipod behavior was strongly influenced by sand type also. We are testing the interaction between wrack type and grain size, in both field and laboratory feeding experiments, to better understand the factors that influence variation in amphipod abundance.

Martone, R.G.*, Markel, R.W.
WHERE'S THE BIOMASS? SEA OTTERS DRIVE REGIONAL DIFFERENCES IN SUBTIDAL ROCKY REEF FOOD WEBS ON VANCOUVER ISLAND
Institute for Resources, Environment and Sustainability, University of British Columbia

The widespread loss of top predators has major consequences for ecosystem structure and function. Sea otters are top predators in temperate rocky reef ecosystems that exhibit strong top-down control of grazers, such as sea urchins, and thereby indirectly facilitate macroalgal-derived habitat and productivity. While this trophic cascade is well documented, little is known about its consequences for food web structure, productivity, biodiversity, and ecosystem function. To understand the effects of the sea otter loss and reintroduction on nearshore rocky reef ecosystems we assessed the distribution of biomass within food webs along a gradient of sea otter recovery on the west coast of Vancouver Island. We found that sea otters support wasp-waisted food webs in which biomass is highest at high trophic levels (i.e. secondary consumers) and low trophic levels (i.e. primary producers and small-bodied primary consumers), and lowest at mid trophic levels (i.e. large-bodied primary consumers). Effects of "trophic downgrading" on how biomass is distributed within nearshore food webs likely has consequences for productivity and, ultimately, resilience of nearshore rocky reef ecosystems.

† Matson, P.G.*, Yu, P.C.¹, Sewell, M.A.², Hofmann, G.E.¹
BIOCHEMICAL CONSEQUENCES OF OCEAN ACIDIFICATION ON EARLY LARVAL DEVELOPMENT IN A TEMPERATE SEA URCHIN.
1 - University of California Santa Barbara 2 - University of Auckland

Ocean acidification (OA) is expected to have a major impact on marine species, particularly during early life-history stages. These effects appear to be species-specific and may include reduced survival, altered morphology, and metabolic depression. However, less information is available regarding the bioenergetics of development under elevated CO$_2$ conditions. Here we examined the biochemical and morphological responses of Strongylocentrotus purpuratus during early development under ecologically relevant levels of pCO$_2$ (365, 1030, and 1450 µatm). The principal findings of this study were: (1) lipid utilization rates and protein content in S. purpuratus did not vary with pCO$_2$; (2) larval growth was reduced at elevated pCO$_2$ despite similar rates of energy utilization; and (3) significant
maternal effects were found in terms of larval size and energy content during development. These results suggest that this species may either prioritize endogenous energy towards development and physiological function at the expense of growth, or that reduced larval length may be strictly due to higher costs of growth under OA conditions. This study highlights the need to integrate maternal variation in global change biology in order to better understand how present populations may respond to global climate change.

†Matthews, J.A.*, Scott, Z., Hentschel, B.T.
IN-SITU ADULT-JUVENILE INTERACTIONS OF THE SPIONID POLYCHAETE, POLYDORA CORNUTA
Coastal and Marine Institute Laboratory, San Diego State University
The interface feeding spionid polychaete, Polydora cornuta, form dense assemblages often exceeding 10000 m$^{-2}$ and aggressively defend their living spaces. Recently metamorphosed juveniles must compete for food resources with conspecific adults. Although it has been suggested that competition for space is not common in soft sediments, results from a flume experiment suggest that the strength of density-dependent interactions between adult and juvenile *P. cornuta* is mediated by flow. The lab growth rates of juveniles were negatively affected by adult density only at slow flows in which fecal mounds accumulated. Because fecal mounds are likely removed as flows increase during tidal exchange, the conclusion from lab experiments needs to be tested in the field. In the present study we transplanted numbered vials each containing a premeasured juvenile *P. cornuta* (<5mm long) and either 0, 3, or 6 adults (>7mm) to the intertidal sediment in the Tijuana Estuary. The relative growth rates of the juveniles were determined by measuring each juvenile’s body volume before and after the 8-d field transplantation. Juvenile growth rates did not differ among adult density treatments, either when analyzed by initial number of adults (0, 3, or 6) (ANOVA: $F_{2, 26} = 0.135$, $P = 0.874$) or by regression analysis of growth rate vs the number of adults actually recovered from each vial ($F_{1, 27} = 0.380$, $P = 0.543$, $r^2 = 0.014$). Our results support published data suggesting that intraspecific competition for resources may not be an important factor for spionid population dynamics.

Messer, K.*, Seng, J.*, Mackie, J.A.*, Craig, S. F.*
A RAPID MOLECULAR METHOD TO RESOLVE INVASION PATTERNS IN THE INVASIVE BRYOZOAN SPECIES COMPLEX, WATERSIPORA ‘SUBTORQUATA’
1 - Telonicher Marine Lab, Humboldt State University 2 - San Jose State University
It is imperative to correctly identify and track invasive species in order to further understand their invasions. However this task is made difficult by the presence of morphologically cryptic species. We have designed a molecular method of quickly and effectively detecting three distinct lineages of Bryozoans of the genus Watersipora, a group of species that are highly invasive and aggressive foulers of ship hulls. These lineages are identified using multiplex-PCR, producing COI lineage-specific fragment lengths that can be easily examined on an agarose gel. The method is a significant improvement over previous methods of *Watersipora* identification, which consist of time-consuming visualization and require a large measurement set to be considered accurate. In initial application, over 200 colonies were typed to identify major COI lineages in collections spanning Humboldt Bay, California. Supporting the reliability of the technique, COI phylotype recognition was achieved in 100% of the DNA extractions (at very low financial cost), and these can even be done using small amounts of tissue added directly to PCR. Cross-amplification of other Bryozoa was not observed. Through increased sampling (compared to previous studies using primary sequencing), we have found that the introduced population diversity in Humboldt bay is in fact greater than was first assumed. Secondly, a mosaic of phylogroup-specific colony patches occurs in Humboldt Bay. Small areas (up to the scale of marinas) appear to be dominated by locally expanding colony populations.
Miller, S.H., Morgan, S.G.

INTERSPECIFIC DIFFERENCES IN DEPTH PREFERENCE REGULATE LARVAL TRANSPORT IN AN UPWELLING REGIME

*Bodega Marine Laboratory, University of California Davis

The population connectivity of most benthic marine invertebrates is determined by a miniscule pelagic larval stage, but larval behavior is poorly understood, particularly in upwelling regions where persistent winds and offshore surface currents could transport larvae far from shore. To investigate the role of swimming behavior in regulating larval transport in upwelling regimes, we observed the larvae of four crab species in the laboratory. Larval vertical positions in acrylic columns were recorded for up to two days, and we determined whether (1) depth preferences differed for the four species, (2) larvae undertook tidal and diel vertical migrations and (3) vertical migrations were timed endogenously or exogenously. Regardless of light or tidal phase, larvae of three species (*Hemigrapsus oregonensis*, *Lophopanopeus bellus bellus*, and *Pachygrapsus crassipes*) that develop offshore stayed high in the water column, where they would be transported seaward in the field. In contrast, larvae of one species (*Petrolisthes cinctipes*) that develop nearshore stayed low in the water column, where they would remain in shoreward-flowing bottom waters. None of the species from the open coast exhibited tidal or diel vertical migrations, but one estuarine species (*H. oregonensis*) exhibited reverse tidal vertical migrations that would expedite their transport to the open ocean. Thus, larvae of species that hatch in different locations and develop different distances from shore exhibited diverse larval swimming behaviors that regulate transport in a dynamic upwelling regime.


LARVAL ADVECTION AND BEHAVIOR REGULATING POPULATION CONNECTIVITY IN UPWELLING REGIONS

1 - Bodega Marine Laboratory, University of California Davis 2 - University of North Carolina Wilmington

Generalizations regarding the role of oceanographic processes affecting larval transport and settlement in productive upwelling regions along the western margins of continents require much closer scrutiny to provide reliable information on larval connectivity between source and sink populations. Contrary to the prevailing view, larvae of many invertebrates appear to exert considerable control over their movements, remain very close to shore, recruit onshore in strong upwelling conditions and settle close to home. We estimated connectivity of a representative species (porcelain crab *Petrolisthes cinctipes*) using a Bayesian modeling approach in which prior estimates of larval transport and connectivity (a dispersal kernel) were combined with field estimates of habitat quality, larval production, and larval settlement to obtain updated estimates of connectivity patterns. The estimated dispersal distance was 0.44 ± 14.7 km and connectivity patterns revealed considerable spatial heterogeneity in the strength of larval sources and self-recruitment, a consequence of both variation in population density and estimated oceanographic dispersal distances. We anticipate that our approach will be broadly applicable worldwide when information on dispersal from larval tracers or circulation models is unavailable, and it will be useful in managing fisheries stocks and designing and evaluating networks of marine protective areas.

† Morgan, C.B.*, Miner, B.G., Donovan, D.A.

DO PARENTS KNOW BEST? REPRODUCTIVE PLASTICITY IN AN INTERTIDAL GASTROPOD

*Western Washington University

For organisms with different life-history stages, adults and their offspring can have different predators. It could be advantageous for parents to alter their reproductive strategy in response to predators of their offspring, although this response has been rarely documented. In this study, we used *Nucella lamellosa*, an intertidal whelk, to test whether cues from crabs and isopods that prey only on encapsulated juveniles alter the timing, rate, and physical characteristics of embryo capsules deposited by adult whelks. We also tested whether different densities of conspecific snails would alter the same capsule properties. In the first experiment, we found that the crab *Hemigrapsus oregonensis* both delayed the time at which whelks deposited capsules and reduced the rate at which deposition took place. In the second experiment, a crab that does not consume capsules, *Petrolisthes eriomerus*,

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delayed deposition and also decreased the rate of deposition while two other crabs (*H. oregonensis* and *Pagurus granosimanus*) lowered the rate of deposition but did not alter the timing of laying. In the third experiment, cues from adult conspecifics accelerated the timing, but not the rate, of laying. Throughout the study, neither conspecifics nor predators induced any change in the size or shape of the capsules or the strength of the capsule walls. These experiments demonstrate that adult *N. lamellosa* respond to cues from predators, species closely related to predators, and conspecific adults. Additionally, *N. lamellosa* alters its reproductive strategy in response to crab species that only pose a threat to juvenile snails.

† Morrison, R.A.*, Williams, G.J., Zgliczynski, B.J., Sandin, S.A.

**COUPLING BETWEEN FISH AND BENTHIC ASSEMBLAGES ON PACIFIC CORAL REEFS**

*Scripps Institution of Oceanography, UCSD*

The structure of coral reef fish assemblages varies with three major influences: (i) oceanographic conditions, (ii) level of fishing activity, and (iii) availability and quality of benthic habitat. Quantifying these influences on fish assemblage structure is necessary to predict functional consequences following from changes in local conditions (e.g., implementation of management regulations). While we are gaining strong insights into the direct effects of (i) oceanographic and (ii) fishing influences through natural experimental studies at large spatial scales, the (iii) coupling between fish and benthic assemblages has not been examined on comparably large scales, nor have all three influences been examined simultaneously. The Coral Reef Ecosystem Division of NOAA has been collecting fish and benthic data at U.S. Pacific islands for the past ten years, enabling comparative analyses that can unique yield insights into the nature of the relationship between fish and benthic assemblages and how this fish/benthic coupling is influenced by oceanography and human disturbance. To explore these linkages, we measured temporal shifts in hard coral cover and reef fish abundance and diversity at 39 U.S.-affiliated islands spanning four archipelagos over the past decade, using individual islands as replicates. In this talk, we describe how the strength of the coupling between fish and benthic communities relates to gradients in oceanography and human disturbance. We also examine which of these factors is most significant in structuring fish communities, and how these structural data could be used to predict functional responses, such as fisheries productivity, in these remote island systems.

† Munday, E.S.*, Tissot, B.N.*, Heidel, J.R.*, Miller-Morgan, T.*

**EFFECTS OF VENTING AND DECOMPRESSION ON YELLOW TANGS (Z. FLAVESCENS) IN THE WEST HAWAII AQUARIUM FISHERY**

1 - Washington State University Vancouver 2 - Veterinary Diagnostic Laboratory, Oregon State University 3 - Hatfield Marine Science Center, Oregon State University

The aquarium trade in west Hawaii removes over 300,000 fish from coral reefs each year. Recent discussions have centered on managing fish collection methods, a topic that is not well-studied. We examined reef fish collection methods that fishers implement to mitigate barotrauma, a suite of symptoms caused by a forced ascent from depth. Venting (puncturing the swim bladder to release gas that has expanded with decreased depth and pressure) and allowing more time for natural decompression are two such methods. We studied the effects of three decompression treatments (fast, intermediate, slow) and venting (no, yes) on fish mortality. In *Z. flavescens* collected from 20m, post-collection mortality was associated with fast decompression and no venting, and occurred within 24 hours of capture. The most popular methods in the fishery, fast or intermediate decompression followed by venting, resulted in no mortality. Though fish were held for 21 days following capture with no delayed mortality, it is possible that stressors following collection such as transport, air travel, and holding in export, import, and retail facilities could exacerbate sub-lethal effects inflicted during collection.
Muth, A.F.*, Graham, M.H.
TEASING APART TEMPERATURE AND NUTRIENT EFFECTS ON MACROCYSTIS PYRIFERA RECRUITMENT FROM BRITISH COLUMBIA TO SOUTHERN CHILE
Moss Landing Marine Laboratories

Nutrient concentrations are typically considered to be the primary factor regulating recruitment success of the giant kelp Macrocystis pyrifera, despite the fact that high nutrients generally co-occur with cold temperatures throughout M. pyrifera’s natural range. Experiments were conducted on M. pyrifera cultured from British Columbia, central California, southern California, and southern Chile to tease apart the effects of temperature and nutrients on recruitment success. Cultures were grown at two temperatures (12°C and 18°C) and three nitrate concentrations (1, 5, and 10 µmol) under saturating irradiances, and monitored weekly for sporophytes. Contrary to expectation, regardless of nitrate concentration, sporophytes were always present and more abundant at 12°C relative to 18°C. Furthermore, differences in recruitment success between temperatures were exacerbated in the colder regions (southern Chile, central California, and British Columbia) relative to southern California. Under temperature conditions where sporophytes were produced, recruitment success did vary with nitrate concentration, however sporophytes were present in all nitrate levels. These results suggest that nitrate concentrations are secondary to temperature in driving recruitment success in M. pyrifera, and that giant kelp populations are capable of acclimating to increasing temperature.

Neufeld, C.*, Barazandeh, M., Palmer, A.R.
DIVERGENT PENIS FORM AND MODES OF SPERM TRANSFER IN TWO SYMPATRIC BARNACLES LIVING ON ROCKY SHORES
Bamfield Marine Sciences Centre, University of Alberta

Thoracic barnacles are hermaphroditic and are thought to reproduce through self-fertilization, or by pseudo-copulation (transferring sperm directly into a partner’s mantle cavity). However, copulation on wave-exposed shores may be difficult, where breaking waves can impose large forces. Building on previous work, we compared penis form, extensibility, and modes of sperm transfer in two sympatric barnacles common on rocky shores. In Balanus glandula, variation in overall penis form across an exposure gradient was accompanied by variation in allocation of cuticle and muscle. Furthermore, penises were capable of extending to 2.2× resting length, and individuals were often seen copulating in the lab and in the field. These observations suggest B. glandula is well-suited for direct sperm transfer on wave-exposed shores. In contrast, the wave-exposed specialist Pollicipes polymerus has an unusually short penis capable of extending to only 1.1× resting length, copulation has never been observed, yet fertilized individuals are often found beyond the reach of any neighbour. Although self-fertilization has always been assumed to account for these isolated-yet-fertilized individuals, using single nucleotide polymorphisms (SNPs) we show that P. polymerus individuals are capable of capturing sperm directly from the water, and often do so even when other potential mates are within reach. Evidence of indirect sperm transfer calls into question many past claims of self-fertilization, and raises many questions about sex allocation and population genetic models in barnacles.

† Nickols, K.J.*, White, J.W., Largier, J.L., Gaylord, B.
IMPORTANCE OF THE COASTAL BOUNDARY LAYER TO LARVAL DISPERSAL AND SELF-RETENTION IN COASTAL POPULATIONS
Bodega Marine Laboratory, University of California Davis

Dispersal is a critical component of marine metapopulation dynamics, and estimates of mean dispersal distance, width of the dispersal kernel, and self-retention (the proportion of individuals that settle near the release site), are of particular importance. To date, these statistics are mostly calculated from offshore velocity data, and overlook the potential importance of conditions near the coastal boundary, where larvae are released. We use a 2-dimensional particle tracking model to explore the effects of reduced flow speeds observed near the coast (Coastal Boundary Layer; CBL) on dispersal of organisms with pelagic larval durations (PLDs) of days/weeks. Incorporating CBLs decreases mean dispersal distances by 20-85%. This effect is most profound for gentle bathymetric slopes associated with broader CBLs, where time spent in the CBL is comparable with the PLD. The maximum dispersal distances are also reduced by 10-60% across a range of PLDs and CBLs. The total number of model
larvae that contact the shore while competent, and thus have the opportunity to settle, is similar with or without a CBL, and most of these settlers spend >75% of their PLD within 3 km of shore. The presence of a CBL, while not affecting the number of total settlers, dramatically increases self-retention by 20-90%. The majority of these larvae spend their entire PLD within 3 km of shore. This work further demonstrates that successfully settling larvae are typically those that remain close to shore, and that ignoring the reduced velocities in CBLs may overestimate coastal connectivity.

Nielsen, K.J.* 1, Morgan, S.G. 2, Dugan, J. E. 3
SAND CRAB POPULATION MONITORING IN MPAS: A METHODOLOGICAL COMPARISON TO INFORM DEVELOPMENT OF ECOSYSTEM INDICATORS
1 - Sonoma State University 2 - Bodega Marine Laboratory, University of California Davis 3 - Marine Science Institute, University of California Santa Barbara
Sandy beaches and surf zones are important foraging areas for shore birds and fishes. We are evaluating prospective long-term ecosystem indicators as part of a study to establish baseline conditions in North-Central California’s new marine protected areas (MPAs). An important component is to develop and assess exiting citizen scientist monitoring efforts so they may contribute to credible ecosystem assessments. Obtaining accurate estimates of sand crab (Emerita analoga) populations can be challenging due to their high mobility, the dynamic nature of the habitat and the risks of surf zone sampling. These issues present unique set challenges and constraints for designing a monitoring protocol, but are especially important considerations when relying on citizen scientists. We conducted paired and spatially replicated sampling efforts at three beaches to compare two sampling methods: 1) the Gulf of the Farallones National Marine Sanctuary LiMPETS (Long-term Monitoring Program and Experiential Training for Students) protocol and 2) a method commonly used in published scientific studies. Results of our paired sampling effort show that Emerita abundances varied strongly and negatively with beach slope and rank order of abundances among beaches was the same regardless of the method used, however the LiMPETS protocol consistently yielded lower estimates of abundance. These results imply that use of historic data collected with the LiMPETS protocol may need to be constrained or a correction factor may need to be developed and that the protocol may need to be modified to optimize its usefulness for future MPA monitoring and ecosystem assessments.

† Nishizaki, M.T.*, Carrington, E.
PHYSIOLOGICAL AND BEHAVIORAL RESPONSES TO TEMPERATURE AND FLOW IN THE BARNACLE BALANUS GLANDULA DARWIN (1854).
Friday Harbor Labs, University of Washington
In aquatic systems, physiological rates such as respiration, photosynthesis, and calcification are potentially limited by the exchange of dissolved materials between an organism and the surrounding water column. The nature and extent of physiological limitation is, therefore, likely to be dependent on environmental factors such as water temperature and flow. Here, we report results from experiments and a model that quantify physiological and behavioral activity of barnacles (Balanus glandula) under a range of water temperatures and velocities. Experimental results demonstrate that respiration rates increase rapidly at low temperatures (Q_{10} = 3.18 ± 0.52 at 5-15°C) and more slowly at high temperatures (Q_{10} = 1.62 ± 0.07 for 15-25°C). Increasing water velocities resulted in a curvilinear response that saturated at flows above 2 to 30 cm s^{-1} depending on temperature. Model analysis revealed that respiration rates were mass transfer limited at slow velocities (< 30 cm s^{-1}) and high temperatures, whereas kinetic limitation occurred at high flows (40 - 150 cm s^{-1}) and low temperatures. Moreover, there are a large number of intermediate flow-temperature conditions where both mass transfer and kinetic limitation are important. Behavioral analysis of cirral beating revealed that barnacles typically displayed full cirral extension at low flows, whereas barnacles at high flows (> 40 cm s^{-1}) displayed a variety of short, abbreviated “testing” beats. The exception to this pattern occurred in the extremely low flow-high temperature treatments where barnacles more frequently displayed intermediate “pumping” beats. Under these low-oxygen conditions, increases in “pumping” behavior may be a behavioral strategy by barnacles to increase rates of ventilation.
O'Donnell, M.J.*
EFFECTS OF REDUCED FOOD AND OCEAN ACIDIFICATION ON AN INTERTIDAL LIMPET
University of Washington, Friday Harbor Laboratories
Ocean acidification has been shown to cause reduced growth rates in a wide range of calcifying marine invertebrates. In order to predict the effects of reduced pH on marine communities, it is essential to put acidification into an ecologically relevant context. For instance, are the effects of acidification magnified or reduced under different levels of food availability? Additionally, it is important to consider whether the response is similar in organisms from environments with chemical conditions that are naturally highly variable. In this experiment, I raised intertidal limpets (Lottia pelta) under 3 different pCO$_2$ levels and 3 different food treatments, and documented net growth of shell area. Limpets grown under the lowest pCO$_2$ treatment experienced the highest growth when provided with maximum food relative to all other food / pCO$_2$ treatments. There was no significant effect on growth at any pCO$_2$ treatment. This is consistent with the high, and highly variable pCO$_2$ conditions in this species' natural habitat.

O'Kelly C.J.*, Mottet G., Little A.
CARBONATE-BORING ALGAE: ASSESSING DIVERSITY IN TROPICAL AND TEMPERATE MARINE WATERS
Friday Harbor Labs, University of Washington
As the role of carbonate-boring algae in tropical reef ecosystems becomes both better understood and of greater concern in the contexts of anthropogenic global warming and ocean acidification, it becomes more important to understand the biodiversity of the algae (chlorophytes, rhodophytes, and cyanobacteria) and the contributions made by individual species to reef productivity and carbonate dissolution rates. Here, we report research based on a library of cultured algal strains isolated predominantly from coral skeletons in Hawai‘i and from the shells of invertebrates (molluscs, bryozoa, etc.) in Washington / British Columbia and Massachusetts. We obtained both morphological and DNA-sequence data for strain identification, assessed strains for their ability to bore into calcareous substrata and for their temperature tolerance, and prepared casts for direct comparison of boreholes with those described in the literature from both Recent and fossil materials. From the morphological, physiological, and molecular data, we infer that the biodiversity of carbonate-boring algae is significantly greater than previously recognized; for green algae previously assigned to Ostreobium queketti and Phaeophila dendroides, at least 10x more species are extant than have been described, and few of those species have been found in both temperate and tropical environments.

