14th Annual
Research Advances in Fisheries, Wildlife, and Ecology Symposium

April 13-14th, 2017
LaSells Stewart Center
Oregon State University
Corvallis, Oregon

Research Advances in Fisheries, Wildlife and Ecology (RAFWE) showcases research, extension, and community outreach activities conducted within or in association with the Department of Fisheries and Wildlife, related departments at Oregon State University, other regional universities, and state and federal agencies. We encourage you to interact with attendees and presenters throughout the day.

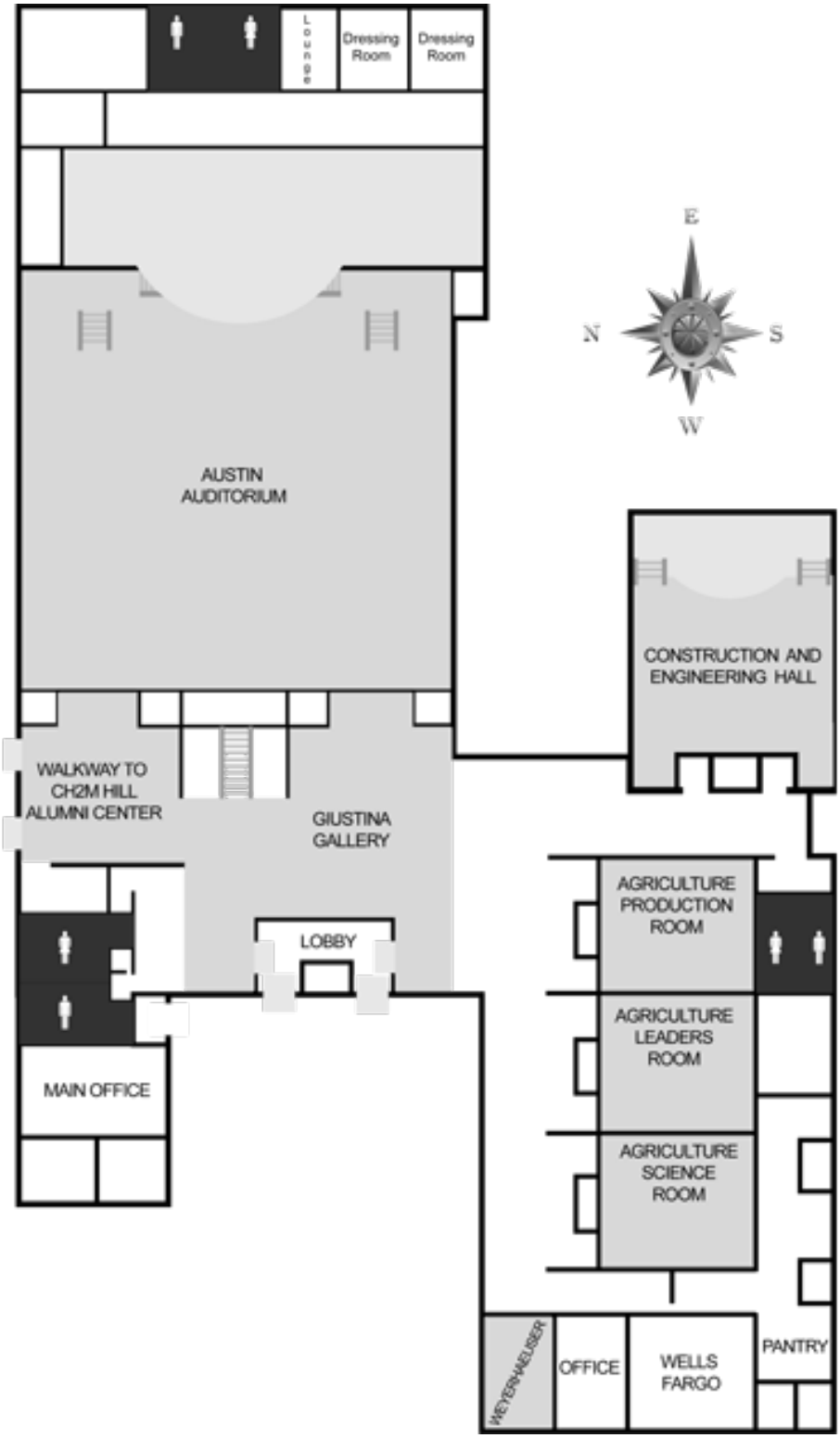
Activities include a speed talk session, oral presentations, workshops, brown bag lunch discussion panel, poster session, and keynote address. Our keynote speaker is Drs. Peter and Rosemary Grant of Princeton University. Generous donors have also provided a variety of goods and services for a silent and live auction.