† Olmeta, F.*
THE MEDITERRANEAN SEA CETACEAN SANCTUARY: PROSPECTS FOR AN EFFECTIVE SANCTUARY AGREEMENT
Washington State University Vancouver
In 2002, the International Mediterranean Sea Cetacean Sanctuary was established. This sanctuary is the world’s first high seas marine protected area for cetaceans and resulted from intense cooperative actions among France, Monaco and Italy governments and stakeholders. My research traced the development and implementation of the sanctuary by examining the legal regimes from which it emerged, and cooperation and coordination activities that took place. The analysis of legal instruments related to protection and conservation of resources of coastal areas, oceans and seas showed a strong inclination toward an integrated and ecosystem-based approach for the conservation of the marine environment and of its biological diversity through the development of marine protected areas. The agreement on the creation of a sanctuary for marine mammals was formulated within the spirit of this legal regime’s movement. My research also investigated the impacts of the lack of exclusive economic zones for France, Italy and Monaco on the implementation and management of the high seas section of the Sanctuary. This study examined cooperation and coordination among the national and international actors involved in the sanctuary development and management through the use of semi-structured qualitative interviews. The main challenges to overcome were the problem of sovereignty and jurisdiction, the organization of cooperation and coordination at the national and...
international levels, and the recognition of the Sanctuary boundaries and protection measures by the international community.

**Paddack, M.J.**, Marlieve, J¹, Frid, A²

**SPECIES-SPECIFIC VARIATION IN POPULATION SIZE, STRUCTURE, AND HABITAT PREFERENCES OF ROCKFISH WITHIN HOWE SOUND, BC**

1 - Santa Barbara City College 2 -

Rockfish are commercially important fish along the west coast of North America and have undergone drastic declines within the past decade. They are a highly species-diverse group, and species are often comingled and thus caught in the same area. Nearshore rockfish species are managed as a single group, yet ecological differences among these species could differentially impact their vulnerability to fishing and ability to recover. In order to evaluate how nearshore species differ in their distribution, we measured species-specific density and size structure of rockfish, lingcod, and greenling on nine nearshore reef areas within Howe Sound, British Columbia. Significant variation in total density, biomass and size structure among sites was observed. We explored how this variation is affected by depth and abiotic and biotic habitat features and found significant differences for two closely related species, copper and quillback rockfish. Abundance and size frequency of these species are influenced by differences in depth distribution, a particularly important aspect in this fjordal system of steep shores and limited rocky habitat. Although the more shallow-dwelling coppers grow and mature more quickly, the proportion of fish observed above the 50% maturity size (7%) was less than half that of the deeper-dwelling quillbacks (15%). This, along with the finding that the largest size classes of either species were only found on the deepest and least accessible sites reveals that the impact of fishing pressure in shallow areas has been high and remains slow to respond to groundfish fishing closures established in the region in 2006.

† Paquin, A.L.¹, Nielsen, Karina J.¹, Largier, John L.²

**AN ABUNDANCE OF NEARSHORE PHYTOPLANKTON: UNRAVELING WHAT DRIVES THE ‘GREEN RIBBON’ ALONG AN UPWELLING COAST**

1 - Sonoma State University 2 - Bodega Marine Laboratory, University of California Davis

Several recent studies demonstrate decoupling between chlorophyll a (chl a) concentration in nearshore (<1 km) and offshore zones (>1 km), calling into question the assumption that estimates of phytoplankton abundance from buoys, vessels, and satellite ocean color images represent nearshore regions. We combine measurements from the shoreline and offshore moorings to document high chl a events nearshore and assess physical and biological correlates. During spring-summer 2010 and fall 2011 we performed high-frequency shore-based phytoplankton sampling at Bodega Head to quantify community patterns on daily and weekly time scales. Intertidal and mooring fluorometers recorded chl a fluorescence and were calibrated to in situ extracted chl a from bottle samples. Peaks in nearshore chl a are correlated with peaks in wave energy, confirming prior results. In spring and summer, chl a peaks are dominated by diatoms in the genera *Chaetoceros, Skeletonema*, and a yet-to-be-determined solitary centric diatom. In fall, different dinoflagellates are present, including *Ceratium, Noctiluca* and *Gonyaulax* spp. Several novel observations were collected during this study: 1.) *Leptocylindrus danicus*, which has not previously been reported as an important component of the phytoplankton community in this area, made up fifty percent of the community during one late summer, high chl a event (~20 mL⁻¹). 2.) In August 2011, an unprecedented and widespread mortality event of intertidal and subtidal invertebrates occurred during calm conditions in northern California. Samples show *Gonyaulax spinifera*, a known producer of yessotoxin, was abundant and may have been responsible.

† Pesce, A.S.¹, Edwards, M.S.

**THE PHYSIOLOGICAL RESPONSE OF KELP FOREST TURF-MACROALGAE TO ELEVATED CO₂**

Coastal and Marine Institute Laboratory, San Diego State University

Large-scale ocean surveys and time-series data for oceanic pH and CO₂ concentrations over the past 20 years demonstrate that ocean acidification is a predictable consequence of rising atmospheric CO₂. Kelp forests are subject to frequent weather-related disturbances such as severe storms and El Niño
events that thin the kelp canopies and subsequently alter benthic light regimes and create bare space, both of which alter competition among turf-forming macroalgae. While our understanding of how these communities respond to disturbances may be quite good under present conditions, it is unclear if these responses will remain similar under future conditions predicted with climate change. This study investigates the physiological responses of dominant red turf-macroalgae from the Point Loma kelp forest San Diego, CA to elevated levels of CO$_2$ by examining changes in photosynthetic performance. Algae were incubated under present day (ambient) and future (elevated) CO$_2$ concentrations at a range of light levels for short-term (two-hour) and long-term (two-week) periods. Results indicate that increasing seawater CO$_2$ concentrations results in increased oxygen production, increased carbon uptake, and varying changes in photosynthetic light curve parameters among turf-forming species. This information will aid in gaining ground closer to understanding how kelp forest ecosystems will respond to future kelp canopy disturbances and the subsequent commercial and ecological consequences.

**Peteiro, L.G., Shanks, A.L., Rumrill, S.S.**
**SEASONAL ABUNDANCE AND TIDAL-TIMED MIGRATION OF OLYMPIA OYSTER LARVAE IN COOS BAY, OREGON**

*Oregon Institute of Marine Biology, University of Oregon*

The decline of native oysters (*Ostrea lurida*) along the U.S. west coast, has prompted recent interest in population recovery and has placed a premium on local information about population dynamics. Because of the complex life-cycle of *O. lurida*, larval dispersal patterns are strongly linked to recruitment of early juveniles into benthic oyster populations. Olympia oysters are estuarine-dependent, and tidal cycles have an important influence on larval export and retention. Simple larval behaviors, such as vertically migrating to the bottom during falling tides, have been observed in several species as a potential mechanism of limiting export out of estuaries. We examined the seasonal pattern of larval abundance and tidal-timed migration for *O. lurida* in Coos Bay, Oregon during the summer of 2010. Weekly zooplankton tows and CTD casts were conducted from June to October, during a series of alternating rising and falling tides. No *O. lurida* larvae were observed in the water column until the end of July, but two distinct peaks in larval abundance occurred in mid August and mid September. Olympia oyster larvae reached greatest abundance in the estuary during the dry season, which was characterized by elevated water temperatures (> 16 deg C), high salinity (> 25), and low stratification of the water column. Although we observed a trend toward lower larval abundance in surface waters during falling tides, no significant differences occurred with regard to tidal phase. Preliminary results suggest that the vertical distribution of *O. lurida* larvae may be influenced by an interaction between current velocities and tidal cycles.

† Ponce-McDermott, M., Bingham, B.L., Salyan, M.E.

**HOW DOES SYMBIONT COMPLEMENT AFFECT LIPID CONTENT OF THE INTERTIDAL ANEMONE ANTHOPLEURA ELEGANTISSIMA?**

*Shannon Point Marine Center, Western Washington University*

*Anthopleura elegantissima*, the common Pacific sea anemone, can host at least two algal endosymbionts: zooxanthellae (*Symbiodinium muscatinei*) and zoochlorellae (*Elliptochloris marina*). The photosynthetic carbon provided by the symbionts supplements the host’s heterotrophic feeding and may increase the energy available for reproduction. Zooxanthellae potentially translocate five times more carbon to the host than do zoochlorellae. We developed a method to measure lipid levels of anemones in different symbiotic states to determine whether more translocated carbon equates to more energy available for growth and reproduction. Lipids were extracted and separated into classes with thin layer chromatography. A semi-quantitative analysis of the chromatography plates is allowing us to determine how lipid content varies seasonally and whether the identity and quantity of lipids differs by the symbiotic state of the anemone. The results are helping us better understand the contribution of different photosymbionts to fitness of the anemone host.
EXTRAORDINARILY RAPID LIFE HISTORY DIVERGENCE BETWEEN CRYPTASTERINA SEA STAR SPECIES

Disruptive selection caused by ecological differences among habitats is widely inferred to be an important cause of phenotypic evolution and reproductive isolation, but is often hard to distinguish from other drivers of speciation. Here, we use multilocus phylogeographic analyses to examine a speciation event involving spectacular life history differences between closely related sister species of sea stars. We show that these species have only been reproductively isolated for approximately 6,000 years, and that within this time frame, Cryptasterina hystera has evolved a suite of highly derived life history traits (including internal self-fertilization and brood protection) that differs significantly from its sister species C. pentagona, a gonochoric broadcast spawner. This life history change had dramatic genetic consequences including low nucleotide diversity, zero heterozygosity, and no gene flow. The rapid and localized divergence of populations and phenotypes rules out some types of speciation mechanisms such as adaptation to different microhabitats in sympatry, or slow divergence by genetic drift during prolonged geological isolation. The large phenotypic differences between species relative to the short divergence time suggests instead that the life history differences themselves may be the direct response to disruptive selection cause by some local environmental or demographic difference at the southern range margin (e.g., colder temperatures or smaller population sizes) that favored the evolution of self-fertilizing viviparity in a new species.

RELATIVE EFFECTS OF INVASIVE INDO-PACIFIC RED LIONFISH VS. NATIVE GROUPER ON MORTALITY OF BRIDLED GOBY IN THE BAHAMAS

Invasive Indo-Pacific red lionfish (Pterois volitans) are highly effective predators that severely threaten Caribbean and Atlantic reef-fish populations. Because lionfish have higher feeding rates than ecologically similar native predators, they have the potential to affect the population dynamics of native prey fishes. The bridled goby (Coryphopterus glaucofraenum) is a major prey of invasive lionfish. Before the invasion, this species was documented to undergo both density-dependent and density-independent mortality, depending on habitat structure. I compared the per capita mortality of adult bridled gobies (2.5cm – 4.5 cm TL) on 4-m2 coral patch reefs distributed among four treatments (5-6 reefs each): (1) one native resident predator (grasby grouper, Cephalopholis cruentatus), (2) one lionfish, (3) one resident predator and one lionfish, and (4) predator-free control. Initial goby abundances ranged from 4 to 36 fish per reef, all within naturally occurring densities, and predators ranged in size from 7 to 10 cm TL. Mortality over 3 weeks was density-independent across all treatments. Treatments that included lionfish (2 and 3), showed a significant additive effect on the per capita mortality of bridled gobies when compared to control reefs and native predator only reefs (4 and 1, respectively). Remarkably, per capita mortality approached 100% on reefs with lionfish. It is clear that lionfish have a devastating effect on bridled goby populations and can extirpate gobies from small patch reefs, leading to the possibility of extinction throughout the invaded range.

PARENTAL EFFECTS MAY INFLUENCE RESPONSE OF BROODING CORALS TO CLIMATE CHANGE STRESSORS

Larvae from brooding reef corals are critical for replenishing coastal reef ecosystems. Reefs globally are threatened from the stress of increased temperature and ocean acidification, both of which are predicted to intensify in the future. To understand the acclimatization potential of reef corals, brooding adult Pocillopora damicornis were exposed to either ambient or high treatments (26.5°C, 416 µatm, or
29.0°C 805 μatm, respectively) for 1.5 months prior to larval release. Adults were sampled for Fv/Fm, photosynthetic and respiration rates, calcification, *Symbiodinium* density, chl-a, and gene expression. Adult colonies in the high treatment displayed reduced photochemical efficiency and photosynthetic oxygen evolution, and 2.2 times lower P:R ratios than those in ambient conditions. In total, ~55% of the colonies (n=22) released larvae over the course of 4 days, with the majority of release occurring in ambient tanks (58% of 12 colonies, 60% of 858 larvae). Larvae collected over the 3 release days following initial exposure were pooled, allocated to secondary treatment in a reciprocal fashion, and sampled for dark respiration, size, *Symbiodinium* density, and gene expression after 5 days. Dark respiration of larval *P. damicornis* was significantly affected by the history (initial treatment) of the parent. Together these results suggest that history and parental effects may play a large role in shaping the physiology of larvae, and subsequent success under future stress. These finding identify the importance of tracking larvae and recruits through time to fully understand these effects at the population level, especially under the continued onslaught of global change.

† Rasher, D.B. † Stout, E.P., Engle, S., Kubanek, J., Hay, M.E. CHEMICAL WARFARE ON FIJIAN REEFS: MACROALGAE DAMAGE CORALS USING SURFACE-ASSOCIATED ALLELOCHEMICALS Georgia Institute of Technology Over recent decades, many tropical reefs have transitioned from coral to macroalgal dominance. These community shifts increase the frequency of algal-coral interactions on reefs, and such interactions may suppress the coral recovery and recruitment necessary to reverse phase-shifts. However, the extent to which macroalgae damage corals, the mechanisms involved, and the species-specificity of algal-coral interactions remain uncertain. Using field experiments, we demonstrate that numerous macroalgae directly damage corals, and do so via surface-associated allelochemicals. Hydrophobic molecules from algal surfaces caused bleaching, decreased photosynthesis, and occasionally death of corals in 75% of 32 interactions assayed. Coral damage was generally limited to sites of algal contact, and algae were unaffected by coral contact. Artificial mimics for shading and abrasion did not damage corals and effects of hydrophobic surface extracts from macroalgae paralleled effects of intact algae, suggesting these localized effects were generated by allelochemical over physical mechanisms. Rankings of macroalgae from most to least allelopathic were similar across the four coral genera tested. However, corals varied in susceptibility to allelopathic algae, with globally declining corals more strongly affected. Bioassay-guided fractionation of extracts from two allelopathic algae lead to identification of two loliiolide derivatives from the red alga *Galaxaura filamentosa* and two acetylated diterpenes from the green alga *Chlorodesmis fastigiata* as potent allelochemicals. When outplanted onto protected reefs, macroalgae were consumed at rapid but variable rates by four fish species with complementary feeding. Our results highlight a potentially widespread competitive mechanism that may partially explain the lack of coral recovery on degraded reefs.

Rius, M. † Potter, E. † Aguirre, J.D. † Stachowicz, J.J. † THE IMPORTANCE OF EARLY LIFE-HISTORY STAGES IN ECOLOGICAL SUCCESSION 1 - University of California Davis 2 - University of Queensland Ecological succession is a crucial process for understanding the spatial distribution of species and the maintenance of species diversity. In marine systems, succession has long been studied in fouling communities, but the focus has been on understanding interactions between adults or effects of adults on new recruits. Despite considerable advances, it is still not clear, for example, how competitively inferior species persist in places with low disturbance intensity and frequency. Here, we studied ecological interactions during early life-history stages to assess their influence on successional dynamics of the fouling community in Spud Point (Bodega Bay, California), a sheltered marina where population and reproductive phenologies have been studied over 10 years. During the period when community development and breeding thrived, we conducted additive and replacement design experiments in the laboratory covering interactions from gamete release to post-metamorphic stages. We also placed new metamorphs in the field in various combinations to examine effects of early life-history neighbors on longer-term success. The solitary ascidian *Ascidia ceratodes* is the clear competitive dominant in this system, yet it does not monopolize the space and coexists with other
competitively inferior species. Similarly, the non-indigenous *Ciona intestinalis* has been slow to invade the system and has not established monocultures as it has elsewhere, despite the fact that it is likely to be competitively dominant. This study seeks to answer whether solitary ascidians are not more dominant because their early life-history stages are susceptible to predation and competition, even though as adults they are generally resistant to both.

**Rodriguez del Rey, Z.¹, Granek, E.F.¹*, Sylvester, S.²**  
**OCCURRENCE AND CONCENTRATION OF CAFFEINE IN OREGON COASTAL WATERS**  
1 - Portland State University 2 - Washington State University Vancouver  
Caffeine, a biologically active drug, is recognized as a contaminant of freshwater and marine systems. We quantified caffeine concentrations in Oregon's coastal ocean to determine whether levels correlated with proximity to caffeine pollution sources. Caffeine was analyzed at 14 coastal locations, stratified between populated areas with sources of caffeine pollution and sparsely populated areas with no major caffeine pollution sources. Caffeine concentrations were also measured in the major water body discharging near sampling locations. Caffeine was detected in seawater at concentrations ranging from below the reporting limit to 44.7 ng/L. The occurrence and concentrations of caffeine in Oregon’s coastal ocean did not correspond well with pollution threats from population density and point and non-point sources, but did correspond with a storm event occurrence. Caffeine concentrations in rivers and estuaries draining to the coast ranged from below the reporting limit to 152.2 ng/L. This study establishes the occurrence of caffeine in Oregon’s coastal waters, but the relative importance of different sources, how sources vary seasonally, and processes affecting transport of caffeine in the coastal ocean require further research.

**Ruesink, J.L.*, Trimble, A.C.**  
**ROLE OF CLIMATE AND OCEAN CHEMISTRY IN AN ESTUARINE INVASION**  
University of Washington  
Pacific oysters (*Crassostrea gigas*) were introduced to western North America about a century ago from Japan and now occur in aquaculture and feral populations. Their natural history makes them sensitive to two dramatic modern changes in marine environments: water temperature, because they originate from warmer waters than experienced in much of their introduced range on the west coast; and ocean acidification, because larval shellfish experience difficulty forming shell as pH and aragonite saturation decline. We tested the sensitivity of oyster larvae to natural variability in a suite of water properties by tracking cohorts across multiple sites and years in Willapa Bay, Washington, including comparisons to data sets collected in the 1950s. Periods of warmer water coincided with improved larval survival and earlier settlement, and these early settlers also had better post-settlement survival and growth than later cohorts. In our studies, the major pattern to emerge in water chemistry was spatial rather than temporal, with low pH and aragonite saturation due to riverine inputs. In 2011, disproportionately few early-stage larvae were observed at the most riverine study sites, although movement during development resulted in highest oyster settlement at these same sites. Because estuaries vary strongly and naturally in water properties over multiple spatio-temporal scales, this leads to contrasting expectations about effects of global change: in some cases, extreme events that become more extreme could cause rapid population responses, but at the same time populations may be buffered by refuges of suitable conditions within an overall mosaic.

**Samhouri, J.F., Tolimieri, N., Feist, B., Levin, P.S.**  
**ECOLOGICAL CONSEQUENCES OF TOP PREDATOR DECLINE IN THE CALIFORNIA CURRENT**  
Northwest Fisheries Science Center  
The paradigm of ‘fishing down the food web,’ whereby the mean trophic level of fisheries landings has declined over time, implies dramatic change in the structure of marine ecosystems. While the ubiquity of this pattern and its causes have engendered much attention and debate, the consequences for the relative abundance of unexploited species (changes in ecosystem structure), and for ecosystem functions such as respiration and production, remain virtually unexplored. Here, we use a fisheries-independent data set to document a pronounced decline in the mean trophic level of the groundfish community along the Pacific U.S. Coast from 2003-2010. We show that while groundfish biomass
decreased at all trophic levels, higher trophic level fishes declined most rapidly. Using a food web model, we illustrate how these shifts in ecosystem structure may have resulted in short-term positive responses by many lower trophic level species. In the longer-term, initial patterns of prey release may be tempered in part by lagged responses of non-groundfish, higher trophic level species, such as mammals and seabirds. Importantly, our model predicts that aggregate ecosystem functions change little following the initial reorganization of biomass from groundfish to other components of the food web. Our findings suggest that efforts to manage and conserve marine ecosystems will benefit from a fuller consideration of the information content contained within, and implied by, fisheries-independent trophic level indicators.

† Sanchez, B.D., Steele, M.A.
THE EFFECTS OF POLLUTION ON GROWTH AND FECUNDITY OF PARALABRAX NEBULIFER (BARRED SAND BASS) IN SOUTHERN CALIFORNIA
California State University Northridge

Organic pollutants and trace metals are environmentally persistent in the marine realm, they have carcinogenic and mutagenic properties, and they can accumulate in tissues of marine organisms and in sediments. These environmental stressors can have detrimental effects on fish populations by limiting the abilities of individuals to acquire resources for growth, reproduction, and survival. Pollutants such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and heavy metals can cause physiological stress in fishes, especially in areas of high pollutant concentrations, like harbors. This study evaluated the impacts of pollutants on growth and fecundity of a common coastal marine fish in Southern California. This study was conducted at four sites: two polluted sites within harbors and two relatively unpolluted sites located outside of harbors. Measures of growth and condition (weight-at-age and weight-at-length) did not differ between the polluted and unpolluted sites, implying that concentrations of pollutants in the harbors studied were not high enough to affect growth rates. Hepatosomatic index did not differ between the polluted and unpolluted sites, suggesting that the level of pollutants is not high enough to induce a response. Reproductive potential did not differ between the polluted and unpolluted sites, confirming that these pollutants have little affects on this multiple batch spawning species. Future work will measure tissue concentrations of pollutants in the fish used in this study to evaluate the assumption that individuals collected in harbors where exposed to higher levels of pollution.

Sanford, E.1*, Lenz, E.A.1, Gaylord, B.1, Hettinger, A.1, Hill, T.M.1, Meyer, K.2, Russell, A.D.3
OCEAN ACIDIFICATION INCREASES THE VULNERABILITY OF NATIVE OYSTERS TO INVASIVE DRILL PREDATION
1 - Bodega Marine Laboratory, University of California Davis 2 - Northern Michigan University 3 - Department of Geology, University of California Davis

Although a growing body of research documents the direct impacts of ocean acidification on calcifying marine organisms, it is less clear how changes in seawater chemistry might alter species interactions. We tested in the laboratory whether ocean acidification might increase the vulnerability of the native Olympia oyster (Ostrea lurida) to predation by the invasive Atlantic oyster drill (Urosalpinx cinerea). Oysters were cultured through their larval phase and until 7 days post-settlement under seawater carbon dioxide concentrations of 380 ppm (control) or an elevated level of 970 ppm. These juvenile oysters were then exposed to juvenile oyster drills, and predation rates were assessed after 48 hours. In the elevated-CO₂ treatment, 20% more oysters were consumed relative to in the control jars. This increased predation was likely due in part to the smaller size of elevated-CO₂ oysters; oysters cultured and drilled at 970 ppm were 29% smaller than those in the control. Oysters raised under acidified conditions may also have been preyed upon more rapidly due to thinner shells, a hypothesis that we are testing using scanning electron microscopy. Our results may have implications for the demographics and restoration of native oyster populations in west coast estuaries. In the inner portions of Tomales Bay, California, invasive oyster drills are abundant and oceanographic records reveal a trend of declining pH since 1987. Restoration of native oysters in Tomales Bay and other estuaries may thus be hampered by the interactive threats of invasive oyster drills and ocean acidification.
Sankaran, S.M.
EFFECTS OF TISSUE NITROGEN AND EUTROPHICATION ON TRACE METAL UPTAKE AND TROPHIC TRANSFER BY ULVA SPP.

Moss Landing Marine Laboratories
The central California coast is enriched with nutrients and trace metals due to annual upwelling as well as natural and anthropogenic terrigeneous inputs, exposing food webs to both limiting and toxic elements. Macroalgae of the genus Ulva are common colonizers in this region, and incorporate elements from the water column, passing them down into sediments or up to higher trophic levels. Studies have linked metal uptake in algae to ambient nitrate concentrations. Given the role of trace metals in photosynthetic enzymes and proteins, variability in productivity may drive the uptake of essential and non-essential elements. This study examined whether either tissue nitrogen or media nitrate affect metal uptake (As, Pb, Mn, Zn) by Ulva spp. Additionally, this study tested if metal burden in the invertebrate Idotea spp. is a function of metal content in their diet. Ulva spp. tissue nitrogen exhibited a significant positive correlation with arsenic and manganese uptake, but no relationship with lead or zinc, and a significant positive correlation with the percent change in manganese and lead. A regression analysis revealed a logarithmic, though statistically insignificant, relationship between media nitrate and both arsenic and manganese. Lead and zinc demonstrated no relationship with media nitrate. Metal in Idotea spp. showed no significant relationship to diet treatments; however, a bioaccumulation trend was observed for arsenic and manganese. Metal concentrations in Ulva were substantially above average when compared to uncontaminated samples and depending on the amount of Ulva consumed, these levels could pose a health risk to invertebrates and/or humans.

† Schmidt, K.T., Starr, R.M., Hamilton, S.L., Cailliet, G.M.
A COMPARISON OF THE LENGTH AT MATURITY AND FECUNDITY OF BLUE ROCKFISH, SEBASTES MYSTINUS, BEFORE AND AFTER OVERFISHING
Moss Landing Marine Laboratories
The increased size-selective mortality that results from intense fishing pressure has been shown to cause reproductive compensation in several marine fishes, whereby subsequent generations of the fished population mature smaller and younger, and may also become more fecund for a given size. The Blue Rockfish, Sebastes mystinus, is a large component of nearshore recreational fisheries in central California. Catches from the 1970s -1990s were large enough to cause a decline in the spawning biomass, down to 10% of its unfished abundance by 1994. During this decline of spawning biomass, the mean lengths of Blue Rockfish also declined, and currently remain well below historic mean lengths. Because Blue Rockfish are faster growing and quicker to mature relative to many other rockfishes, resulting in shorter generation times, they are a good candidate species to determine whether reproductive compensation is possible in Pacific rockfishes. Historic estimates of fecundity and size at maturity are available for Blue Rockfish from the 1960s and early 1980s, collected in central California before overfishing occurred. A comparison of the historical data to samples also collected in central California throughout the past two years indicates that the current population of Blue Rockfish are maturing smaller and are more fecund for specific sizes than prior to the onset of overfishing.

Shanks, A.L.
CAUSES OF VARIATION IN THE ABUNDANCE OF RETURNING CANCER MAGISTER MEGALOPAE AND THE SIZE OF THE COMMERCIAL CATCH
Oregon Institute of Marine Biology, University of Oregon
Several years ago I gave a talk at WSN based on a 5-year time series describing the causes of variation in the number of returning C. magister megalopae and the size of the commercial catch. Megalopal abundance varied with the date of the spring transition (early transitions = more megalopae) and megalopal abundance was strongly correlated with commercial catch. I have six more years of data and the story is more complex and interesting. Returns in 2006 fit the earlier model perfectly. In 2007 through 2009 megalopal abundance jumped by >20 times; something in the ocean had radically changed and increased megalopal abundance. The step change in megalopal abundance appears to be due to a shift in the Pacific Decadel Oscillation (PDO); high catches have
occurred during years with negative PDOs. In 2010 and 2011, the PDO was negative, but catches were much lower than expected. In these years, shortly after the spring transition upwelling stopped and did not resume for weeks. The number of returning megalopae appears to be related to three factors, the PDO, the spring transition date, and amount of upwelling in spring/early summer. Through 2006, the abundance of megalopae was linearly related to the commercial catch, but with the recent spike in megalopal abundance this relationship has become non-linear; density dependent mortality following settlement has become more important.

RESPONSE OF EELGRASS HABITAT AREA TO SEA LEVEL RISE AND ITS AVAILABILITY TO FORAGING BLACK BRANT IN PACIFIC COAST ESTUARIES
1 - Humboldt State University 2 - Pacific Watershed Associates, Inc., Arcata, California 95518 USA 3 - United States Geological Survey-Alaska Science Center, Anchorage, Alaska 99508 USA 4 - Ducks Unlimited Inc., Western Regional Office, Vancouver, Washington 98683 USA
We modeled the effects of sea level rise on eelgrass (Zostera marina) habitat area and on the amount of that area that is accessible to brant (Branta bernicla), which feed on eelgrass. A digital elevation model was developed for seven estuaries from Alaska, Washington, California, and Mexico. Future distributions of eelgrass were derived from estuarine specific tectonic and sediment change rates (i.e. bottom change) in conjunction with three rates of eustatic sea level rise (ESLR). The percentage of total eelgrass area accessible to direct brant grazing was determined for December when brant overwinter and during April when they use sites for fattening prior to northward migration. Initial accessibility was affected by variables such as daytime tide height that limit brant reaching depth. Model projections 100 years into the future indicated that present day ESLR and bottom change rates should sustain the current estuarine pattern of brant use across the flyway, but eelgrass beds at mid and northern latitudes will experience an extinction effect due to the loss of light if ESLR accelerates. Predicted tectonic uplift or sedimentation may eject eelgrass from mid and southern estuaries but brant usage should not change dramatically due to their ability to switch food sources and estuaries. ESLR rates greater than 2.8 mm yr⁻¹ should result in less overwintering by brant at the northern and southern ends of the flyway. The highest ESLR rate may also reduce the amount of food available for spring fattening at staging sites on the lower Alaska Peninsula.

† Siple, M.C.
DEFINING THE ECOSYSTEM ENGINEER: FOOD WEB CONTRIBUTIONS OF THE INVASIVE ALGA GRACILARIA SALICORNIA
University of Hawai‘i at Manoa
Ecosystem engineers are often defined in terms of physical effects on biological systems. The effects of invasive engineers on habitat availability can be particularly dramatic, especially in island ecosystems. However, the relative contributions of physical structure and biological inputs to these community effects are generally unknown. In Hawai‘i, recently introduced species, such as invasive red alga Gracilaria salicornia provide a model system in which to test these impacts. G. salicornia forms a dense, stiff canopy, reducing water flow and providing hard substrate in soft-bottom habitats. The impacts of this invasive species on the food web of a tropical estuary were studied between 2010 and 2011. Carbon and nitrogen stable isotope compositions (del13C and del15N) of several primary producers (phytoplankton, benthic microalgae, G. salicornia and its epiphytes) as well as two opportunistic detritivores (the blue swimming crab Thalamita crenata and glass shrimp Palaemon sp.) were measured from four sites in He‘eia fishpond, a semi-enclosed tropical estuary on the island of O‘ahu. Initial results suggest that despite its high cover and annual die-offs, G. salicornia is not a significant carbon source for the estuarine food web. Mixing model results may provide a quantitative assessment of the extent to which this species is an ecosystem engineer.
† Smith, D.M.*, Storer, C., Frazee, N., Vermeire, M.
UNIVERSITY OF WASHINGTON GRADUATE STUDENTS IN THE HIGH SCHOOL: WHO’S TEACHING WHO?
Friday Harbor Labs, University of Washington
The ability to effectively communicate scientific concepts and research results to future scientists, as well as the general public, is now essential to all graduate programs to properly train students for a future that includes outreach at all levels. In its fourth year at the University of Washington Friday Harbor Laboratories, the NSF-funded GK12 grant Ocean and Coastal Interdisciplinary Science (OACIS) has connected dozens of graduate students with high school classrooms in Seattle and Friday Harbor area high schools. Through interactions with teachers and students in the high schools, these graduate students have improved their communication and teaching skills while enriching STEM instruction by bringing their own research and learning experiences to the classroom. Here, we present an interactive learning experience as a model to develop dynamic lesson plans for use in science education and outreach. These techniques can help scientists and teachers transition from standard ‘lecture-to-the-crowd’ styles to engaging experiences that promote learning and aid in concept retention.

USING METABOLOMICS TECHNIQUES TO INVESTIGATE METABOLIC IMPLICATIONS OF DIVERSITY IN CORAL-SYMBIODINIUM UNIONS
1 - Hawaii Institute of Marine Biology, University of Hawaii at Manoa 2 - National Museum for Marine Biology and Aquarium 3 - Hawaii Pacific University
Increases in anthropogenic stress, such as rising sea surface temperature, are causing mass mortalities on coral reefs that lead to changes in community structure. However, coral species do not respond equally to stressors and some species are more resistant to environmental disturbances than others. Current evidence suggests that coral susceptibility to environmental pressure may be linked to physiological responses associated with endosymbiotic identity. While the taxonomic diversity of Symbiodinium is well described, the functional differences associated with diversity in coral-Symbiodinium assemblages have yet to be fully explored. To this end, we employ metabolomics techniques as a new approach to study metabolite production and translocation within the coral-Symbiodinium union. Akin to other ‘omics’ fields, metabolomics is an unbiased tool in systems biology that describes the metabolic state of a biological system by measuring the presence and abundance of low-molecular weight compounds (<1000 daltons). We investigated the metabolome of two corals from Nanwan Bay, Taiwan that vary in their endosymbiotic assemblages. Coral fragments were sampled at two time points to capture the photosynthetic and the non-photosynthetic metabolome. Chloroform/methanol/water (10:10:7) extracts were made from each sample and were measured using 1H-NMR. Following data acquisition, metabolite profiles were analyzed using multivariate analyses, such as Principle Components Analysis, to display patterns in metabolite assemblages. Our results demonstrate that metabolomics is a viable and powerful tool that can be used to investigate metabolite production in coral-algal unions.

† Sorber, L.E.*, Donovan, D.A.
PHYSIOLOGICAL TOLERANCE AND FEEDING MECHANISMS OF THE INVASIVE PURPLE VARNISH CLAM, NUTTALLIA OBSCURATA
Western Washington University
The invasive Purple Varnish Clam, Nuttallia obscurata, has steadily increased its range in the Pacific Northwest since its introduction via ballast water in the late 1980’s. Nuttallia obscurata has the ability to maintain populations in the high intertidal zone where it is subjected to a wide range of environmental conditions such as salinity fluctuations and limited food availability. In this study, I investigated physiological tolerance of whole gills and feeding mechanisms that may allow N. obscurata to thrive in the high intertidal. Previous research has shown that N. obscurata has a wide salinity tolerance. Physiological response to salinity was measured through oxygen consumption of whole gill tissue at salinities of 5, 30 and 55 ppt. Oxygen consumption per dry gill weight decreased with increased salinity but was overall lower than the native little neck clam, Protothaca staminea, at all.
salinity levels. Previous research has shown that *N. obscurata* may have two modes of feeding; filter feeding and pedal feeding. This adaptation may prove beneficial to survival in the high intertidal because it allows the clam to feed when not submerged by the tides. For this study, I investigated the gill/palp mass ratio and foot size of *N. obscurata* at high, mid and low tide levels to determine if differences existed in feeding structures based on method of food acquisition as well as distance from high tide. My results indicate that *N. obscurata* from the high intertidal have a smaller gill/palp ratio and foot than those at the mid intertidal.

**Sosik, E.†, Simenstad, C.A.‡**
YOU ARE WHAT YOU EAT? TESTING ASSUMPTIONS IN ISOTOPICALLY-BASED FOOD WEB MODELS
1 - Friday Harbor Labs, University of Washington 2 - University of Washington
Multiple stable isotope (MSI) analyses are increasingly popular techniques in the ecologist’s toolbox. By harnessing the unique properties of certain isotopes, researchers have developed novel methods to approach otherwise difficult-to-answer inquiries such as ecosystem connectivity. Using MSI analyses, we are investigating the contribution of detrital macroalgae to subtidal benthic food webs. Our isotope data will be used as inputs in a multivariate model to determine the extent to which primary consumers may rely on this organic matter subsidy from shallow, photic ecosystems. However, any conclusions drawn from these results are only as good as the assumptions upon which these food web models are based. I am currently conducting a series of experiments to evaluate the assumption that no biogeochemical changes that could significantly affect our isotope values will occur as macroalgae drift into the aphotic zone and decompose. Specifically, I seek to know: 1) if the isotopic value of drift kelp changes over the course of decomposition; 2) if there is a microbial loop component that must be included in the model as a potential organic matter source or intermediary; and, 3) if these factors significantly alter the expected isotope values of the primary consumers that feed on detrital algae. Failure to account for potential biogeochemical changes caused by detrital decomposition in our data may confound our interpretation of the relative contributions of discrete organic matter sources. Isotopically-based techniques are powerful tools in food web ecology; however, they come with a suite of underlying assumptions that must be addressed.

† Spitzack, T.S.†, Tissot, B.N.
AN EMPIRICAL STUDY OF CORAL REEF RESILIENCE IN HAWAII
Washington State University Vancouver
Understanding ecosystem behavior is vital to inform conservation and natural resource management efforts. The concept of resilience (the size of a disturbance an ecosystem can tolerate without fundamental changes to function and structure) is essential to understanding ecosystem dynamics. The west coast of the island of Hawaii has a network of Marine Protected Areas (MPAs) that provide various levels of protection for herbivorous fish species. Overfishing is often assumed to reduce resilience however the empirical evidence for a direct connection is limited, particularly in coral reef ecosystems. The different levels of protection along west Hawaii allows us to determine how protection level affects resilience. We used multivariate analysis of a long-term community-level data set from West Hawaii as well as a fish exclusion experiment to assess the relative resilience of six reefs with three levels of protection. We found that MPAs had significant effects on the abundance of herbivores and the herbivore diversity variability in multivariate space over time was significantly higher in areas open to all fishing than in MPAs. Furthermore, early results from experimental data suggest reducing herbivore diversity may lower the relative resilience of the benthic community.

† Stevenson, T.C.†, Tissot, B.N.†, Walsh, W.J.‡
SOCIOECONOMIC CONSEQUENCES OF FISHING DISPLACEMENT FROM MARINE PROTECTED AREAS IN HAWAII
1 - Washington State University Vancouver 2 - Hawaii Division of Aquatic Resources
Marine protected areas (MPAs) have been implemented across the globe to protect marine biodiversity and critical habitats, and to enhance commercially harvested fish stocks. While ecological influences of MPAs are well documented, their impacts on fishing communities remain elusive and
poorly understood. In 1999, a MPA network was implemented to protect against perceived declines of reef fish harvested for the aquarium trade on the Big Island of Hawaii. We investigated 1) whether the MPA network displaced spatial fishing efforts; 2) if the economic and catch benefits offset costs in the newly established non-MPA fishing areas; and 3) whether the MPA network impacted perceived fisher socioeconomic well-being and fishing operations. Data were collected using social surveys, experimental fishing, and catch reports, and were analyzed using parametric and non-parametric statistics. The results suggest the MPA network significantly displaced fishing efforts from the central to the northern and southern coastal regions of the island; profits and catch per unit effort were statistically greater as distance from port of origin increased; and fisher socioeconomic well-being was unaffected, but fishing cost and travel time increased significantly post-MPA network implementation. Although the MPA network displaced fishing efforts, fisher socioeconomic well-being was uncompromised likely because they expanded their operating range to offset potential economic losses. The implications of our findings are relevant because they help clarify how MPA networks impact fishing communities.

† Stier, A.C.†, Kulbicki, M.‡, Hein, A.M.†
BIOGEOGRAPHY DRIVES MARINE FOOD WEB STRUCTURE
1 - University of Florida 2 - Laboratoire Arago, Institut de Recherche Pour le Développement
The predator-prey ratio is a fundamental structural feature of food webs that can affect the function and stability of ecosystems. Historically, the predator-prey ratio has been considered an invariant property among food webs. However, recent advances in metacommunity theory suggest that differences in colonization-extinction dynamics between trophic levels may produce predictable variation in the predator-prey ratio across islands of variable size and isolation. Specifically, theory predicts the predator-prey ratio will increase with island size and decrease with isolation for two separate mechanisms: i) predators should have lower colonization success than their prey because smaller more isolated islands are likely to have a reduced reliability and nutritional quality of prey, and ii) predators should have higher extinction probabilities than prey due to greater metabolic demand and smaller population size. Existing empirical evidence largely supports this Trophic Rank Hypothesis. Here, however, we find conflicting evidence in a study of coral reef fishes across 55 islands in the South Pacific. The relative composition of predator and prey species varies drastically and is strongly correlated with both island size and isolation; communities on larger and less isolated islands contain two prey per predator, whereas smaller and more isolated islands have approximately one prey per predator. Given that predator diversity has been linked to ecosystem function, the smaller and more isolated islands of the eastern South Pacific may exhibit inherently different dynamics than the larger highly connected islands in the coral triangle. Consequently we may require unique management strategies that are tailored to an island’s biogeographic characteristics.

† Stokes, J.A.†, Nielsen, K.J.
BLADE MORPHOLOGY VARIATION AMELIORATES EMERSION STRESS AND PHOTOSYNTHETIC PERFORMANCE OF THE INTERTIDAL KELP SACCHARINA SESSILIS
Sonoma State University
Saccharina sessilis, a dominant kelp of rocky intertidal shores of the northeastern Pacific, exhibits two distinct blade morphologies: bullate and strap-like. Bullate organisms have upright, rugous blades that grow in a cabbage-like habit. Thalli with strap-like growth have blades that are smooth and long, and lie flat upon emersion. Researchers have argued that the bullate morphology is an adaptive response to growing in wave protected shores where boundary layer formation can limit nutrient and carbon dioxide supply for strap-like individuals, while bullae disrupt boundary layers. We observed the two morphologies vary systematically with tidal height, and bullate thalli retain small pools of water on blades during low tide. We hypothesized that the bullate morphology in intertidal kelps ameliorates emersion stress during low tide, and allows Saccharina to persist in higher intertidal habitats. During a sunny morning low tide in Northern California, we found that high zone bullate thalli remained hydrated longer than low zone strap-like thalli despite longer emersion times. Using a pulse-amplitude-modulation (PAM) fluorometer to measure two metrics of photosynthetic performance: maximum quantum yield \( (F_v/F_m) \) and electron transport rate (ETR) we found that these high zone, bullate thalli...
also had greater $F_v/F_a$ and greater ETR than the low zone, strap-like thalli. These differences were less pronounced during the more environmentally benign conditions of a foggy morning low tide. These results contribute to our understanding of the physiological ecology of Saccharina and how it responds to environmental stress.

**Sutherland, K.R.**, **Dabiri, J.O.**, **Costello, J.H.**, **Colin, S.P.**

SWIMMING AND FEEDING IN TURBULENCE BY THE INVASIVE CTENOPHORE, *Mnemiopsis leidyi*

1 - University of Oregon 2 - California Institute of Technology 3 - Providence College 4 - Roger Williams University

Interactions between predators and prey in the ocean frequently occur in turbulent fluid motion. In order to examine the impact of local environmental flows on swimming behavior and filtration rates of the invasive ctenophore, *Mnemiopsis leidyi*, we used a laboratory turbulence apparatus that generates fluid motion, without damaging fragile organisms, via two submerged speakers. Turbulent dissipation rates measured in the apparatus using Digital Particle Image Velocimetry (DPIV) ranged from $10^6$ to $10^9$ W kg$^{-1}$. These rates were comparable to our own field-measured dissipation rates ($10^6$ to $10^7$ W kg$^{-1}$) as well as measurements from the surface mixed layer reported in the literature (range: $10^5$-$10^9$ W kg$^{-1}$). DPIV methods were also used for visualization of fluid structures at the scale of the organism. Data showing swimming behavior and the amount of flux to ctenophore feeding structures in the presence of background turbulence will be presented and compared to still-water conditions. The potential for varying flow conditions to mediate trophic impacts of *M. leidyi* will be discussed.

**Tait, L.W.**, **Menge B.A.**, **Hacker S.A.**, **Chan F.**, **Nielsen K.**

IMPACTS OF CLIMATE CHANGE ON THE PRIMARY PRODUCTIVITY OF MACROALGAE: EFFECTS OF PH AND TEMPERATURE ON NET PRODUCTIVITY

Oregon State University, Department of Zoology

The increase in atmospheric CO2 leading to ocean acidification is expected to impact the physiology of many calcifying organisms. Although impacts of acidification may be widespread, the regions likely to observe the greatest pH changes are cooler temperate waters. Furthermore, regions of strong upwelling may experience even greater pH change due to heterotrophic respiration in deeper waters. In the cool temperate waters of the Oregon coast, one of the dominant calcifiers of rocky reefs is coralline algae (primarily Corallina vancouleriensis), an important facilitator of many algal and invertebrate species. The effects of pH change on the growth and abundance of coralline algae could have wide-reaching consequences in near-shore ecosystems, including large changes in the recruitment and productivity of macroalgal assemblages. Here we set out to examine the potential impacts of ocean acidification in a region regularly exposed to pulses of very low pH water using physiological techniques. Our preliminary results show that lower pH has a negative impact on the productivity of coralline algae, but can have a positive or neutral effect on the productivity of other non-calcium based algae such as the dominant surfgrass Phyllospadix and the abundant kelp Saccharina. Although the effects of low pH on corallines could have wide-scale impacts on these ecosystems, overlying canopies could potentially alter the gas chemistry and buffer some of the effects of low pH water.