Don’t forget to use #RAFWE for all of your social media posts!

Schedule

Time	Location: Nash 032	Location: ALS 4000
April 13th 5-7PM	**Workshop 1:** Identifying the human dimensions of your project	**Workshop 2:** Unlocking QGIS
April 14th	**LaSells Stewart Center**	
10:30-11:30	**REGISTRATION**	
Construction and Engineering Hall		
11:30-12:30	*Brown Bag Lunch: "The importance of scientific societies"*	
Break 12:30-12:45		
Time	Agricultural Leaders Room	Agricultural Science Room
	Session 1: **Habitat & Feeding Ecology**	**Session 2:** **Morphology and Acoustics**
12:45	Brittany Schwartzkopf	Thaddaeus Buser
1:00	Matthew Ramirez	Justin Hansen
1:15	Elizabeth Orning	Samara Haver
1:30	Samantha Roof	Selene Fregosi
1:45	Dawn Barlow	Laura McCourt
Break 2:00-2:15		
Time	Agricultural Leaders Room	Agricultural Science Room
	Session 3: **Management**	**Session 4:** **Environmental Factors**
2:15	Ryan Baumbusch	Cassandra Glaspie
2:30	James Pearson	Jessica Andrade
2:45	Kerrick Robinson	Virni Budi Arifanti
3:00	Eric Wade	Imam Basuki
Break 3:15 - 3:30		
Construction and Engineering Hall		
3:30-4:30	*Key Note Address*: Drs. Peter and Rosemary Grant	"In search of the causes of evolution "
LaSells Stewart Center		
4:30-5:30	Poster Session	
5:30-7:00	Evening Social and Silent Auction	

The LaSells Stewart Center



Keynote Address: Drs. Peter and Rosemary Grant

This year we have the privilege to host Dr. B. Rosemary Grant and Dr. Peter Grant as our keynote speakers. Dr. and Dr. Grant are both emeritus professors of Ecology and Evolutionary Biology at Princeton University where their lab uses a variety of methods and approaches to study the interaction between genetics, ecology, and behavior. Over 40 years ago they decided to study this interaction and the resulting diversity of individuals with Darwin's Finches on the Galápagos Islands.

Dr. B. Rosemary Grant graduated in 1960 from Edinburgh University, then acted as a research associate at the University of British Columbia, Yale University, McGill University, and University of Michigan. She completed her doctoral dissertation work at Uppsala University in 1985 and joined Princeton University shortly after. Dr. Peter Grant graduated in 1960 from Cambridge University then moved to University of British Columbia to complete his dissertation work in 1964. He was a post-doctoral fellow at Yale University and a professor at McGill University and University of Michigan before joining Princeton University in 1985.

We are grateful that they have agreed to speak at the RAFWE symposium this year and invite you to come hear about their research. You can learn more about their work at
http://www.princeton.edu/eeb/people/display_person.xml?netid=rgrant and
http://www.princeton.edu/eeb/people/display_person.xml?netid=prgrant.

Brown Bag Lunch Discussion:

“History, functions, and benefits of society membership”

Construction and Engineering Hall: 11:30-12:30pm

Participants include:

Dr. Ben Clemens

Dr. Ben Clemens is the Past President of the Oregon Chapter of the American Fisheries Society. His self-described interests include “animal migration, life history diversity, and the mechanisms involved in the creation and maintenance of diversity”. After completing his Ph.D. at Oregon State University in 2011, Dr. Clemens began his career with the Oregon Department of Fish and Wildlife (ODFW). He currently serves as a Fish Biologist and Statewide Lamprey Coordinator in addition to serving as OSU Affiliate Faculty (2013-2015). Before earning his doctorate at OSU, he completed his masters in Zoology at the University of Guelph in 2002.

Jeff Barna, MS, PWS

Jeff Barna will represent the Northwest Chapter of the Society for Ecological Restoration. After completing his MS at University of California, Santa Cruz in 2004, Jeff held several ecologist positions with Alaska Biological Research Inc. in Forest Grove, Oregon and Fairbanks, Alaska and Tetra Inc. in Portland, Oregon. He is currently a research ecologist and senior biologist for Environmental Science Associates in Portland, Oregon. Jeff has coordinated projects and research “focusing on plant and vertebrate taxa, as well as wetland and riparian ecology, with a concentration on protected resources.”