LONG TERM HORIZONTAL AND VERTICAL MOVEMENTS OF YELLOW SNAPPER AND LEOPARD GROPER AT THE LOS ISLOTES RESERVE, GULF OF CALIFORNIA

1 - CSU Long Beach, California State University Long Beach 2 - 3 - Gulf of California coastal fisheries heavily target fish species that form seasonal spawning aggregations. The exploitation of spawning aggregations is thought to have lasting negative effects for populations, and marine reserves have been proposed as a tool to mitigate losses resulting from this practice. However, it is difficult to properly design or implement effective reserves without information about the site fidelity and movement patterns of target species. We implanted 32 yellow snapper (*Lutjanus argentiventris*) and 25 leopard groper (*Mycteroperca rosacea*) with coded acoustic transmitters, a portion of which were pressure-sensing and provided instantaneous depth data. Fish
movements were monitored within an array of underwater acoustic receivers at the Los Islotes no-take reserve, a potential spawning site for both species in the southwest Gulf of California. As of September 2011, both species showed high overall site fidelity to the reserve, calculated as the proportion of days present since release (snapper, 0.66 ± 0.30; grouper, 0.97 ± 0.05). Spectral analyses revealed diel and tidal rhythmicity in patterns of presence for both species at the reserve. Overall, snapper used less of the available reserve area, exhibiting greater site attachment to specific areas of the reserve and occupying a shallower, narrower range of depths than grouper (snapper, 10.9 ± 3.6 m; grouper, 14.5± 5.5 m). Continued monitoring of Los Islotes will allow us to quantify annual fidelity, identify changes occurring during spawning periods, and evaluate the role of this reserve in the management of these species.

† Toews, S., Garza, C.

LINKING HABITAT HETEROGENEITY TO GENETIC PARTITIONING IN THE ROCKY SUBTIDAL USING BLACK SURFPERCH (EMBIOTOCA JACKSONI)

California State University Monterey Bay

Habitat composition and complexity can play an important role in structuring populations of marine organisms. However, the interactions between the physical and biological landscape on marine population dynamics are not well understood. In this study we explored the role of habitat complexity (three dimensional habitat structure) and habitat composition (abundance and distribution of habitat types) in structuring genetic variation in populations of black surfperch Embiotoca jacksoni, within Monterey Bay, California. Black surfperch have no pelagic larval stage, limited adult dispersal, and associate strongly with benthic habitat making them an excellent model system for this study. Structural complexity of subtidal habitat was calculated using digital elevation models of the sea floor. Habitat composition was estimated from photoquadrats of the subtidal benthos and collections of benthic algal samples which were sampled for the surfperch’s major prey sources in order to calculate prey biomass and distribution. Surfperch were collected for tissue samples and their stomach contents were analyzed for prey categorization (species and size distribution). We used 10 microsatellite markers to generate allele categorization. GIS and spatial statistics were used to visualize and analyze the relationship between subtidal landscape variables and genetic diversity in black surfperch populations. This approach can provide rigorous quantitative estimates on the relationship between subtidal landscape complexity and genetic diversity in nearshore marine organisms.

Tolimieri, N., Andrews, K., Williams, G., Harvey, C., Levin, P.

HOW DOES THE AMOUNT OF INFORMATION ON FISH HOME RANGES AFFECT ESTIMATES OF THE EFFICACY OF MPAS?

NOAA Fisheries, NWFSC

Work that uses acoustic tracking to estimate home range (HR) size often explicitly states that the results will be useful for the design of marine protected areas (MPA). Acoustic tracking and associated statistical procedures provide a range of detail about HRs—from mean HR estimates to detailed, probabilistic maps of space use by individual fishes (utilization distributions, UDs). We examined how the amount of detail on space use by lingcod influenced predictions about efficacy of an MPA. We developed an MPA-population model for lingcod using information on its home range from acoustic tracking studies. The model examined the amount of protection (probability of being in the MPA at any point in time) under several levels of HR information: one HR for all individuals, HRs that varied in size among individuals, HRs that varied in size and shape among individuals, and full UDs selected from 11 actual UDs derived from field tracking. First 5000 individual fish were added to the model space, and the proportion of their HR within the reserve was calculated to create a probability distribution of ‘protection’ under each information scenario. This probability was then used to modify fishing mortality at the level of individual fish in a population model in a population model over 30 years. The way in which fishes were exposed to fishing mortality differed among the scenarios. As a result, total biomass and population size was higher when full UDs were used suggesting that using less information underestimates the efficacy of reserves.
† Tootell, J.S.*, Steele, M.A.
EFFECTS OF ALGAL ABUNDANCE ON HERBIVOROUS FISHES OF MOOREA, FRENCH POLYNESIA
California State University Northridge
Disturbance can play a major role in shaping the benthic structure of coral reefs by reducing coral cover and causing a phase shift from a coral to algae dominated state. Such shifts are often detrimental to other reef organisms, especially those dependent on coral for nutrition or refuge, but herbivores may benefit from the increase in their food. In some systems, herbivores are thought to be important agents of recovery following such disturbances by consuming large amounts of algae, thus allowing coral recolonization. The effect of increased algal resources on herbivores themselves, however, is not well studied. The purpose of this study was to examine how the distribution and behavior of herbivorous fishes differed across sites with varying levels of resource availability in the back reef environment of Moorea, French Polynesia. At six back reef sites, we found that biomass of herbivorous fishes increased with algal turf cover and decreased with sea urchin density. Behavioral observations focused on two species, *Chlorurus sordidus* (Scaridae) and *Acanthurus nigrofuscus* (Acanthuridae), revealed differences in the distance covered by *C. sordidus* and the agonistic interactions of *A. nigrofuscus*, where distance increased with algal turf cover and agonism increased with herbivorous fish density respectively. Overall, the results indicate that herbivorous fishes alter their distribution and behavior in response to varying resource abundance, which supports the hypothesis that fundamental changes may occur within populations of herbivorous fishes following shifts in benthic composition that allow them to contribute to coral recovery.

Traiger, S.B.*, Kushner, D.J., Sprague, J.L.
MULTIPLE APPROACHES TO ASSESSING THE EFFECTIVENESS OF MARINE RESERVES USING THE COMMERCIAL SEA CUCUMBER, *PARASTICHOPUS PARVIMENSIS*
Channel Islands National Park
The warty sea cucumber, *Parastichopus parvimensis*, has declined in some areas at the California Channel Islands since a dive fishery began in the 1990s. We evaluated the effectiveness of four reserves established in 2003 for *P. parvimensis* density. Annual *P. parvimensis* densities were collected during SCUBA surveys as part of Channel Islands National Park’s long-term kelp forest monitoring program. We used one-way ANOVAs with Tukey post-hoc test and before-after, control impact (BACI) analyses to evaluate marine reserve effectiveness. The ANOVAs showed significantly higher density at three reserves. Before-after, control-impact (BACI) analysis could only be conducted for two reserves and showed significantly higher *P. parvimensis* density at one reserve. There were no increasing or decreasing trends at Santa Rosa Island, where fishing pressure for *P. parvimensis* is low. We examined recruitment data of *P. parvimensis* with Artificial Recruitment Modules; no discernable patterns were found. *Parastichopus parvimensis* is a model species of the importance of monitoring before MPAs and/or fisheries are established and the importance of long-term monitoring. Marine reserves are proving to be valuable management tools in maintaining fished populations of organisms such as *P. parvimensis*.

† Trebilco, R.*, Salomon, A.K., Dulvy, N.K.
SIZING UP FISHING IMPACTS ON THE REEFS OF Haida GWaIi: THEORETICAL ECOSYSTEM BASELINES AND CONSERVATION REFERENCE POINTS
Simon Fraser University
The size-selective nature of fisheries and strong size-structuring of marine foodwebs provides compelling impetus for size-based approaches to describing community structure and guiding conservation targets. However, size-based approaches have received little attention in reef research, where the prevailing paradigm is to describe communities and evaluate impacts in terms of the abundances of species and trophic guilds. As predator-prey relationships in the sea are typically constrained by body size, and marine species commonly exhibit indeterminate growth, body size is often a better indicator of trophic position than species. This size structuring combined with the size-selective impacts of fishing means that fisheries can fundamentally change the trophic structuring of communities. Using visual surveys combined with stable isotope data for reef fish communities on
Haida Gwaii, an isolated island archipelago in northern British Columbia, Canada, I evaluated the community-level relationships between body size, abundance and trophic position. I found that these relationships conform to theoretical expectations, with a negative linear relationship between log(body mass) and log(abundance) and a positive linear relationship between log(body mass) and trophic level across species. Comparing the observed scaling between body mass and abundance with theoretical expectations indicates that, although the fish communities of Haida Gwaii are considered relatively “pristine”, the abundance of large fish is depleted. This approach offers a way to overcome the shifting baseline syndrome and develop theoretical ecosystem baselines to underpin conservation.

† Turner, B.C.*, de Rivera, C.E.
EXAMINING THE POTENTIAL FOR OVERCOMPENSATION BY THE EUROPEAN GREEN CRAB, CARCINUS MAENAS, IN RESPONSE TO CONTROL EFFORTS
Bodega Marine Laboratory, Portland State University
Population size can decline or, via overcompensation, increase, as mortality increases from harvest efforts targeting adults. Overcompensation increases in likelihood with high fecundity, constant survivorship, and short juvenile stages, likely characteristics of successfully invasive species. Overcompensation was documented as the result of removal efforts targeting the invasive small mouth bass, but has rarely been investigated for marine invaders. With increasing efforts of managing destructive non-indigenous marine species, such as the European green crab, Carcinus maenas, it is important to determine the likelihood of overcompensation to inform whether removal efforts must be intense (to outweigh the overcompensation effect) or are not even worthwhile. We examined the overcompensation potential of C. maenas, using experiments and surveys performed in Bodega Harbor, CA. Species that exhibit strong negative interactions between adults and juveniles are more likely to overcompensate. Therefore, these experiments examined cannibalism rates by C. maenas with and without alternative prey, survivorship of juvenile C. maenas at varying adult densities, impacts of the presence of adults on the foraging rates of juveniles, and impacts of the presence of adults on juvenile growth. Adult presence does not appear to affect juvenile growth or survivorship significantly; we detected minimal cannibalism and only short-term reductions in foraging rates. Therefore it is unlikely that C. maenas will overcompensate in response to removal, and this conclusion is consistent with survey data on demographics in Bodega Harbor, throughout a removal effort.

† Valentino, L.M.*, Peyton, K.A.2, Maruska, K.P.3
DUAL ROLE OF A KEYSTONE SPECIES IN CULTIVATING AND CONTROLLING AN INVASIVE ALGA IN A MARINE PROTECTED AREA
1 - Hawaii Institute of Marine Biology, California State University Northridge 2 - University of Hawaii, Manoa, Dept Zoology, Hawaii Cooperative Fishery Research Unit, Honolulu, HI, USA, Hawaii Institute of Marine Biology 3 - Stanford University
Healthy populations of herbivores can shape community structure on coral reefs. Marine protected areas (MPA) facilitate conservation of these populations and help control invasive macroalgae. However, in the Pūpūkea MPA, O’ahu, Hawaii, where many grazers were present, we observed large canopies of a highly palatable invasive macroalga, Acanthophora spicifera, growing in the tide pools. The invasive alga appeared to be present only in the territories of the damselfish, Stegastes marginates, a keystone species on Hawaiian reefs. We hypothesized that in addition to being cultivated by Stegastes, A. spicifera is also being defended from grazing. Comparing benthic macroalgal assemblages inside and outside Stegastes territories found inside-territory coverage to be 45% turf algae and 55% A.spicifera. Nearly 100% of benthic composition was turf, with no A.spicifera outside the territories. For our experiments, the invasive macroalga was tethered inside and outside territories and in caged controls for one hour. Underwater videography was used to assess identities and bite rates of the grazers consuming the tethered macroalgae. Stegastes solely fed within its territory. Outside the territories macroalgae were consumed by other grazers. On average, over half of the algal biomass was lost on the outside treatments within the hour. These findings have large implications on benthic community structure and also for management of this MPA. The Stegastes marginates’ mutual relationship with the invasive Acanthophora spicifera and the damselfish’s ability to feed opportunistically illustrates a dual role that has not previously been documented.
Vaughn, D., Turnross, O., Carrington, E.
SEX-SPECIFIC FORAGING AND GROWTH IN THERMALLY-STRESSED INTERTIDAL SNAILS
1 - Friday Harbor Labs, University of Washington 2 - University of California Santa Barbara
Temperature influences species across a range of organizational scales – from individual performance to ecosystem function. Effects of global climate change, including elevated temperatures and increased frequency of extreme climatic events, are predicted to measurably impact organisms at each of these scales. The consequence of temperature for individual performance is determined in part by an organism’s physiology. For ectotherms, warmer temperatures may increase demand for energy by increasing metabolic rate, which may then reduce energy available for growth and reproduction. Given differences in reproductive physiology, temperature-related increases in metabolic demand may be experienced differently by males and females of a species. In this study we manipulated low-tide aerial temperature to test the predicted effects of climate change on sex-specific differences in foraging and growth in the intertidal predatory whelk, Nucella ostrina. Snails foraged periodically (every two weeks) and subjecting snails to either chronically or acutely elevated aerial temperatures did not alter the timing or magnitude of this pattern. However, despite a similar foraging pattern across treatments, a sex-specific difference in snail growth was pronounced; females exposed to chronic increases in temperature lost body mass over the month-long study. These results suggest differences in the thermal tolerance of male and female N. ostrina that may reflect differential costs for the production of eggs and sperm. Moreover, these results suggest the importance of sex-specific differences that, if widespread, could have considerable consequences for species persistence in an increasingly warm world.

† Wall, C.B., Edmunds, P.J., Cumbo, V.R., Fan, T.
PCO₂ DOES NOT AFFECT THERMAL BLEACHING IN JUVENILE COLONIES OF THE CORAL SERIATOPORA CALIENDRUM
1 - California State University Northridge 2 - National Museum for Marine Biology and Aquarium
Elevated temperature causes coral bleaching, a major cause of coral decline worldwide, and it has been suggested that ocean acidification (OA) could accentuate this response. OA refers to the decline in pH of seawater from the absorption of atmospheric carbon dioxide (CO₂). Here we examine the effects of elevated temperature and pCO₂ on coral symbiont (Symbiodinium spp.) photophysiology, holobiont net productivity, and chlorophyll a concentration in juvenile Seriatopora caliendrum and test the hypothesis that elevated pCO₂ affects the severity of bleaching. Experimental metrics were chosen for their capacity to detect the chronology of bleaching: initially the decline in symbiont photo-efficiency as measured by dark-adapted (Fv/Fm) and effective quantum yield of PSII (ΔF/Fm’), next reduced net photosynthesis as assessed by photosynthesis vs. irradiance (PI) curves, and finally drastic reduction in photopigmentation (chlorophyll a) concentration and symbiont density. Colonies (n=8/treatment) were collected from Nanwan Bay, Taiwan, and subjected to combinations of temperature (27.5/30.5°C) and pCO₂ (445ppm/839ppm) for 14 days. High-temperature reduced chlorophyll a/cm², Fv/Fm, ΔF/Fm’, and significantly affected PI-curves standardized by surface area by reducing maximum photosynthesis and the slope of the light-limiting portion of the PI curve (alpha). pCO₂ did not affect photophysiology or productivity, however the interaction of temperature x pCO₂ affected chlorophyll a/cm². These results suggest that pCO₂, alone and in combination with elevated temperature, has negligible effects on thermal bleaching, symbiont photophysiology, and net productivity in juvenile corals exposed to 30.5°C.

† Wells, E.H., Grosholz, E.D.
POST-INVASION CHANGES IN PREDATION PREFERENCES OF THE EASTERN OYSTER DRILL (UROSAVIPNX CINEREA): A BICOASTAL COMPARISON
University of California Davis
Invasive species present a moving target for researchers. Both the invading species and the recipient communities are capable of changing after the initial invasion, confounding attempts to predict the impact of a new or potential invader. We examined whether the Eastern oyster drill (Urosalpinx cinerea) has changed after its invasion of the Pacific coast of North America. In a series of lab
experiments, we compared the predation preferences of *U. cinerea* from three Atlantic (native range) populations to four Pacific (invasive range) populations. We found that *U. cinerea* from the two coasts differed from each other in their preferences among groups of oysters and mussels. Pacific *U. cinerea*, which have had historical experience of both native Californian (*Ostrea lurida*) and Japanese (*Crassostrea gigas*) oysters, consumed higher proportions of both oysters, when offered together with the evolutionarily familiar Eastern oyster (*Crassostrea virginica*), than did Atlantic *U. cinerea*. Pacific *U. cinerea*, when offered combinations of Eastern mussels (*Mytilus edulis*), Californian mussels (*Mytilus trossulus* x *galloprovincialis*), and Japanese mussels (*Musculista senhousia*) consumed higher proportions of the Japanese mussel than did Atlantic *U. cinerea*, and showed a marked preference for it. These differences in predation preference may have developed rapidly within the lifetime of the initial invaders, but differences among Pacific populations of *U. cinerea*, which have had different lengths of historical exposure to invasive Japanese species, indicate that shifts in predation preference may take years and perhaps several generations to be established in *U. cinerea*.

† Weltz, A.E.*, Shaughnessy, F.J.
USING A GIS MODEL TO PREDICT THE SPREAD OF A NON NATIVE IN AN ESTUARY: THE EXAMPLE OF ZOSTERA JAPONICA IN HUMBOLDT BAY, CA
Humboldt State University
A geographic information system allows the ability to predict potential distributions of spreading non-native species by identifying suitable habitat area. *Zostera japonica*, a non-native seagrass from the subtropical western Pacific, has expanded its distribution in the Pacific North West since its introduction in the mid 1900s. Humboldt Bay and the nearby Eel River estuary now represent the southern extent of its non-native range. In this study, two seasons of *in situ* intertidal temperature data are used to predict optimum *Z. japonica* habitat in Humboldt Bay. Kriging analysis is used to produce an interpolated temperature map of the Humboldt Bay intertidal mudflat during the 2010 growth season, and the scenario of a warmer growth season is examined. Optimal habitat is identified by the amount of time a given section of mudflat spends within a temperature range that is optimal for *Z. japonica* growth (20°C – 30°C). Our model identifies large areas of upper-intertidal mudflat as optimal *Z. japonica* habitat, especially in northern Humboldt Bay where *Z. japonica* has been spreading since 2001, and describes southern Humboldt Bay, where the non-native is absent, as less optimal.

† Wheeler, S.G.1*, Anderson, T.W.2*, Morgan, S.G.3
BIOLOGICAL AND OCEANOGRAPHIC DRIVERS OF VARIATION IN RECENT SETTLEMENT OF COPPER ROCKFISH
1 - Bodega Marine Laboratory, San Diego State University and University of California Davis 2 - Coastal and Marine Institute Laboratory, San Diego State University 3 - Bodega Marine Laboratory, University of California Davis
Variation in larval condition may affect settlement of coastal fishes and thus recruitment patterns. Larvae are often treated as equivalent in growth and survival, ignoring the potential individual variability in larval condition from maternal effects or oceanographic processes that may influence survival to adulthood. We aim to determine whether there is temporal variation in condition that may be explained by apparent maternal investment, timing of parturition to a larval food source or other factors. We are also investigating the relative importance of parturition date, larval growth and upwelling-relaxation cycles on the magnitude of recent settlement. Recently settled copper rockfish (*Sebastes caurinus*) were collected weekly from Apr-Oct 2010 in Bodega Harbor and Tomales Bay. Otolith microstructure analysis is being used to assess the growth rate (as a measure of condition) and parturition date of fish that settled at different times during the season and among large (>50 individuals) and small (<10 individuals) pulses of recent settlers. Our results suggest that parturition date influences larval growth, but does not have a strong effect on the magnitude of recent settlement relative to coastal oceanography. In particular, settlement appears to be facilitated by the onset of strong upwelling.
† Whippo, R. 1*, Britton-Simmons, K.H. 2, Lowe, A.T. 2
BENTHIC COMMUNITY STRUCTURE MEDIATED BY THE RED SEA URCHIN STRONGYLOCENTROTUS FRANCISCANUS IN THE SAN JUAN ARCHIPELAGO
1 - Friday Harbor Labs, University of British Columbia 2 - Friday Harbor Labs, University of Washington
The red urchin Strongylocentrotus franciscanus is a ubiquitous member of the San Juan Archipelago marine community ranging from the shallow subtidal to depths greater than 100m. Despite the absence of attached algae on which to feed in the deep subtidal, red urchins are quite common in these habitats, subsisting primarily on detrital seaweeds produced in the shallow photic zone. They are known to be strong interactors in shallow algal habitats, but very little is known about interactions between urchins and the surrounding community in the deep subtidal. These urchins are up to 20cm in diameter, and extensive field observations suggest that the presence of urchins dramatically alters localized benthic invertebrate abundance patterns. This study tested the hypothesis that red sea urchins alter benthic invertebrate community structure and abundance patterns in the deep subtidal zone. This was accomplished through the use of underwater photography pairing invertebrate communities underneath and adjacent to randomly selected urchins across three sites in the San Juan Channel. Analysis revealed that sea urchins are significantly altering abundance patterns of sessile and mobile fauna. The influence of urchins on mobile community abundance varied widely between sampling depths, while sessile organismal abundance did not. Future work will be aimed at understanding the mechanism by which urchins alter these communities. This study increases our ecological understanding of deep subtidal environments in the Pacific Northwest and highlights the important role dominant grazers play in biological communities.

† Wolfe, B. 1*, Lowe, C.
LONG-TERM, FINE-SCALE MOVEMENTS OF WHITE CROAKER AND BARRED SAND BASS IN THE PALOS VERDES SHELF SUPERFUND SITE, CALIFORNIA
California State University Long Beach
Although the presence of organochlorine contaminants in food fishes is well documented, the relationship between habitat usage and contaminant uptake in fishes is poorly understood. We used VPS acoustic telemetry technology and traditional passive tracking to record fine-scale movements of 100 white croaker (Genyonemus lineatus) and 25 barred sand bass (Paralabrax nebulifer) across a 20 km² area encompassing the Palos Verdes Shelf Superfund Site (PVSSS), CA from July 2010 – September 2011. Site fidelity, home ranging behavior and habitat utilization of both species were quantified with regards to benthic sediment DDT levels. Barred sand bass showed higher site fidelity to non-spawning season home ranges on the shelf, whereas white croaker ranged over much greater areas. Over 40% of the white croaker tagged on the PVSSS were observed to move into Los Angeles Harbor. Over 25% of the barred sand bass left their non-spawning season home ranges to join spawning aggregations on Huntington Flats. These data provide a needed understanding of the spatial ecology of two recreationally and ecologically important fishes, especially with regards to contaminant uptake within the PVSSS and throughout the Southern California Bight.

† Wood, C.L. 1*, Micheli, F.
FISHING OUT MARINE PARASITES? MARINE RESERVES FACILITATE PARASITE POPULATIONS AMONG EXPLOITED HOST SPECIES OF CENTRAL CHILE
Hopkins Marine Station, Stanford University
Half of all species on the planet are parasites. Despite this ubiquity, we have only a rudimentary understanding of anthropogenic influences on parasite biodiversity. As one of the most disruptive and long-standing human impacts on the ocean, fishing may indirectly influence parasites by reducing the availability of parasite habitat and food resources (i.e., fish hosts). Here, we present the results of a study that addresses this hypothesis by assessing the burden of gill parasites of two exploited fishes (Cheilodactylus variegatus and Aplodactylus punctatus) collected from a series of marine reserves and matched open-access areas along the central Chilean coast. We did not detect significant differences in proportion of host individuals infected (prevalence) or the number of parasites per infected host (intensity) between protected and open-access areas, except for a single monogenean parasite.
species, which was both more prevalent and more intense in reserves than in open-access areas. But while we observed an epidemiological effect of fishing on only this single parasite, nearly all parasites responded to protection from fishing with an increase in their ecological abundance (i.e., abundance per unit area, rather than per host). These data therefore suggest that protection from fishing may facilitate fish parasite abundance and that the removal of fish from the world’s oceans over the course of hundreds of years may be driving a long-term, global decline in fish parasite populations.

† Yorke, C.E.*, Miller, R.J., Page, H.M
KELP DETRITUS: QUANTIFYING CARBON CONTRIBUTIONS AND SIZE DISTRIBUTION
Marine Science Institute, University of California Santa Barbara
To determine the potential of particulate kelp (*Macrocystis pyrifera*) detritus to serve as a trophic resource for coastal suspension feeders, we quantified the rate of production and size distribution of kelp detritus in relation to water motion, state of blade erosion, and percent cover of the bryozoan *Membranipora* sp. on blades. We enclosed kelp blades in specially designed bags both in the lab and in the field to collect detritus particles, which we then fractionated by size. Carbon and nitrogen content were quantified for each size fraction. Preliminary results show significant overlap in kelp detritus size distribution with the 0-300 micron size range consumed by suspension feeders. Blade area and age of blade were significant predictors of mass-specific detrital carbon generation rate of kelp blades. Water motion and percent cover of *Membranipora* sp. did not significantly affect rates of detritus production. These data allow estimation of the relative abundance of kelp detritus in coastal waters within size ranges that are relevant to benthic and pelagic suspension feeders. The results from this experiment can be used to assess possible trophic consequences of long-term changes in kelp production on coastal food webs.

† Young, M.A.*
A LANDSCAPE OF POSSIBILITIES: GEOSPATIAL APPROACHES FOR MODELING SPECIES HABITAT ASSOCIATIONS IN CALIFORNIA’S SUBTIDAL ENVIRONMENT
Long Marine Laboratory, University of California Santa Cruz
Accurate, efficient estimation of actual and potential species distribution are critical requirements for effective ecosystem based management and marine protected area design. In California, the California State Mapping Project (CSMP) has provided an unprecedented dataset of high resolution seafloor topographic maps out to 3 nautical miles along the entire 1200 km coastline. Because species are not randomly distributed throughout their environment and are often closely associated with specific habitat types, seafloor maps, when used in conjunction with spatial analyses, can be used to discern spatial variation in the strength of species/habitat association across subtidal landscapes. In this talk I will discuss three studies that apply landscape based approaches to quantitatively estimate species-habitat relationships. In Cordell Bank National Marine Sanctuary, we combined georeferenced video observations with derived seafloor habitat variables to accurately predict the distribution and abundance of three ecologically important species of rockfish. In Monterey Bay, sidescan sonar and multibeam bathymetry data were used to look at inter- and intra-annual variability in spawning locations of the California market squid. Lastly, seafloor habitat variables were used to calculate abundance estimates, weighted by seafloor habitat type, from the SCUBA observation data collected by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) surveys along the North Central Coast of California. The results from these studies indicate that landscape based algorithmic habitat classification of bathymetric data can be used to quantify and predict the distribution and abundance of ecologically and economically important species across broad areas of habitat as part of the evaluation and designation process for marine protected areas.
Alioto-Jurado, D.*
ANATOMICAL, HISTOLOGICAL, AND MOLECULAR CHARACTERIZATION OF THE VENOM OF SQUALUS ACANTHIAS AND HETERODONTUS FRANCISCI
University of California Los Angeles
Chondrichthyian fishes are now known to include many venomous taxa, but most of what is known about the venom molecules and delivery apparatus in this group comes from studies of the batoid members. The distribution pattern and content of venoms found in either the chimaeras or sharks have never been documented and remains poorly understood. Within sharks the taxonomic families Squalidae, Etmopteridae, and Heterodontidae are known to possess fin spines that could be potentially venomous. Here, histological examination of fin spine tissues and basic biochemical and toxicological analyses of fin spine extracts from several specimens of Squalus acanthias and Heterodontus francisci are used to both confirm the presence of and provide a basic description of the venom in these groups.

† Baibak, B.L.*
THE POPULATION GENETICS OF EELGRASS (ZOSTERA MARINA) IN HUMBOLDT BAY, CALIFORNIA
Humboldt State University
The purpose of this masters thesis project is to describe the genetic structure and diversity of eelgrass (Zostera marina) in Humboldt Bay, California. Eelgrass is the dominant marine plant in Humboldt Bay where it performs a number of ecological functions including filtering sediment and organic matter from the water column, stabilizing the substrate, recycling nutrients, exporting organic matter, lessening coastal eutrophication, and providing habitat for numerous invertebrates, fish, and waterfowl. Eelgrass is protected by the U.S. Clean Water Act and the California Department of Fish and Game. Approximately 45% of the eelgrass in California is found in Humboldt Bay. Restoration projects are currently underway in Humboldt Bay and additional projects will continue to be mandated due to the use of eelgrass beds for oyster leases and the potential growth of the shipping channel. This project aims to establish population genetic information for Humboldt Bay, which has never been done, to maximize the success of future restoration projects through the identification of unique genotypes and pinpointing pockets of unusual genetic diversity. Sampling sites were chosen throughout Humboldt Bay and neighboring sloughs to geographically represent the Bay’s eelgrass populations. DNA was extracted from 240 samples according to the CTAB/PVP protocol for plants developed by the USGS Alaska Science Center’s Molecular Ecology Laboratory. Ten microsatellite loci will be examined to assess genetic structure and diversity observed in Humboldt Bay.

Barr, R.J.*
A CONCEPTUAL MODEL FOR ASSESSING THE EFFECTS OF MPA ESTABLISHMENT ON PATCH CONTRIBUTION IN A SOURCE-SINK NETWORK
Coastal and Marine Institute Laboratory, San Diego State University and University of California Davis
Several metrics have been used to explore the effects of the establishment of marine protected areas (MPAs) on metapopulation networks. One such metric that is particularly useful for maximizing post-MPA network biomass for a range of species with different life histories is the contribution of a patch to the entire network (primarily via larval production) in a source-sink metapopulation model framework. Using this framework, I develop a conceptual model for exploring how MPA establishment at a site changes the patch contribution of that site. Specifically, the model addresses how MPAs change demographic rates, such as recruitment and fecundity, that are important components of the patch contribution metric, and whether protecting high-contribution sites or sites with the biggest change in contribution due to MPA establishment has the largest effect on total network biomass. Results from this model will help inform future management decisions regarding MPA site selection and network design.
NOVEL TRACKING TECHNIQUE INDICATES IMPORTANCE OF RARE EVENTS DRIVING LARVAL CONNECTIVITY OF GEODUCK CLAMS IN PUGET SOUND, WA
1 - University of Washington, Tacoma 2 - Pacific Lutheran University 3 - University of California Santa Barbara
Quantifying the connectivity among populations of sessile marine invertebrates has important implications for answering ecological, evolutionary, and conservation questions. Traditional sampling techniques, such as nets and pumps, collect larvae during a discrete time period. These approaches are further limited by the resource-intensive task of sorting and identifying larvae from the rest of the plankton, which restricts the number of time points that can realistically be sampled. We use a novel approach, passive larval trapping, which takes a time-integrated sample, paired with Fluorescent In Situ Hybridization with Cell Sorting (FISH-CS), which automates the sorting and identification processes, to map the distribution of the larvae of geoduck clams (Panopea generosa) throughout their reproductive season in Quartermaster Harbor, Puget Sound, WA. This approach allowed us to collect an integrated time series over four months across our study area. Our preliminary findings indicate that although there is a low level of small larvae in the Harbor throughout the season, a single pulse of larger, more abundant larvae were captured in late May and early June. This implies that despite the apparent oceanographic isolation of the Harbor, there was more connectivity than expected with outside geoduck populations. These economically and culturally important clams are extensively farmed throughout the area, and a high level of connectivity among these populations will have management implications in the region. Our results also underscore the importance of time-integrated sampling of ecological parameters that are dominated by rare events rather than average conditions.

Behrens, M.D.*
RESOURCE PARTITIONING BY INTERTIDAL STICHAeid FISHES ON THE OLYMPIC PENINSULA, WASHINGTON
Pacific Lutheran University
Ecological theory predicts that coexistence of ecologically similar species may depend on interspecific variation in resource use. Three morphologically and ecologically similar Stichaeid fish species (Anoplarchus purpurescens, Xiphister atropurpureus and Xiphister mucosus) are commonly found living in close proximity in rocky intertidal habitats of the northeastern Pacific, from California to Alaska. Past research has found that these species differ in feeding habits, but the differences in diet between these species may not be the only factor allowing their coexistence. Locations along the northern Olympic Peninsula, Washington were surveyed to determine elevation and habitat characteristics where these three species were encountered. Additionally, a sample of each fish species was collected from each location for diet analysis. As shown in past studies, there was significant variation in diet among the three species. In addition, X. mucosus was found to be distributed at higher tidal heights than the other two species. The two lower intertidal species showed differences in the types of substrate on which they were found, with A. purpurescens found more commonly on sand and X. atropurpureus found more often on gravel substrates. The fish species did not differ in the size of rocks under which they were found. Combinations of these species were often found under the same rock; therefore, habitat affinities alone likely cannot explain their coexistence. The coexistence of these three closely related fish species can likely be attributed to the simultaneous partitioning of both biotic and abiotic resources to reduce potential competitive interactions.

Benko, H.M.*, Mackie, J.A.*, Craig, S.F.*
MEASURING THE EFFECTS OF ANTI-FOULING PAINT ON SETTLEMENT AND COMMUNITY DEVELOPMENT OF FOULING ORGANISMS IN HUMBOLDT BAY, CA
1 - Telonicher Marine Lab, Humboldt State University 2 - San Jose State University
Testing the effects on fouling organisms of exposure to toxicants, such as the copper in anti-fouling paints, gives a greater understanding of the ecological effects of these pollutants. In particular, the tolerance of settling larvae of various species can be readily observed, allowing the more resistant
species to be detected. In addition, these studies can elucidate the effects of anti-fouling paints on settlement and community development by introducing a “disturbance” that can be followed through time. We followed community settlement and development for 17 weeks on plastic settlement panels painted along their edges with anti-fouling paint containing 3 different concentrations of copper (low, medium and high). These panels, along with controls, were suspended horizontally beneath the dock at Eureka Public Marina in Humboldt Bay, CA. Panels were individually photographed each week, and initial settlement and community development was followed. Early settlement was significantly lower in the high copper treatment, with greater numbers of Balanus eburneus, Schizoporella errata, Scrupocellaria sp. and spirorbid polychaetes on control, mid and low copper panels. Community development was initially strongly affected by the presence of copper paint, especially in the high treatment. However, by week eight solitary and colonial ascidians began to dominate all panels and by week 17 these ascidians dominated all panels. In conclusion, despite initial effects of copper treatment on early settlement and community development, these communities converged after 17 weeks to become relatively homogenous. These experiments therefore do not support the alternative stable states found in previous research on fouling marine communities.

† Blair, E.M.*, Allen, B.J., Whitcraft, C.R.
EVALUATING RESTORATION PLANTING REGIMES IN A NEWLY RESTORED SOUTHERN CALIFORNIA SALT MARSH
CSU Long Beach
Salt marshes are one of the most productive ecosystems in the coastal zone with functions ranging from erosion reduction and storm surge buffering to toxin filtration and fish nursery provision. Plant cover within the marsh not only ameliorates harsh abiotic conditions but also serves as a nesting habitat for endangered bird species endemic to the area. In this study, we evaluated structural and functional recovery of a marsh using active restoration in Brookhurst Marsh, Huntington Beach, California. We planted polyculture treatments (which included nine common marsh species) and monoculture treatments (all Sarcocornia pacifica, pickleweed) in a randomized block design to evaluate the effectiveness and recovery trajectory of active restoration on an unvegetated berm. Throughout the study, S. pacifica had the highest plant cover of the two treatments until one year post-planting when almost all plots, regardless of treatment, reached 100% cover. Canopy insect communities do not vary by treatment but may be affected by seasonal changes. The benthic invertebrate community shifted from virtually nothing pre-planting to an amphipod-dominated community after five months. This remains constant a year and a half post planting with no differences among treatments in either diversity or abundance. Stable isotope analysis and mixing models suggest these invertebrates feed on sediment, algae, and plants regardless of treatment. Evaluating how plant community composition drives community trajectory and assessing the most successful planting regime in terms of plant cover and algal and invertebrate abundance has implications for future restoration planning and the regeneration of endemic bird nesting habitat.

Bonsell, C.E.1, Swarzenski, P.W.2, Wyllie-Echeverria, S.1
SUBMARINE GROUNDWATER DISCHARGE IN THE SAN JUAN ISLANDS AND ASSOCIATED IMPACT OF NITRATE ENRICHMENT ON EELGRASS (ZOSTERA MARINA)
1 - Friday Harbor Labs, University of Washington 2 - US Geological Survey
Submarine groundwater discharge (SGD) describes the reversible exchange of porewater with marine bottom water and often occurs in the intertidal or subtidal zone where tidally driven water pressure differences are greatest. SGD can provide vital nutrients to coastal systems, but it can also contribute to coastal eutrophication, especially if the groundwater contains high levels of nutrients and anthropogenic pollutants. SGD was studied in the San Juan Islands due to both the general lack of rivers that could otherwise provide a direct source of terrestrial nutrients to coastal waters and the prevalence of septic tanks that could pose a pollution risk. We present two studies encompassing this topic: a field study quantifying SGD at four sites in the San Juan Islands, and a mesocosm experiment examining the response of local Zostera marina to a pulse nitrate enrichment mimicking a groundwater-borne pollution event (30µM and 150µM added). Using the radioactive tracer 222Rn which is highly concentrated in groundwater compared to seawater, we found significant SGD rates at three
out of the four sites. Results from the mesocosm experiment indicate that both levels of nitrate enrichment negatively affect *Z. marina* growth rates. However, change in photosynthetic capacity was significantly different between the two enrichment treatments, showing an increase under 30µM enrichment, but a decrease under 150µM. These results indicate that *Z. marina* can physiologically adapt to compensate for higher available nitrogen up to a certain level of enrichment. Together, these studies highlight the importance of groundwater monitoring to coastal ecosystem health.

† Brower, J.P.*, Anderson, T. W.
NONLETHAL CONSEQUENCES OF PREDATOR-INDUCED STRESS IN A MACROPHYTE-ASSOCIATED FISH
Coastal and Marine Institute Laboratory, San Diego State University
The effects of stress in fishes have usually been examined in aquaculture settings. Slower growth, lower fecundity, and changes in behavior have been identified as responses to stress. Such effects have been linked to increases in the production of cortisol, a physiological indicator of stress. Fish also encounter stressful conditions in the natural environment, especially during their early life stages when they are most vulnerable to predation, and the impacts of stress may alter individual performance and survival. The goal of this study is to characterize stress in juvenile giant kelpfish (*Heterostichus rostratus*) when exposed to a natural stressor, predation threat. Behavioral and physiological indices are used to quantify the degree of stress in juvenile fish when exposed to a common predator, the kelp bass (*Paralabrax clathratus*). Our results thus far indicate that juvenile giant kelpfish are able to visually recognize a predator and change their proximity to the predator. Juvenile giant kelpfish also display a physiological response, through elevated cortisol levels, in the presence of a predator. Future experiments will be conducted to assess the consequences of stress from predation threat on growth, swimming performance, and survival in subsequent predator encounters.

Brown, M.B., Edwards, M.S.*
THE EFFECTS OF CLIMATE CHANGE ON AN HERBIVORE-PREY INTERACTION
San Diego State University
As global warming threatens to disrupt biological and physical processes in the world’s ecosystems it will be necessary for us to predict how those changes will impact species interactions within those ecosystems. While numerous studies have examined the effects of climate change on single species, there is considerably less information on the potential impacts to how species will interact with one another, especially when those species are impacted in different ways. I am examining the effects of elevated temperature and pCO$_2$ on an herbivore (i.e. the purple sea urchin *Strongylocentrotus purpuratus*) and three species of primary producers (i.e. the kelps *Macrocystis pyrifera*, *Pterygophora californica* and *Laminara farlowii*). Specimens are being raised under different temperature and pCO$_2$ conditions within laboratory mesocosms. These mesocosms have been shown to be effective at holding these organisms for periods exceeding one month without introducing measurable experimental artifacts. Currently, I am measuring how elevated pCO$_2$ impacts urchin and kelp growth rates, kelp photosynthetic performance and tissue chemistry, and urchin gonad development. Initial results indicate elevated relative rates of photosynthesis under elevated pCO$_2$ in kelps, and increased steady state photosynthesis in other kelp forest algae. In addition, the changes to the palatability of the kelps (feeding rate) and changes in food preferences (measured by a two choice bioassay) are being assessed. This study will provide greater insight into the complicated and indirect effects of climate change on natural communities and ecosystem functioning.

† Carrillo, A.*, Vargas, F.*, Hulse, K.*, Hockersmith, B.*, Dickson, K. A.*
HOW DO VARIABLE AMBIENT TEMPERATURES DURING EMBRYONIC INCUBATION AFFECT DEVELOPMENT AND HATCHING IN CALIFORNIA GRUNION?
1 - California State University Fullerton 2 - Troy High School
The California grunion, *Leuresthes tenuis*, spawns on sandy beaches on nights during spring high tides. Fertilized eggs develop within the sand and hatch only when they receive a mechanical stimulus (wave action) during the following spring high tides. The purpose of this study was to investigate the effects of fluctuating ambient sand temperatures on grunion development and hatching success. Data
loggers were placed at depths where grunion eggs were found at Cabrillo Beach, Los Angeles, CA, and recorded sand temperatures every 10 min during the 2011 spawning season. Gametes collected from adult grunion were mixed to produce replicate containers of fertilized eggs, which were placed into three incubators representing the temperature treatments: one at 20°C, one at variable temperature (set hourly to match sand temperatures recorded, which ranged from 11.7 to 27.9°C), and one set at the mean ambient temperature (16.3°C). Embryos from 20°C began hatching at 8 days post-fertilization (dpf), and began at 14 dpf in the 16.3°C and variable temperature treatments. Hatching success was greater than 80% after 10 dpf for 20°C, but averaged only 32% at 16.3°C and 35% at variable temperatures. At hatching, larval length did not differ among groups. The decrease in yolk area did not differ between the 16.3°C and variable-temperature treatments. Thus, fluctuations in temperature during incubation had little effect on grunion embryos when compared with the average temperature (16.3°C). However, incubation at 20°C resulted in higher hatching success and earlier decreases of yolk area when compared to the ambient sand temperatures tested.

† Chan, A.*, Van Auken, S.M., Henkel, S.K.
ORIENTATION AND MOVEMENT OF CRYPTOCHITON STELLERI IN NATURAL AND ENHANCED MAGNETIC FIELDS
Oregon State University
Cryptochiton stelleri, commonly known as the Gumboot Chiton, is the largest chiton in the world with a life span of at least 40 years, and it is the only chiton that has all eight calcareous shell plates covered by a soft mantle. Furthermore, it has an iron oxide (Fe₃O₄) mineral coating of magnetite that covers the denticles of the radula. There have been increasing accounts of marine species that navigate using the Earth’s magnetic field lines. Since the magnetite in these chitons could be sensitive to magnetic fields and play a role in navigation, we investigated how different magnetic field strengths affected orientation and movement in C. stelleri. We observed the behavior of C. stelleri in paired tests under the Earth’s natural magnetic field and in a stronger externally applied magnetic field. We created the magnetic field by using a Helmholtz coil made from copper wiring and a PVC ring oriented parallel to the Earth’s field to alter only the intensity and not the direction of the field. The number of movements, degree of rotation, and distance travelled by the chitons were recorded by analyzing video taken of the chitons in experimental chambers. Additionally, we set up an experiment to determine if an enhanced magnetic field would act as a barrier to the chiton. We found that the number of movements and the degree of rotation were significantly greater in the enhanced magnetic field, and the stronger magnetic field did not act as a barrier for C. stelleri.

† Chavdarian, Y.*, Kechichian, S., Kazaryan, E.
A TALE OF TAILS: ARSENIC LEVELS IN LOBSTER
Clark Magnet High School
The purpose of this study was to determine if contamination existed in lobster, an important commercial and recreational fishery. Our hypothesis was that we would find heavy metals and organic contaminants to be present when tissues were tested. Our class worked with the Institute for Integrated Research in Materials, Environments, and Societies staff at California State University, Long Beach to test for a suite of organic and inorganic contaminants in 10 Panulirus interruptus lobster tails caught throughout Los Angeles County and the Channel Islands. IIRMES lab technicians assisted with the analysis of heavy metals content using inductively coupled plasma mass spectrometry and for organic contaminants like PCBs and DDT using gas chromatography mass spectrometry. A weighted average of arsenic levels by lobster size was created in Excel. ArcGIS was used to map sample locations and classify arsenic levels in tail tissues using a graduated red color ramp. Levels of arsenic in Southern California lobster tails exceeded ATSDR guidelines for the safe minimum daily consumption of Arsenic, which is 0.005 ppm. Tissue samples from Anacapa Island was the highest for our study area at 43ppm. Expanding the study to 12 more lobster tails of genus Homarus and other Panulirus species from East Canada, Nicaragua, West Australia and South Africa, found arsenic contamination to be a global problem. Most notable levels of arsenic in lobster tail tissue samples were found in South Africa, which greatly exceeded the ATSDR guidelines for minimum risk level daily consumption of Arsenic. Our hypothesis was conditionally accepted.
EXPLORING FISH ‘PERSONALITIES’: CONSISTENT INDIVIDUAL BEHAVIORS IN A COMMON ESTUARINE FISH, *FUNDULUS PARVIPHINNIS*

1 - Coastal and Marine Institute Laboratory, San Diego State University 2 - California State University Monterey Bay

The behavior of fishes has been studied extensively. More recently, ecologists have explored the extent of variation and consistency in behavioral types of individuals, populations, and species. Recent evidence suggests that some organisms display suites or syndromes of behaviors that are correlated across different circumstances, such as boldness when foraging and continued foraging under predation risk. We investigated the existence of behavioral types in a resident estuarine fish, the California killifish, *Fundulus parvipinnis*. Juvenile fish were collected from Paradise Marsh in San Diego Bay using nets and minnow traps. Using a blinded 151-liter experimental arena, we conducted three behavioral experiments with individual fish. We first measured an individual’s activity and latency to explore an unfamiliar environment as a measure of boldness. Next, we recorded the time before foraging was initiated and the time to resume foraging after the attack of a model avian predator. Finally, we introduced three conspecifics into the tank and noted the time spent by the focal fish within one body length of its conspecifics. Preliminary results indicate that individuals that were quick to explore their unfamiliar environment were also significantly more active, and hid less. Furthermore, these individuals were significantly faster in resuming their foraging activity after a predator attack. These results provide compelling evidence of individual behavioral types in an estuarine fish and lay the foundation for future research to investigate individual variation and consistency in fish responses to stressors such as anthropogenic contaminants.


MARINE DEBRIS IN THE DEEP PACIFIC

*Monterey Bay Aquarium Research Institute (MBARI)*

Marine debris is a global issue with negative impacts upon both benthic and pelagic habitats in coastal and open-ocean areas. Debris is introduced to marine environments via improper disposal or accidental loss, either at sea or from land, and is subject to wide dispersal by ocean currents and tides. Little is known about marine debris in the deep ocean due to technical challenges and prohibitive costs of conducting research in deep waters. The Monterey Bay Aquarium Research Institute (MBARI) uses high-resolution video equipment to record hundreds of remotely operated vehicle (ROV) dives each year to 4,000 meter depths. Over the past 22 years, more than 17,000 hours of underwater video have been archived and managed as a centralized institutional resource. This video library contains footage of the biological, chemical, geological and physical aspects of the Monterey submarine canyon and other areas including the Pacific Northwest, Santa Barbara Basin, Central California seamounts, Northern California, Hawaii, and the Gulf of California. This study characterizes the kinds of debris observed and the geology of habitats where those items accumulated on the seafloor.


THE EFFECT OF INVASIVE *CHRYSANTHEMUM CORONARIUM* ON A COASTAL SAGE SCRUB ARTHROPOD COMMUNITY IN SOUTHERN CALIFORNIA

*Scripps Institute of Oceanography, University of California, San Diego*

Non-native plant invasions can drastically alter basal resources and abiotic properties leading to effects that ripple throughout an ecosystem. Arthropods often mediate these effects—responding quickly to changes and in turn influencing other species including native vertebrate communities. These invasions are of particular concern in the dwindling coastal sage scrub ecosystems of Southern California. Large population densities and encroachment increase propagule sources and decrease native community resistance. The introduced annual *Chrysanthemum coronarium* is a common invader of coastal sage scrub whose community-level effects are largely undocumented. Our study, therefore, aimed to answer the following questions: 1) how does the presence of *C. coronarium* affect the coastal sage scrub arthropod community, and 2) what mechanisms underlie any effects? To answer these questions, we performed a mensurative field study in the coastal sage scrub of The
Tijuana River National Estuarine Research Reserve. Preliminary data from spring 2011 reveal that taxonomic diversity was lower in plots with C. coronarium than in native plant only plots, while total canopy abundance was not affected. Further, plots with C. coronarium had higher abundances of opportunistic and/or detritivorous arthropods (e.g., dipterans) and lower abundances of herbivores (e.g., hemipterans) than native-only plots. Differences in arthropod communities were associated with more stressful abiotic properties (e.g., less shading, lower moisture) in the C. coronarium plots than native plots. This project reveals that C. coronarium may be altering some basic ecological processes of this ecosystem (e.g., food web support), and provides management suggestions for removal strategies.

† de Nesnera, K.L.*; Anderson, L.M.
MUSSEL TRANSPLANTATION AS A STRATEGY FOR RESTORATION OF INJURED MUSSEL BEDS

Long Marine Laboratory, University of California Santa Cruz
Mussel beds are critically important to the ecological health of rocky intertidal systems, providing an important source of food and habitat for a variety of organisms. Human-induced disturbances, like oil spills, have been shown to be extremely damaging to mussel beds and natural recovery can take as long as two decades. This project is exploring a strategy to speed up the natural restoration process of injured mussel beds. It is thought that the presence of adult mussels and their byssal threads facilitate the settlement of mussel recruits. We transplanted adult mussels (Mytilus californianus) into cleared 50 x 50 cm plots at two sites along Vandenberg Air Force base during the fall of 2009 and spring of 2010. Each month the number of remaining transplants was recorded. Preliminary results show considerable variability in transplant success, suggesting local attributes will be an important consideration in determining if this is an effective strategy to implement. Percent cover of mussels was estimated in each plot using a point contact grid with 100 evenly spaced points and mussel recruitment was measured within plots and using artificial substrata. Overall, the presence of mussel transplants does appear to increase mussel recruitment and species diversity compared to control plots, suggesting this strategy could speed recovery of injured mussel beds. However, this restoration strategy will likely be best for small spatial scale restoration as large-scale implementation would be cost prohibitive and potentially damaging to the donor population.

Didden, C.D.*; Sella, C.; Arnold, A.; Brown, D.; Edmunds, P.
THE DISTRIBUTION OF CERITHIUM LITTERATUM ALONG THE COAST OF ST. JOHN, US VIRGIN ISLANDS, AND THE USE OF ITS SHELL BY HERMIT CRABS.

Viewpoint School
The gastropod Cerithium litteratum is common on reefs along the south shore of St. John, particularly in shallow water (< 5 m depth), and its shells are favored by hermit crabs including Paguristes punticeps, P. cadenati, and Calcinus tibicen. Larvae of these taxa are delivered to the benthos by slow (< 5 cm s\(^{-1}\)) westerly seawater flow, and there is evidence from corals that larval delivery to this shore conforms to a patch depletion model. The purpose of this study was first, to quantify C. litteratum along 3 km of shore and test the hypothesis that its distribution conforms to a patch depletion model of larval delivery, and second, to determine whether hermit crab distribution corresponded to inferred larval supply from the east, or an alternative process such as adult motility. The density of C. litteratum was higher at eastern (10.4 ± 2.0 snails m\(^{-2}\)) compared to western sites (1.2 ± 0.4 snails m\(^{-2}\)), and the distribution of empty shells followed the same pattern. Hermit crabs in C. litteratum shells were equally abundant along the shore (~1.2 crabs m\(^{-2}\)), but relative to the density of C. litteratum, were more common to the west. We conclude that the distribution of C. litteratum is consistent with the patch depletion model for larval recruitment. In contrast, the distribution of hermit crabs does not follow this model, and instead, they may move as adults to locations with empty C. litteratum shells. Further studies will be needed to assess the implications of these distributional patterns.
Divine, L.M.*, Eckert, G.L.
MARINE ECOSYSTEM SUSTAINABILITY IGERT: INTERDISCIPLINARY GRADUATE EDUCATION IN ALASKA
School of Fisheries and Ocean Sciences, Juneau Center, University of Alaska Fairbanks
The National Science Foundation’s Integrative Graduate Education and Research Training (IGERT) program provides an excellent opportunity for funding graduate programs in marine science. Because ocean sciences are inherently interdisciplinary, they are well suited to this NSF program, although relatively few marine-related IGERTs exist. IGERTs offer $30K per year fellowships plus a cost of education allowance to PhD students. Many programs awarded IGERTs survey that the quality of their applicants and interest in graduate programs increase. At the University of Alaska Fairbanks IGERT in marine ecosystem sustainability, trainees gain a broad background in fishery science and management, ecology, marine science, marine policy, economics, traditional ecological knowledge and anthropology to complement their own specialized expertise acquired through dissertation research and study. Training and research addresses ecosystem-based solutions to critical research and stewardship questions in the sustainable use of living marine resources, skills that are critically needed in today’s society.
* Students collaborate on research that transcends traditional disciplinary boundaries.
* They learn to address the unique challenges of ecosystem-based management and to understand its implications for society.
* The program challenges students to develop innovative approaches to pressing real-world problems.
* Students have opportunities to mentor Alaska Native and rural Alaskan undergraduates.
The UAF IGERT is actively recruiting PhD students through 2012. Please visit http://www.uaf.edu/mesas and https://www.iger.org for more information.

† Elsberry, L.A.*, Burnaford, J.L.
REGIONAL AND SEASONAL COMPARISONS OF PHOTOSYNTHETIC RESILIENCE IN THE RED ALGA ENDOCLADIA MURICATA
California State University Fullerton
Because the timing of low tides varies among locations along the US West coast, individuals of a species can experience different abiotic conditions in different regions. *Endocladia muricata*, a high intertidal alga, is found from Alaska to Baja California. We characterized temperatures experienced by *Endocladia* in southern California and Washington at low tide and determined the effect of temperature on the ability of individuals from each region to recover normal photosynthetic rates following re-immersion at high tide. We measured ambient temperature by deploying temperature recorders modified to mimic thermal properties of *Endocladia*. We collected *Endocladia* individuals from the high and low edges of the alga’s tidal distribution in two seasons and determined their ability to recover from one hour exposure to low tide conditions using a factorial experiment with two hydration levels and three temperatures (summer=20°C, 30°C, 40°C; winter=10°C, 20°C, 30°C). We compared post-emersion photosynthetic rates (over 3 hours) to pre-emersion rates to evaluate recovery. In winter, southern California temperatures reached 41°C, more than double the maximum temperature in Washington (19°C). In summer, maximum recorded temperatures were similar in both regions (southern California=44°C, Washington=41°C). Overall, individuals from the high edge of *Endocladia*’s tidal distribution recovered from low tide conditions more completely than low edge individuals. Time-course of recovery and overall ability to recover were strongly affected by temperature and hydration state and patterns differed between regions. Understanding how *Endocladia* responds to environmental conditions in different parts of its range may help predict geographic range shifts in response to climate change.
Non-native zooplankton species have been introduced to many estuaries of the northeast Pacific Ocean as a result of ballast water discharge. The Asian copepod *Pseudodiaptomus forbesi* has recently established in the Columbia River Estuary, and has been found as far upstream as the lower reaches of the Snake River. However, little is known about its distribution and abundance. Our objectives are to determine the seasonal variation in distribution and abundance of *P. forbesi* in the Columbia-Snake River system, and to elucidate the species-environment relationships that exist within the mesozooplankton community of the Columbia-Snake River system. Here we present results from two years of sampling (July 2009-June 2011). Plankton tows were collected by vertical hauls of a 0.5 m diameter, 73 µm mesh net in the Bonneville, John Day, Priest Rapids, and Ice Harbor dam reservoirs of the Middle Columbia and Lower Snake Rivers. The invasive Asian copepod, *Pseudodiaptomus forbesi*, was present in high abundances in three of four reservoirs, with the zooplankton community of the fourth reservoir (Priest Rapids) being made up entirely of native species. A consistent pattern of seasonal succession was evident. Peak abundances of native cyclopoid and cladoceran species occurred in the summer, the invasive *P. forbesi* was most abundant in the late summer and fall, and a distinct bloom of rotifers occurred in the winter and spring. This pattern of succession appeared in all three reservoirs that have been invaded by *P. forbesi*. In the uninvaded reservoir, total zooplankton abundance was very low year-round.

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**† Encinas, M.Y.**, **Diaz, E.**, **Desharnais, R.**

**MODELING THE DYNAMICS OF DISTURBANCE IN MUSSEL BEDS**

*California State University Los Angeles*

Cellular automata (CA) models have been used to model the dynamics of disturbances in marine mussel beds, *Mytilus californianus*. These models usually consider transitions among a small number of states, for example, “empty,” “occupied,” and “disturbed”, and assume a homogenous spatial environment without boundaries. On the other hand, more complex CA models have also been used to study mussel bed boundary formation. These models consider mussel settlement and growth and predator-prey dynamics within gradients of tidal height and wave exposure. We present results from a model that combines these approaches. Small “patches” of the mussel bed are modeled using a mean field ODE approximation to the complex CA model. Each patch represents an area of constant tidal height and wave exposure. Adjacent patches are linked through local interactions to form a “quilt” that spans gradients of tidal height wave exposure. Patches are vulnerable to random disturbances that can propagate to neighboring patches, forming gaps in mussel cover. The probabilities of disturbance and propagation increase as functions of mussel biomass. Using this model, we report preliminary results on how the frequencies of disturbance and the size distribution of gap sizes vary with tidal height, wave exposure, and intensity of predation. We also show how healing gaps from previous disturbances influence the dynamics of gap formation.

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**† Fuller, T.L.**, **Hughey, J.R.**

**MOLECULAR INVESTIGATION OF THE INVASIVE SPONGE HYMENIACIDON SINAPIUM FROM ELKHORN SLOUGH**

*1 - Marine Landscape and Ecology Lab, California State University Monterey Bay 2 - Department of Science and Engineering, Hartnell College*

A large number of invasive marine invertebrates are recognized from Elkhorn Slough, California. One of the more conspicuous invasive species in the slough is a bright orange colored sponge, identified with a question mark by previous workers as *Hymeniacidon sinapium* (Family Halichondriidae). This sponge is native to Korea and Japan, but is a known exotic reported from the eastern and western Atlantic and the eastern Pacific oceans. The purpose of this research is to 1) confirm the identification of this invasive sponge, and 2) determine its geographic distribution in the slough. Twenty-seven specimens of the sponge were collected from Elkhorn Slough and analyzed using DNA sequences of the nuclear rDNA internal transcribed spacers (ITS1 + ITS2) and the 5.8S exon. All specimens were
identical in sequence, and were very similar to other sequences of *H. sinapium* deposited in GenBank from Mission Bay, San Diego, California, and South Korea. *H. sinapium* samples from Elkhorn Slough showed ITS sequence heterogeneity (positions 181 and 195 in the ITS1 region were C/T), reflecting varying degrees of sponge sequence characteristics from California and South Korea. Backtracking these genetic variants led to areas of concentrated sequence diversity—areas near to locations that had been subject to disturbance from a long ceased oyster culturing industry. These elevated genetic diversity levels support a second, unrelated introduction of *H. sinapium* to California. This molecular data represents the first report of a heterogenic population for the genus, as well as conclusively demonstrates the presence of *H. sinapium* in Elkhorn Slough.

† Ghukasyan, T.*, Zakarian M.
**EFFECT OF MARINE PROTECTED AREAS ON KELP BASS PARALABRAX CLATHRATUS**
*Clark Magnet High School*

The purpose of our project was to investigate the abundance and distribution of the kelp bass, *Paralabrax clathratus*, in the CINMS using ArcGIS. Survey data from PISCO, taken in 1998 through 2008, was used to analyze the abundance and distribution of *P. calthratus* within the warmer water areas of the Channel Islands. We joined the survey locations to the average abundance of kelp bass in the survey sites. The marine protected areas were mapped to show the areas where fish species are protected. The abundance levels were classified in four classes of equal intervals to illustrate hotspots of abundance in our study area. Warmer red tones represented higher abundance and cooler blue tones represented lower abundance. Our results show that out of 13 surveyed areas around Santa Cruz Island in 2008, seven were located in the scorpion marine reserve. Out of these seven zones, six showed a higher abundance of kelp bass. Six survey zones were outside the scorpion reserved areas with only one survey site showing a higher abundance of kelp bass. At Anacapa Island nine spots were surveyed in 2008, none of which were located in the marine protected area. There were no surveys showing a higher number of kelp bass. Similar results were found in 2007. Years prior to 2003 showed lower abundance of the kelp bass in areas that are now protected. We can conclude that marine protected areas are in fact working to increase the abundance of kelp bass within the CINMS.

Graiff, K.*, Roberts, D., Howard, D.
**A FIRST LOOK AT DEEP-SEA CORALS AND SPONGES ON THE CONTINENTAL SLOPE WEST OF CORDELL BANK, CALIFORNIA**
*Cordell Bank National Marine Sanctuary*

Interest in the conservation of deep-sea coral and sponge communities (DSC) has grown over the last decade as they are often long-lived, slow growing, structurally complex animals that can provide habitat to fishes and other invertebrates. An effort to locate and characterize DSC communities using a remotely operated vehicle (ROV) in the Cordell Bank National Marine Sanctuary was conducted in June, 2010. The survey took place in an area on the continental slope predicted from multibeam sonar data to be hard substrate; the most likely habitat for DSC assemblages. Analysis of ROV video showed that the substrate was primarily (>90% of total area) mixed cobble and sand rather than rugose rocky bottom. Therefore, observed assemblages of DSC were not as large, diverse, or abundant as predicted. Six deep-sea coral species were observed, two of which are structure forming (*Paragorgia* sp. and *Plumarella longispina*). Sea pens (*Virgulariidae*) accounted for over 80% of observed DSC and individuals were small and uniform in height (<10cm). The abundance of sponges was low (<5%). This region experienced moderate (~40 hours) bottom trawl effort between 1997 and 2001. We believe that the lack of consolidated rugose bedrock is probably limiting the DSC assemblages. It is also possible that historic bottom trawling degraded the habitat and removed many of the DSC. A reduction in trawl effort (a consequence of fishery closures enacted over a decade ago) may have allowed the small DSC we observed to become established and grow.
Gray, V.A.*, Allen, B.J.
PHYSIOLOGICAL CONSEQUENCES OF THERMAL STRESS ON GROWTH AND SURVIVAL OF THE MARINE SNAIL, LOTTIA GIGANTEA
CSU Long Beach

Marine intertidal invertebrates are likely to be especially vulnerable to global warming as their physiology, behavior, and demography are all critically influenced by local environmental temperatures. Nevertheless, the mechanistic links between abiotic conditions and individual performance are not yet well understood. We are using the owl limpet, Lottia gigantea, as a model organism to identify the physiological consequences of thermal stress on key demographic parameters. Abundances of L. gigantea in the mid-intertidal zone are negatively related to maximum temperature, suggesting that this species may already be living near its upper thermal tolerance limits. We transplanted marked limpets into intertidal plots across a wave exposure gradient on a rocky headland in Rancho Palos Verdes, CA, and are tracking limpet growth and survival monthly as a function of local temperatures. We also exposed limpets to one of three body temperatures (18°C, 32°C and 36°C) for several hours during a simulated low tide under controlled conditions in the laboratory before extracting and analyzing proteins from gill tissues. Environmental proteomics is a biotechnological approach that allows one to analyze simultaneously the expression levels of many proteins in response to different environmental conditions. Protein expression profiles varied characteristically among treatment groups; we are currently working to identify with mass spectrometry the proteins most responsible for those differences. The ability to link effects of abiotic stress on individual growth and survival to protein-based bioindicators will provide insight into the potential responses of individuals and populations to future environmental conditions.

Hayman, N.T.*, Young, C.M.
INVERTEBRATE SPECIES RICHNESS ON DEEP COBBLE AND GRAVEL BOTTOMS OFF CAPE ARAGO, OREGON
Oregon Institute of Marine Biology, University of Oregon

Although conservation of marine diversity is a major goal of an ongoing process to establish marine reserves in the Oregon Territorial Sea, virtually all subtidal studies off Oregon have considered only fishes and the largest invertebrates. Using dredge samples, we assembled comprehensive species lists of sessile and motile invertebrates on cobble and gravel substrata between 50 and 70m depths off Cape Arago, Oregon. The species richness on cobble substratum (112 species) was much higher than species richness on gravel substratum (31 species). Species accumulation curves suggest that we found most of the species on the cobble substratum but that more samples would be required to fully assess the gravel community. Sessile invertebrates, especially sponges and bryozoans, accounted for 65% of the richness on cobble, but only 32% on gravel. The data also showed significant patchiness, as indicated by between-sample differences. This study shows that sea-floor mapping that does not resolve substratum particle size cannot be used to predict richness of the rocky-bottom community.

† Hill, A.D.†, Dumbauld, B.‡, Bosley, K.‡, McCoy, L.‡
A METHODOLOGY FOR POPULATION ASSESSMENT OF THALASSINIDEAN SHRIMP ON INTERTIDAL MUDFLATS OF YAQUINA BAY, OREGON
1 - Hatfield Marine Science Center, Portland Community College 2 - Hatfield Marine Science Center, US Department of Agriculture, Agricultural Research Service 3 - Hatfield Marine Science Center, Oregon State University, Corvallis, Orego

By increasing turbidity in the water and decreasing compaction of the intertidal mudflat sediment, two species of burrowing thalassinidean shrimp (Neotrypaea californiensis and Upogebia pugettensis) have been shown to increase mortality of juvenile oysters, a commercially important shellfish in the Pacific Northwest. A population dynamics model will be an essential tool for improving the Integrated Pest Management (IPM) adopted by the aquaculture industry and regulatory agencies involved in management of these shrimp. Though the relationship between shrimp and burrow holes observed on the surface of the sediment varies by season, species, and locale, previous assessments have relied upon haphazard sampling of burrow densities to estimate shrimp populations. We combined previously established methods of correlating burrow density to shrimp density with a randomized
sampling grid for estimating burrow density within high-density shrimp beds. We expected to find similar but lower shrimp population estimates using a randomized sampling method within a larger shrimp bed compared to estimates using the previous sampling method. Initial findings support the viability of this tool for population assessment and continued application will contribute to the development of population dynamics models for *N. californiensis* and *U. pugettensis* and an IPM strategy for the oyster aquaculture industry in the Pacific Northwest.

† Holtz, S.B.*, Dickson, K.D.
EXTRAOCULAR MUSCLES AS A POTENTIAL HEAT SOURCE FOR CRANIAL ENDOtherMY IN TUNAS
*California State University Fullerton*
In endothermic tunas (family Scombridae) counter-current heat exchangers, *retia mirabilia*, associated with the prootic region of the skull conserve metabolic heat, allowing cranial temperatures to be elevated above that of the ambient environment (cranial endothermy). Although the *retia* of tunas have been described, relatively little is known about the source of metabolic heat used in cranial endothermy. We hypothesized that one or some combination of the six extraocular muscles serves as the source of heat for cranial endothermy in tunas. The specific activity of the enzyme citrate synthase (CS units g$^{-1}$ of muscle) and muscle mass were measured as indices of heat production potential in all six extraocular muscles of five species from the family Scombridae: three endothermic tunas – Pacific Bluefin (*Thunnus orientalis*), Yellowfin (*T. albacares*), and Skipjack (*Katsuwonus pelamis*) – and two ectothermic scombrids – Eastern Pacific Bonito (*Sarda chilliensis*) and Pacific Chub Mackerel (*Scomber japonicus*). Within individual species, the medial rectus muscle had a higher CS specific activity than the other muscles. However, CS activities of homologous muscles were similar among species, except that the CS activity of all extraocular muscles in *T. albacares* was consistently low. These results suggest that it was not necessary for tunas to evolve higher metabolic heat production rates in the extraocular muscles, but that conserving heat via *retia* was sufficient for cranial endothermy.

† Jarvis, M.A.*, Shanks, A.L.
NEARSHORE HYDRODYNAMICS AND LARVAL DISPERSAL: THE EFFECTS OF FRONTS ON ZOOPLANKTON DISTRIBUTIONS AT SUNSET BAY, OREGON
*Oregon Institute of Marine Biology, University of Oregon*
Larval dispersal plays an important role in structuring marine populations with complex, biphasic lifecycles. Larvae of intertidal and shallow subtidal organisms are spawned in the nearshore and either remain nearshore throughout development or have to return when ready to settle. Thus these larvae all interact with nearshore hydrodynamics. Prior research suggests that many of the foamlines visible in the nearshore may be surface convergences associated with fronts. Surface convergences favor partial concentration and might play an important role in structuring intertidal and shallow subtidal communities by altering larval supply to the nearshore. Differential distribution of zooplankton across the nearshore is expected in the presence/absence of fronts. To test this hypothesis, I took stratified plankton tows along with CTD profiles across a topographical front at the mouth of Sunset Bay, Oregon during August and September of 2011. Preliminary data shows concentration of larvae of many taxa, including crabs, barnacles, polychaetes and gastropods, several orders of magnitude higher than adjacent waters with the presence of the front. Nevertheless, these observations were not consistent over the sampling period, suggesting the interaction of other variables in nearshore larval distribution, including wind intensity and direction.

† Kauzer, T.1*, Spaulding, J.D.2, Cohen, C.S.2
CONTRASTING EFFECTS OF FLOW ON ADULT AND JUVENILE ASCIDIAN LIFE HISTORY STAGES, INCLUDING GLOBALLY INVASIVE *DIDEMNUM VEXILLUM*
1 - Romberg Tiburon Center for Environmental Studies, California Polytechnic State University San Luis Obispo 2 - Romberg Tiburon Center for Environmental Studies, San Francisco State University
The colonial ascidian *Didemnum vexillum* has shown an incredible propensity to invade marine ecosystems and poses a threat to both native species and the aquaculture industry. For sessile filter
feeders, flow is a critical element influencing survival and growth, determining success across life history stages. However, few studies have quantified the relationship between flow and the recruitment, growth and survival of colonial filter feeders. In this study we evaluated the growth of *D. vex* and larval recruitment under different local flow conditions in Half Moon Bay, California, USA. *D. vex* colonies were subjected to four different manipulated flow conditions over the course of three weeks, and growth and recruitment were measured. A direct relationship was seen between inferred increases in flow and adult growth, and an inverse relationship was seen between inferred increases in flow and recruitment. These trends suggest that optimal flow conditions differ for juveniles and adults. Significant differences in growth were seen between colonies subjected to almost no flow and the other three conditions. The adults' ability to grow over a range of flow conditions adds to its danger as a biological invader. Understanding how adult and juvenile ascidians behave under different flow conditions could be used to determine which marine environments are most vulnerable to invasion and could help those who wish to eradicate or control its spread.

† Korcheck, K.M.*, Kelly, J.A., Craig, S.F.
CRYPSIS OF *DIAULULA SANDIEGENSIS* ON SPONGE PREY *HALICLONA PERMOLLIS*
*Telonicher Marine Lab, Humboldt State University*
Many marine organisms show polymorphism in color and pattern across environmental gradients. The nudibranch *Diaulula sandiegensis* shows phenotypic variation in color and spot pattern along the Pacific Coast of the U.S., from Alaska to Mexico. The spots on the dorsum of this species can be ringed or solid, and range from few (4-10) to many (50-200). Photographs of *D. sandiegensis* were collected from rocky intertidal and subtidal sites along the Pacific Coast, and the size, density, number and distance between spots on all nudibranchs were measured. Results showed a latitudinal and depth gradient, with few spotted nudibranchs common south of San Francisco in both subtidal and intertidal habitats, and many spotted nudibranchs primarily found intertidally north of San Francisco. The spotting pattern for *D. sandiegensis* in juveniles may help them blend in with their prey species, the purple sponge *Haliclona permollis*. Nudibranchs that were photographed in the field touching *H. permollis* were significantly smaller in size than those that were not touching their prey sponge. To test the hypothesis that *D. sandiegensis* is cryptic on its sponge prey, we quantified the spotting pattern of *D. sandiegensis* and the oscular pattern of *H. permollis* by measuring the area of dark spots with light rings, and dark oscula with light rims on each, respectively. A high product-moment correlation between nudibranchs and a random sample of sponge areas adjacent to the nudibranchs confirms a cryptic relationship.

† Kramp, H.E.*, Lindholm, J., Knight, A.
HABITAT ASSOCIATIONS OF SPOTTED RATFISH (*HYDROLAGUS COLLIEI*) IN THE MONTEREY BAY NATIONAL MARINE SANCTUARY
*Institute for Applied Marine Ecology (Ifame), California State University Monterey Bay*
Improved knowledge of seafloor habitat features and how species associate with those features is imperative for understanding how species are distributed. The spotted ratfish (*Hydrolagus collliei*), is a deep water species of the Chimaeridae family occurring along the west coast of the United States. Despite its abundance, habitat associations and distribution of spotted ratfish are not well understood. Videographic imagery collected via remotely operated vehicle (ROV) and benthic towed camera sled within the Monterey Bay National Marine Sanctuary (MBNMS) between 2006 and 2011 provided an opportunity to quantify the relationship between spotted ratfish and the habitat attributes (e.g., substrate type and relief) over which they were observed. Spotted ratfish, sized using 10cm sizing lasers mounted on the ROV and camera sled, allowed for distinction of individuals as juvenile or adult based on maturity-size classifications from the literature. Results to date have identified 152 spotted ratfish over 174km within the MBNMS. Spatial analyses of the distribution of spotted ratfish indicated that they were distributed latitudinally across the MBNMS and over all substrate types. However, frequent capture and discard of spotted ratfish by recreational and commercial fishermen presents a significant management challenge to address and mitigate bycatch concerns. Therefore, analysis of the habitat types with which spotted ratfish associate will inform ongoing efforts to manage these and other species through limits on catch and spatial management measures.
† Lopez, E.K.†, Gedan, K.B.‡
FILTRATION CAPABILITIES OF FOUR BIVALVE SPECIES IN THE CHESAPEAKE BAY
1 - Marine Landscape and Ecology Lab, California State University Monterey Bay 2 - Marine Ecology Lab, Smithsonian Environmental Research Center
As population around the Chesapeake Bay increases, so does pollution associated with urban sprawl and development. The increased nutrients in the Bay cause for massive algal blooms, which rob the Bay of biodiversity through the increased numbers of planktonic species themselves. Filter-feeding bivalves have the ability to provide a “top-down” control on phytoplankton activity. Bivalve species in the Chesapeake clear particulate matter from the water, differentiate between more and less nutritionally valuable particles, and excrete those that are less nutritious as pseudofeces, effectively sequestering seston from the water column into the sediment, reducing water turbidity. In order assess the differing filtration capabilities of four experimental bivalve species - Crassostrea virginica, Ischadium recurvum, Macoma balthica, and Rangia cuneata – lab trials were performed over 6 hour periods to determine chlorophyll a drawdown of the species. Twelve mesocosms were set up in a raceway, filled with a seawater and algae solution, and five individuals of each species. Hourly water samples were tested for chlorophyll a concentrations using fluorometry. Macoma balthica and Rangia cuneata do not appear to be proficient at filtering water, yet Rangia show some promise if larger size classes were used for restoration purposes. Crassostrea virginica and Ischadium recurvum were both proficient at removing chlorophyll a from the water, individually and in combination. Therefore, further studies should be performed to analyze the feasibility of restoration using these two species as well as to better understand the filtering abilities and life history of Ischadium.

† Mostow, R.S.†, Stekoll, M.‡
THE EFFECT OF CHELATED IRON ON ALASKAN KELP GAMETOPHYTE GROWTH AND MATURATION
1 - Oberlin College 2 - University of Alaska Southeast
The life cycles of kelp, a group of brown macroalgae, are characterized by an alternation of generations between a large 2N sporophyte life form and a microscopic 1N gametophyte. It has been demonstrated that some species of kelp require chelated iron to produce gametes. The aim of this poster was to investigate the relationship between gametogenesis, gametophyte growth and chelated iron (Fe-EDTA) in a variety of Southeast Alaskan kelp species. The rate of gametogenesis and growth of gametophytes in response to varying concentrations of Fe-EDTA was investigated for Agarum clathratum, Alaria marginata, and Nereocystis luetkeana. A. marginata and A. clathratum gametophytes were kept infertile by culturing single female clones in enriched artificial sea water without added iron. The gametophytes were grown into 2-10 cell fragments, anchored on coverslips, and treated with different concentrations of Fe-EDTA. Released spores from fertile N. luetkeana sori were treated with the Fe-EDTA solutions as they grew into gametophytes. The presence of Fe-EDTA stimulated growth of the gametophytes in all three species. The optimum concentration of Fe-EDTA to stimulate gametophytic growth was between 0.1 and 4 µM. Growth was inhibited at iron concentrations higher than 4 µM. No eggs were formed by the A. clathratum or N. luetkeana gametophytes at any iron concentration. A. marginata gametophytes produced eggs with an optimum concentration of between 1 and 4 µM. We conclude that iron is a required nutrient for gametogenesis in A. marginata and affects gametophytic growth in A. clathratum, A. marginata and N. luetkeana.

† Nelson, J.C.†, Harley, C.D.G.†, Therriault, T.W.‡
A WAR ON TWO FRONTS: THE INTERACTIVE EFFECT OF CLIMATE CHANGE AND INVASIVE SPECIES ON COASTAL MARINE COMMUNITIES
1 - University of British Columbia 2 - Fisheries and Oceans Canada
Climate change will alter many important ecological and environmental conditions, but these impacts will not be experienced in isolation. They will interact with each other and stressors already present, such as invasive species. Rising temperature and salinity are beneficial to the invasive tunicates Botryllus schlosseri and Botrylloides violaceus, on which we focused our investigation. We tested the hypothesis that the combined impact of climate change and invasive species will exceed the additive sum of these stressors occurring in isolation. Using a fully factorial field design we deployed settlement
plates from docks in eight ports in each of four regions that differ in temperature and salinity, but that are otherwise similar, along the west coast of North America. Half of the ports were selected for presence of *B. schlosseri* and *B. violaceus*, while other half were selected for absence in order to evaluate their ecological effect. The natural gradients in temperature and salinity informed a prediction of the effect that climate change will have on biodiversity and community structure. At each site we measured the species diversity and placed *in situ* loggers for hourly measurements of temperature and salinity for the duration of the four month deployment. Factors that may affect tunicate establishment and propagule pressure, such as distance to aquaculture sites and large ports, were also quantified. Our study provides an understanding of multiple stressors on a regional scale using field data, while gathering information on important invasive species that could have even greater impact as climate change progresses.

**Newcomb, L.*, O'Donnell, M., George, M., Carrington, E.**

**MUSSEL BYSSAL THREAD STRENGTH VARIES WITH WATER TEMPERATURE**

*Friday Harbor Labs, University of Washington*

Mussels must remain attached to the substratum and resist dislodgement from wave action to maintain their competitive dominance in the rocky intertidal. Mussels attach by secreting many collagenous byssal threads that form an extracellular attachment. Yearly monitoring suggests that some mussel populations are more susceptible to dislodgement during the summer months, due to a decrease in byssal attachment strength. Using a fully-orthogonal design, we tested two possible explanations for this increase in susceptibility: (1) mussels grown in warmer water manufacture weaker byssal threads and (2) byssal threads are weaker when tested in warmer water. Mussels (*Mytilus trossulus*) were grown in temperature-controlled aquaria for three weeks at 10 and 18˚C. The threads synthesized during the experiment were pulled to structural failure at a rate of 15 mm min\(^{-1}\) either at the temperature they were manufactured at or the reciprocal. Two-way ANOVA analyses of thread mechanical properties indicate significant interaction effects between growth temperature and test temperature. For example, threads produced in 18˚C water were stronger and more extensible when tested in 18˚C than in 10˚C. These data suggest the production of byssal threads is a plastic response hinging on external cues such as temperature.

**† Newsom, A.J.*

**INTERACTIONS AMONG INTRODUCED SPECIES: FUNCTIONAL RESPONSE MODEL RESOLVES CONFLICT BETWEEN LABORATORY AND FIELD RESULTS**

*Bodega Marine Laboratory, University of California Davis*

We investigated the potential for the introduced cephalaspidaean sea slug *Philine orientalis* to interfere with the feeding of the introduced European green crab (*Carcinus maenas* L.), and the native Dungeness crab (*Cancer magister* Dana). We found that *P. orientalis* deterred predation by *C. maenas* and *C. magister* in laboratory feeding trials, but not in field experiments with *C. maenas* and *P. orientalis*. Deterrence in the laboratory was probably due to crabs contacting defensive mucous secreted by *P. orientalis*, which drops precipitously to a pH of ~1 when slugs are mechanically disturbed. The Beddington-DeAngelis functional response model revealed that the discrepancy between laboratory and field results was likely a result of high crab foraging efficiency, rather than some unmeasured difference between laboratory and field conditions. The foraging model also provided unique insights into the nature and ecological importance of interactions among these introduced predators.

**Perkins, S.R.*, Peterson, A., Wood, C.L., Micheli, F.**

**HOW DO HUMANS AFFECT THE DISTRIBUTION OF TREMATODE PARASITES ON PALMYRA ATOLL?**

*Hopkins Marine Station, Stanford University*

During World War II, the US Navy significantly expanded the land area of Palmyra Atoll, vastly altering water flow through the lagoon. Because human impacts can affect parasite abundance and diversity, we were interested in how the Navy’s alterations may have changed the prevalence of trematode infections in intertidal snails on the lagoon flats. We measured the prevalence of two trematode genera...
in two intermediate host snails, *Clypeomorus brevis* and *Planaxis sulcatus*, across fifteen sites and found significant spatial variation among sites. Prevalence was positively correlated with distance from the lagoon flat edge, which we consider a proxy for the restriction of water flow as a result of man-made land modifications. We have three hypotheses about why this might be: (1) snail parasites are found where their definitive hosts (curlews) defecate and curlews prefer to forage on the highly emergent flats formed by artificial islands; (2) snail parasites are found where low-velocity water flow facilitates infection of their snail hosts; and (3) snail parasites are found where the concentration of definitive host fecal matter is highest. We will be testing these hypotheses by assessing curlew habitat usage across the atoll, quantifying water velocity at snail collection sites, and using GIS to assess drainage patterns of guano-conditioned water. By exploring the correlations between these three factors and parasite prevalence, we hope to gain a greater understanding of how humans can shape the distribution of parasites.

**Picard, M.**, Harley, C.D.G., McClelland, E.K.

**THE EFFECTS OF INCREASED ACIDITY ON MOLLUSCAN EARLY DEVELOPMENT: CRITICAL THRESHOLD AND ACCLIMATION**

*University of British Columbia 2 - Fisheries and Oceans Canada*

Ocean acidification has many negative effects on marine organisms especially on calcifying species. Due to the economic importance of the latter, research has already been undertaken to determine the extent of the effects however, little is known about the effects at early developmental stages. Therefore, we will investigate which early developmental stage of oysters, mussels, and scallops is most vulnerable to high pCO$_2$ levels and whether larvae grown in high pCO$_2$ demonstrate signs of acclimation. Conducting this study under aquaculture setting, we will measure growth and feeding rate as well as activity and condition of the individuals at four different pCO$_2$ levels. Our study could provide hatcheries with a better yield by determining the pH levels at which chemical interventions must be employed. In the long term, a better insight in the effects of ocean acidification in the development of shellfish could provide managers with a tool for restoring stocks that are negatively impacted in the wild.


**FRESH VS. AGED KELP: FEEDING PREFERENCES OF RED URCHINS**

*Friday Harbor Labs, Oregon State University*

Kelps create a large amount of biomass in nearshore temperate marine ecosystems. Kelps also provide structure, habitat and food to many organisms. However, attached kelps are only minimally consumed by large herbivores. When kelps detach from rock, their biomass is transported elsewhere in the ecosystem, providing a spatial subsidy of carbon to consumers in other habitats. One consumer is the red urchin, *Strongylocentrotus franciscanus*, which occurs from the intertidal to 120m depth. Urchins are known to feed on kelps transported as drift and due to their low assimilation efficiency, urchin waste becomes a viable food source to other benthic organisms. Drift kelps gradually degrade as they are transported into deep water, but the effect of degradation or aging on kelp palatability to urchins is not well known. I investigated the feeding preferences of red urchins to fresh or aged kelps: *Nereocystis luetkeana*, *Agarum fimbriatum*, and *Saccharina subsimplex*. I simultaneously offered a fresh and aged sample of each kelp species to urchins and recorded which sample was bitten first. My results show strong preferences for aged *N. luetkeana* but for fresh *A. fimbriatum* and *S. subsimplex*. Due to their preferential feeding behavior, urchins act as a biological filter in the spatial subsidy, therefore serving a critical role in determining the rate at which kelps are integrated into the food web.

**Rehr, A.P.**, Williams, G.D., Harvey, C., Choo, C., Ashkenazy, B., Levin, P.

**OUR DESIRED FUTURE: IDENTIFYING ECOSYSTEM-BASED MANAGEMENT TARGETS**

*NOAA Fisheries, NWFSC* 2 - *Studio/216*

Determining what constitutes a “healthy” ecosystem requires the establishment of clear management targets. Because targets are an expression of the desired state of the ecosystem, establishing targets must include ecological understanding and societal values. We are employing an approach for identifying scientifically rigorous ecosystem targets that explicitly considers social perspectives. To do
this we are generating images of alternate future ecosystem states in Puget Sound that visually display the tradeoffs among social, economic and ecological goals. These visualizations form the basis of a large-scale public survey to elicit public opinion about potential future scenarios. Due to significant scientific uncertainty about the relationship between management actions and ecosystem or economic states, we have constructed Bayesian Belief Network (BBN) models to capture the expert judgment of policy makers, business community members, engineers and scientists. We have combined the results from the BBN with empirical analyses and food web modeling to generate a rich picture about potential future ecosystem states. Visualizations depicting different ecosystem states require careful validation, and we will validate our visualizations using WSN membership under different levels of intoxication. Results from this exercise will inform images that ultimately are used in our public survey.

† Schultz, J.G.*
AERIAL RESPIRATORY RATES AND ACTIVITY PATTERNS OF NORTHERN CALIFORNIA INTERTIDAL SNAILS ACROSS AN INTERTIDAL GRADIENT
Humboldt State University
Abiotic stress associated with aerial exposure has a defining role in delineating the upper range limits for sessile and semi-sessile intertidal species. Desiccation is a primary stressor for intertidal invertebrates, and is associated with air exchange across respiratory membranes leading to differential ability of marine invertebrates to sustainably respire oxygen aerially. Emerged respiratory rates may be linked to zonation and emersed activity. The aerial respiratory rates and activity pattern was evaluated for select littoral snails from Northern California. The emersed mass-specific respiratory rates were measured for Littorina scutulata, Tegula funebralis, Calliostoma ligatum, and Tegula brunnea that respectively correspond to descending upper limits in the intertidal habitat. Time spent in locomotion or feeding while emersed, and an assay of radular activity was also recorded. Emersed respiratory rates were not observed to follow allometric scaling, but rather, the intertidal gradient, with highest respiratory rates occurring in the highest zone, suggesting the importance of adaptive evolution in zonation and organismal physiology. Emersed activity levels of L. scutulata and T. funebralis, the higher intertidal species, were higher than that of C. ligatum and T. brunnea. T. funebralis emersed activity levels remained near 80% of its immersed activity level, representing the smallest drop-off between treatments. T. funebralis was also the only species observed to actively feed while emersed. Observed respiratory rates and activity patterns suggest differences in how resistant intertidal species are to aerial stress, as well as coping strategies, which may influence feeding ecology as well as niche partitioning.

† Sheets, E.A.*, Cohen, C.S.
USING A MULTI-GENE APPROACH TO INVESTIGATE POPULATION STRUCTURE OF THE COLONIAL TUNICATE BOTRYLLOIDES NIGRUM
Romberg Tiburon Center for Environmental Studies, San Francisco State University
Botrylloides nigrum is a cryptogenic colonial tunicate that currently shows a global distribution, most likely due to human mediated dispersal. However, little is known about its taxonomic identity, geographic source, and introduction vector. In this study, we are using a multi-gene approach to investigate population structure across sections of its current range. Genetic markers are subject to varying selection pressures, highlighting the importance of multi-gene approaches for understanding evolutionary processes at multiple scales. We plan to compare genetic results from a candidate polymorphic allorecognition locus with microsatellites and mitochondrial cytochrome oxidase I (COI), markers commonly used in population studies. Allorecognition, in botryllid tunicates, is the ability for close kin to fuse into chimeric individuals, potentially altering colony fitness. The use of functional markers in marine invertebrate studies is rare, despite their potential ability to inform us about the survival capability and invasion ability of a species. Current analysis using the COI gene shows low haplotype diversity, and reveals two broadly distributed haplotypes, suggesting that populations may be highly connected across the Atlantic and Pacific Oceans. Comparison with a polymorphic functional marker may provide finer genetic resolution for investigating population connectivity, and an
understanding of the potential role of fusions in establishment ability. As seawater temperatures rise, non-indigenous species ranges are expected to shift, elevating the importance of understanding patterns and processes involved with invasion events.

† Shippey, A.C.*, Whitcraft, C.R.
EFFECT OF CLIMATE CHANGE ON STRUCTURE AND FUNCTION OF A RESTORED SOUTHERN CALIFORNIA SALT MARSH
California State University Long Beach
Salt marshes provide several critical ecosystem functions, e.g. nutrient cycling, faunal biodiversity support, and filtration. These functions have been threatened by human activities such as urban development, pollutants, and climate change. One strategy to deal with loss and deterioration of salt marsh ecosystems is restoration. We know current methods, e.g. actively planting native plants, are effective under known climate conditions. Yet the success of restorations under altered climate conditions is unknown. Southern California has a Mediterranean climate characterized by rain in the winter and dry conditions in the summer. Climate change projections for this region include increased frequency of severe storms, longer periods of drought, and increases in temperature (2-10°C). In order to understand these effects I am evaluating how altered precipitation and increases in temperature will affect a restored high marsh berm in a southern California salt marsh. I have placed structures made of PVC pipe and greenhouse plastic along the berm in a randomized block design. Pre-treatment invertebrate counts demonstrated no difference among blocks with an overall low total abundance (0-2 organisms/18.1m²). Continuous data loggers placed within each experimental plot indicate treatments are effective. Four month sampling indicates an increase in plant height and algal biomass but no difference among treatments. Our final results can provide managers of future restorations information to assist in design and budgets by understanding the success of restoration under different climate change scenarios.

† Shukla, P.*, Hill, T.M., Gaylord, B., Hosfelt, J., Nickols, K.J.
UNDERSTANDING IMPACTS OF OCEAN ACIDIFICATION ON SEAGRASS AND SALT MARSH ECOSYSTEMS BASED ON STUDIES IN BODEGA HARBOR, CALIFORNIA.
Bodega Marine Laboratory, University of California Davis
Seawater is rapidly becoming more acidic due to the burning of fossil fuels and subsequent input of carbon dioxide (CO₂). This process has been shown in some cases to adversely affect calcifying organisms by decreasing carbonate ion (CO₃²⁻) availability, but can be modulated by biotic processes. Effects of the native Pacific eelgrass (Zostera marina) and a Salicornia dominated salt marsh on seawater pH and alkalinity during cycles of photosynthesis and respiration were examined at field sites in Bodega Harbor, CA. Measurements at all sites were taken every meter along five parallel cross-shore transects, each separated by 6 meters. pH was expected to be greatest in the eelgrass bed due to its high photosynthetic rate and lowest in a bare mudflat with no vegetation. However, pH was highest in the salt marsh, ranging from 7.7 to 8.0, exhibited intermediate values in the bare mudflat (pH between 7.6 and 7.8), and was lowest in the eelgrass bed, with values varying from 7.4 to 7.6. This pattern may have arisen from differences in sampling time relative to the period of greatest respiratory CO₂ accumulation, since measurements at the three sites were conducted at varying phases of the day-night cycle. Alkalinities in the eelgrass bed and salt marsh did not differ significantly, averaging 2320 µmol/kg. However, alkalinity was higher in the bare mudflat, averaging 2848 µmol/kg. This study demonstrates that densely vegetated habitats can experience substantially altered carbonate system parameters, potentially making it difficult for calcareous organisms to precipitate shell material.

† Sloan, L.M.*, Marks, S.B.
THE BANE OF BULLFROGS: POPULATION STRUCTURE OF WESTERN POND TURTLES (EMYS MARMORATA) IN LENTIC HABITATS ALONG THE TRINITY RIVER
Humboldt State University
As populations of a species decline an understanding of regional variation in population structure and its potential causes is an important conservation goal. Western Pond Turtle (Emys marmorata) populations have declined over the past century. In the core of their range (northern CA and southern
OR) population numbers are reasonably substantial, but there is still concern about the health of these populations. We studied the regional variation in population structure of Western Pond Turtles living in lentic habitats along the upper Trinity River (Lewiston to Junction City). In six different regions we examined 1) the ratio of adults to juveniles (using a 125 mm carapace length as juvenile cutoff) and 2) the ratio of young (<10 years) to old (≥10 years) turtles. Two of the six sites had significantly more juveniles (>47% juveniles) and young turtles (>43% young turtles) than the other four sites (6-16% juveniles and 8-24% young turtles). These latter four sites are heavily adult biased compared with Western Pond Turtle populations that are considered stable; in the long term they may not be viable populations. We examined a variety of variables to attempt to explain this difference in age structure among sampling regions: temperature, depth, aquatic vegetation cover, and Bullfrog presence. The most striking difference was the lack of Bullfrogs (an introduced species) in the two regions that had more juveniles/young turtles. Given that Bullfrogs will eat hatchling turtles, it appears that lentic habitats that support high bullfrog populations may inhibit turtle recruitment.

1 - California State Polytechnic University, Pomona 2 - California State University Fullerton
The ecological impacts of non-indigenous seaweeds are relatively understudied. In southern California, several exotic seaweeds have become integrated in the community structure of coastal habitats and are important contributors to community primary productivity. To examine the ecological impacts of exotic seaweeds on southern California shores, we examined 1) the impacts of a non-native seaweed on community structure; and 2) how native macroalgal consumers are responding to exotic seaweeds. For community structure examination, we compared species composition and diversity in the upper-intertidal zone in patches dominated by the non-native red alga, Caulacanthus, with native barnacle patches. Macroalgal diversity was higher in Caulacanthus patches while macro- and meiofaunal assemblage structure also differed. The dissimilarity in assemblages is likely attributable to sediment and moisture accumulation within the Caulacanthus turf. To examine how non-indigenous seaweeds fit into trophic-dynamics of coastal ecosystems, we measured both feeding rates and feeding preferences of native herbivores on native and non-native seaweeds. In single food feeding rate experiments, several native consumers were fed a variety of native and non-native seaweeds; consumers varied in their feeding rates with no striking pattern in consumption rates of native or non-native seaweed foods. In two-choice feeding trials, feeding preferences of native herbivores were determined for morphologically and/or taxonomically similar pairs of native and non-native seaweeds offered to the consumer. Again, no strong pattern was discernable among consumers or within seaweed pairs. Feeding patterns suggest that predicting a response of native herbivores to a seaweed introduction must be evaluated on a case-by-case basis.

† Spies, B.T.; Steele, M.A.
A COMPARISON OF ENVIRONMENTAL VARIATION IN ESTUARIES INHABITED BY THE ENDANGERED TIDEWATER Goby (EUCYCLOGOBIUS NEWBERRYI)
California State University Northridge
Estuaries in California are highly variable transitional zones of the coastal marine environment. Factors such has temperature, annual precipitation, and freshwater input vary among estuaries and can affect the dynamics of each estuary and the species that inhabit it. The first step in understanding the effects of such environmental variation is documenting the patterns of environmental variation. Species such as the endangered tidewater goby (Eucyclogobius newberryi) may be predisposed to local extirpation due to their preference for highly seasonally variable estuaries. The tidewater goby generally inhabits estuaries that contain somewhat persistent low-salinity areas. This preference differs from that of its closest relative, the arrow goby (Clevelandia ios), which inhabits cooler, higher salinity estuaries. Habitat characteristics of 20 estuaries spanning the California coastline were compared to evaluate the variation among known tidewater goby sites (11 sites) to that of non-tidewater goby habitats (9 sites) where the arrow goby was abundant. Water temperatures of the 20 sites were measured hourly from July – October 2011; water quality parameters including salinity, pH, and dissolved oxygen were
measured as single time at each estuary; and the size of each estuary was measured. Although there was considerable latitudinal variation in temperature regimes, tidewater goby estuaries were characterized by higher fluctuations in environmental factors than were estuaries occupied by arrow gobies.

† Stein, D.P., Idjadi, J.A.
INDUCIBLE DEFENSES IN CORALS: THE ROLE OF NEMATOCYSTS IN CORAL COMPETITION
Eastern Connecticut State University
Inducible defense in response to competitors is a well-described phenomenon in cnidarians. We tested the hypothesis that corals can adjust their defenses on small spatial scales to respond to their competitive neighborhood. We exposed small coral colonies of *Porites* spp to three competitive treatments with conspecific and heterospecific competitors and compared the density of nematocysts between and within coral colonies. We will discuss the reactions of corals to these competitive treatments and their development of different nematocyst types.

Stoike, S.L., Haupt, A. J., Lovewell, M. A., Hallenbeck, T.,
WEST COAST GOVERNORS’ AGREEMENT ON OCEAN HEALTH
WCGA Sea Grant Fellow
Launched in September 2006 by the governors of California, Oregon, and Washington, the West Coast Governors’ Agreement on Ocean Health (WCGA) addresses ocean uses, resources, and issues with tribal governments, stakeholders, and communities along the West Coast. This agreement underscores the importance of managing activities that affect our oceans and coastal communities by studying the relationships among people, ecosystems, and natural resources. The WCGA seeks to protect and restore the health of West Coast ocean and coastal resources and the economies that depend on them.
In 2008, the WCGA released an action plan describing 26 key actions to achieve its seven goals, and then formed 10 Action Coordination Teams (ACTs) composed of agencies, tribal governments, academia, and stakeholders. Recently, the WCGA identified the following strategic priorities to advance West Coast ocean initiatives and provide economic stimulus during the next several years:
· Climate change effects on marine and coastal environments and communities, e.g., sea level rise and severe climatic events
· Sustaining working waterf racks, which leads to healthy and vibrant coastal communities
· Support sustainable, efficient marine transportation initiatives
· Advance understanding of and planning for renewable ocean Energy alternatives
In 2011, in cooperation with West Coast Sea Grants, four students were selected for the West Coast Governors’ Agreement Sea Grant fellowship to advance these goals through work with the ACTs. The fellows will present an overview of the WCGA and fellows’ work over the past 6 months.

COMPARING PATHWAYS OF FUNCTIONAL RESPONSE OF TOP PREDATORS TO SEASONALITY OF UPWELLING IN THE CALIFORNIA CURRENT
1 - Farallon Institute for Advanced Ecosystem Research 2 - Hatfield Marine Science Center, Oregon State University 3 - Northwest Fisheries Science Center 4 - Cascadia Research Collective
Upwelling is an important driver of coastal productivity and an essential mechanism to predator-prey interactions in eastern boundary current systems worldwide. In the California Current, nutrients supplied by upwelling processes support abundant phytoplankton and zooplankton communities that serve as the basis for trophic interactions leading to upper trophic level marine predators. We hypothesized that 1) predator productivity is indirectly affected by upwelling through intermediate trophic levels, and 2) different upper level predators would show different pathways of response. We tested these hypotheses using path analysis of paths beginning with winter or summer upwelling through intermediate trophic levels to the productivity and relative abundance of two species of seabirds (common murre and Cassin’s auklet), Chinook salmon, rockfish, and humpback whales. Intermediate levels included phytoplankton, proxied by chlorophyll-a concentrations, and mid-trophic
level prey, indexed by measurements of copepod biomass and community structure and proxies of euphausiid and juvenile rockfish abundance based on seabird diets. Multiple intermediate trophic levels were important to include in the path models, and predators had specific key prey. Results confirmed indirect effects and variation in the pathways of response for different predators. Contrasting the differential pathways of response of predators to upwelling and intermediate trophic levels enhances understanding of fundamental ecosystem dynamics and mechanisms of ecosystem change.

† Toyon, Z.D.
COMPARISON OF REEF AND PISCO DATA OF GOBIES IN THE CHANNEL ISLANDS
Clark Magnet High School
The purpose of this study was to compare REEF data, from a volunteer collected database, to PISCO data, a scientifically collected database for two species of gobies endemic to Southern California. Data from 2005 to 2008 from both organizations were compared by mapping a classification scheme for the average number of sightings for Lythrypnus dalli and Coryphopterus nicholsii within the survey zones of Southern California. I created a basemap of the study area consisting of digitized polygons of REEF survey zones made 30% transparent over an ArcGIS imagery layer. I classified the abundance of gobies for each dataset with natural breaks (Jenks) and chose a green to red color ramp to reflect high to low abundance levels. I found that PISCO only gave data for two areas, and in those two areas, only three blue banded gobies were found, while the REEF dataset gives abundance categories for most of the Channel Islands. The results displayed in the maps show that the data from REEF was much more extensive than that of PISCO for the blue-banded goby. We see this again in the black-eyed goby; only 6 found by PISCO yet REEF gives abundance categories for every island. The flaw in the PISCO data may be due to the method used. The goby is a very shy fish and darts away at the slightest disturbance. Because of this, conventional methods fail if you want to survey this fish. The REEF Roving Diver Technique is much more attuned to finding the goby.

A TEMPORAL EXPLORATION OF SEA OTTER PREY DIVERSITY IN SOUTHERN SOUTHEAST ALASKA
University of Alaska Fairbanks
Sea otters (Enhydra lutris) are keystone species, which have the ability to disproportionately affect the ecosystems in which they live. Extensively hunted for their luxurious pelts, these pivotal predators were completely removed from Southeast Alaska by 1911. Between 1965 and 1969 sea otters were re-introduced to the area in an effort to re-establish the historical population. Sea otter abundance surveys conducted in 1988, 2003, and 2010 document their expanding distribution and abundance during recolonization. We examined differences in sea otter diets in locations that varied with duration of sea otter presence. Throughout the summer of 2011, our field crew used shore-based high powered telescopes to identify and quantify prey items of the foraging otters. Sea otters have a less diverse diet in recently occupied locations. Sea otter diets included 31 prey species at locations that were occupied in 1988 (n=615), 30 prey species within the 2003 range (n=314), 17 prey species within the 2010 range (n=401). The species composition of the major prey items was similar across occupancy areas with the exception of red and green sea urchins, which were more abundant in areas of recent occupancy. This pattern of heavy urchin predation during initial residence in an area was observed when sea otters recolonized in California. Further study of sea otters in Southeast Alaska could similarly demonstrate a shift to other prey items as urchins become less frequent in their diet over time.

† Turner, K.R.*, Sebens, K.P.
LINGCOD AND ROCKFISH IMPACTS ON BENTHIC COMMUNITY STRUCTURE
Friday Harbor Labs, University of Washington
Fishing can dramatically alter fish populations and thus marine ecosystems. Management decisions affect not just species targeted by management, but also unharvested species connected to target species through ecological networks. Removal of top predators may allow prey populations to increase. Examples from around the world have shown that impacts from predator removals can
cascade to harvestable species at lower trophic levels. Predator removals can also significantly change the composition of the entire marine community. We are studying the effects of large carnivorous fishes (lingcod, Ophiodon elongatus, and rockfishes, Sebastes spp.) on the rocky subtidal communities of San Juan Channel. Predatory fish abundance is variable within San Juan Channel, in part due to marine protected areas, which allows us to study community structure across a range of predator abundance. We use surveys of all trophic levels in this system, combined with exclusion cages that restrict fish access from large swaths of the benthos and non-lethal diet analysis, to determine the community-wide impacts of predatory bottom fishes. Our analysis of copper rockfish (S. caurinus) diet demonstrates close agreement with the findings from previous studies, although the individuals in this study show less reliance on fish prey, in exchange for shrimp. This finding suggests that shrimp should be less abundant at sites with higher rockfish abundance, and our results from surveys and predator exclusions appear to confirm this prediction. The results from this research may be used to support ecosystem-based management goals by informing managers about potential community-wide impacts of recovering bottomfish populations.

† Turnross, O.†, Vaughn, D.², Carrington, E.²
EFFECT OF INCREASED AERIAL TEMPERATURE ON SEX SPECIFIC FORAGING BEHAVIOR IN NUCELLA OSTRINA.
1 - University of California Santa Barbara 2 - Friday Harbor Labs, University of Washington
Species interactions are fundamental drivers of ecosystem and community dynamics, and respond differently to the changing abiotic conditions under global climate change. Elevated aerial and aquatic temperatures and increased frequency of heat waves and cold snaps induce behavioral and morphological changes in organisms subjected to physiological stress. A distinct gradient of thermal stress and periods of aerial emersion driven by the tidal cycle make the intertidal an ideal system for studying potential trade-offs between foraging and thermal stress. In this outdoor mesocosm study, we manipulated low-tide aerial temperature to test the predicted effects of climate change on the interactions between a mobile predator, the whelk Nucella ostrina, and its sessile prey, the barnacle Balanus glandula. N. ostrina exhibits a 14-day periodicity in foraging on B. glandula, with maximum foraging occurring during periods of nighttime exposure. Subjecting N. ostrina to chronic and acute aerial temperature manipulations did not alter the timing or magnitude of these foraging bouts, though asynchrony in the feeding of males and females was observed. The whelks were surprisingly mobile during low tide; more than 25% of foraging whelks were active when emersed in air. Movement of Nucella was independent of aerial temperature and was more commonly away from food than towards it, suggesting behavioral refuge. Sex specific trends in movement may be due to different energetic costs for production of eggs and sperm. These results suggest thermal stress affects male and female Nucella ostrina differently, but does not disrupt the tide-specific timing of foraging bouts.

Van Parys, J.M.¹, Rodriguez, M.², Preisler, R.², Haskins, J.², Hughes, B.², Wasson, K.²
WATER QUALITY AT ELKHORN SLOUGH AND IMPACT ON OLYMPIA OYSTERS (OSTREA LURIDA) AND STAGHORN SCULPIN (LEPTOCOTTUS ARMATUS).
1 - California State University Monterey Bay 2 - Elkhorn Slough National Estuary
Elkhorn Slough is an estuary in central California located in a productive agricultural watershed. Water quality monitoring has revealed that some sites are impaired. No previous studies have directly linked water quality to biological indicators. The goal of our study was to correlate water quality to two indicators of estuarine biodiversity, native Olympia oysters (Ostrea lurida) and Pacific Staghorn sculpin (Leptocottus armatus). The fish and sculpins were each collected at one central location at Elkhorn Slough and distributed to six sites located across the estuary. At each site a multiparameter water quality sonde was continuously deployed to measure: temperature, conductivity, pH, dissolved oxygen, and turbidity. We tracked survival of the fish and oysters linking them to the water quality that they experienced in particular testing the hypothesis that hypoxia events would be linked to fish mortality. Our results indicate that Olympia oysters can survive at a range of tolerances but Pacific Staghorn sculpin survival depends on the duration of hypoxic events. A better understanding of water quality and its impacts on aquatic life will help managers prioritize restoration strategies.
† White, T.D.*, Daly, B.2, Eckert, G.L.2
IN SITU PREDATION OF JUVENILE RED KING CRAB (PARALITHODIES CAMTSCHATICUS)
1 - University of California Los Angeles 2 - School of Fisheries and Ocean Sciences, Juneau Center, University of Alaska Fairbanks
Predation of juvenile red king crab (Paralithodes camtschaticus) is hypothesized to be a key factor in limiting the recovery of commercially-important crab populations in Alaska, USA based on correlation analyses of groundfish and king crab populations. However, few direct observations of predation are available. We tethered age-0 juvenile red king crabs in gravel substrate and measured in situ predation rates, attack rates, and times of attacks using underwater cameras during 24 h trials in July and September 2011. Generally, predation was high (70% mortality in 24 h), and crabs were consumed by a diverse group of predators including juvenile flatfish, ronquils, kelp greenling, and hermit crabs. Pacific cod were not observed feeding on juvenile king crab although they were commonly recorded by the cameras. Kelp greenling were the least efficient predators and frequently made strikes that damaged but did not capture crabs. Predation events were concentrated during late afternoon and early morning hours. These results can inform release strategies for hatchery-raised crabs, as red king crab stock enhancement is currently being considered as a population recovery tool. For example, releases might avoid early morning or late afternoon hours and areas with abundant juvenile fish and hermit crabs. Furthermore, these results confirm that predation impacts on juveniles may be important in limiting red king crab population growth.

† Wigginton, R.D.*, Spautz, H., Grenier, L., Whitcraft, C.R.
IMPACTS OF LEPIDIUM LATIFOLIUM ON FOOD WEB STRUCTURE OF SUISUN SONG SPARROWS IN A BRACKISH MARSH
CSU Long Beach
Over the last two decades, human-induced habitat changes have degraded 90% of California’s coastal wetlands. Lepidium latifolium (perennial pepperweed) is a pervasive invader of California wetlands, potentially altering ecological and community dynamics. This project assesses the potential impact of L. latifolium on food web structure for Suisun song sparrows in the brackish marsh of Rush Ranch Open Space Preserve (RROSP). Food web structure was assessed through analysis of invertebrate communities (soil infauna, canopy insects, mobile ground-dwelling invertebrates) and stable isotope analysis. Seasonal shift in vegetative community were assessed by examining percent cover of individual species, L. latifolium stem count, and L. latifolium stem angle to the ground. Presence of L. latifolium increases amphipod and insect abundance but decreases abundance of mites. The more mobile canopy insect community appears to be structured mainly by season. Isotope analysis was conducted on soil, plants, invertebrates, and Suisun song sparrows (feathers and blood). Lepidium latifolium’s isotopic signature may be detectable in some invertebrates. There is an isotopic shift in bird blood between winter (pre-L. latifolium) and summer (L. latifolium bloom), but it is unclear if this shift is due solely to seasonal changes in diet or to shifts in vegetative and invertebrate communities as influenced by presence of L. latifolium. We predict integration of L. latifolium into the food web of Suisun song sparrows. This implies L. latifolium eradication within the marsh of RROSP should be closely paired with restoration efforts to avoid impacts on this and other sensitive marsh vertebrates.

Zamudio, S.1*, Ninokawa, A.2, Cumbo, V.1, Edmunds, P.J.1, Fan, T-Y.3
TESTING THERMAL ACCLIMATIZATION IN LARVAE FROM THE CORAL POCILLOPORA DAMICORNIS COLLECTED FROM A DECADES-OLD PLUME OF HOT SEAWATER
1 - California State University Northridge 2 - California State University Fullerton 3 - National Museum of Marine Biology and Aquarium, Taiwan
Natural situations where corals are exposed for prolonged periods to elevated temperatures provide a unique opportunity to test for acclimatization to high seawater temperatures. In this study, we exploited such an opportunity created by a 27-year old thermal plume from a nuclear power plant in Nanwan Bay, Taiwan. We tested the hypothesis that brooded larvae from Pocillopora damicornis residing in this plume would exhibit an enhanced physiological tolerance to increased temperatures compared to colonies in adjacent ambient waters. Within this plume, seawater is typically ~2 °C warmer than
ambient areas, and based on the size of the colonies sampled, we inferred that they had been exposed for at least 4 y to these conditions. Six colonies were collected from inside and outside the plume, and larvae freshly released from these colonies were incubated at 27.2, 28.3, 29.7, 30.5, 31.6, and 32.1 °C for 6d. Aerobic respiration, protein content, and Symbiodinium densities were sampled after 2d and 6d to quantify the physiological responses. Larval respiration ranged from 0.04-0.44 nmolO₂ larvae⁻¹ min⁻¹ and displayed a positive threshold response to temperature with maxima at ~29.8°C, and steep increases and then declines on either side of this temperature, regardless of parental origin. Temperature and time, but not origin, had a significant effect on larval protein content and Symbiodinium densities, with both variables decreasing with increasing temperature. Our findings suggest that weedy corals like P. damicornis may not possess a strong capacity to acclimate to rising seawater temperatures.