Julia Burco, PhD, DVM

Dr. Julia Burco will represent the Oregon Chapter of the Wildlife Society. After receiving her Doctorate in Veterinary Medicine at Oregon State University in 2000, she went on to University of California, Davis and earned her MPVM in Veterinary Preventive Medicine, Epidemiology, and Public Health. At UC Davis she also received her PhD in Comparative Pathology where she performed clinical rehabilitation work and oil spill response with aquatic birds. Since 2011, Julia has worked for Oregon Department Fish and Wildlife as a wildlife veterinarian.

F. Teal Waterstrat,

Teal Waterstrat is the current president of the Society for Northwestern Vertebrate Biology (SNVB). During his time as president, he hopes to foster the ongoing growth, advancement and enjoyment of SNVB. Teal earned his undergraduate degree in Biology from the University of Washington and went on to earn his Masters of Environmental Studies from The Evergreen State College. He has worked for various natural resources management agencies, museums and non-profits over the past 10 years. He currently works for the USFWS as a biologist at their Washington Field Office in Lacey, Washington.

Workshops

Thursday April 13, 2017: 5-7pm

RAFWE Workshop #1

Identifying the human dimensions of your project

(Led by Dr. Kelly Biedenweg, Department of Fisheries and Wildlife, OSU, and Dr. Ana Spalding, School of Public Policy, OSU)

In this interactive workshop, we will define the human dimensions of natural resource management and participate in activities to identify the different human dimensions of your research topic, how you might learn more about human dimensions, and briefly consider the requirements for incorporating human dimensions into your study.

Location: Nash 32

RAFWE Workshop #2

Unlocking QGIS
(Led by Rick Debbout, Associate Software Engineer/GIS Analyst, Environmental Protection Agency)

QGIS is free, open-source software that provides many tools for the viewing and manipulation of geographic data. This workshop will give a brief overview of the interface and demonstrate a few examples of common GIS operations. Skills covered by this workshop may include: working with data frames, raster files, building queries and selecting locations, adjusting layer styles, composing maps, and creating other types of documents.

Location: ALS 4000

Oral Presentations

Session 1: Habitat & Feeding Ecology

Agricultural Leaders Room (12:45-2:00)

12:45 – Understanding the feeding ecology of juvenile rockfishes in Oregon's estuaries

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Estuaries are thought provide greater food resources for juvenile fishes compared to other habitats. Higher growth rates have been reported for juvenile fishes in estuarine habitats compared to coastal habitats, potentially due to the high abundance of prey. Multiple species of rockfish (*Sebastes* spp.), which make up important commercial and recreational fisheries, utilize Oregon estuaries during their early life. This utilization gives rise to the hypothesis that these estuaries function as nursery habitat for rockfishes, playing a significant role in rockfish settlement and recruitment and are therefore important for population productivity. Although juvenile rockfish abundances have been found to differ between Oregon estuaries, other life history traits such as age, growth, settlement date, and feeding ecology have not been fully evaluated. With large dietary variations found for juvenile rockfishes in nearshore and offshore environments, further investigation into feeding ecology in Oregon estuaries is necessary to evaluate habitat quality of these potential nursery areas. Feeding ecology will be assessed in this study using stomach content and stable isotope analyses. This work will examine if feeding ecology differs among Alsea, Yaquina, and Nehalem estuaries and between eelgrass and dock habitat types within Yaquina.

1:00 – Kemp's ridley sea turtle habitat use and diet variation revealed through combined trace element and stable isotope analyses

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An understanding of intrapopulation variation in resource use is fundamental to effective species conservation and management. Multiple biogeochemical analyses can be used

to characterize long-term resource use in marine species (e.g., stable isotopes, trace elements). In particular, trace element analyses conducted using laser ablation (LA-ICP-MS) may provide for rapid, detailed assessments of life history in sea turtles. Here, we combine skeletochronology and multiple biogeochemical analyses of humerus bone tissue to characterize intrapopulation variation in Kemp's ridley sea turtles (*Lepidochelys kempii*) resource use. Annual humerus bone growth increments were sequentially sampled for stable nitrogen isotope ratios to identify a known oceanic-to-neritic habitat shift, which served as a baseline for exploration of the trace element data. LA-ICP-MS was used to collect continuous elemental data ($^{86}Sr/^{43}Ca$, $^{138}Ba/^{43}Ca$) along transects perpendicular to growth layers. Biogeochemical data showed distinct patterns with age; mean values plateaued after either increasing ($\delta^{15}N$) or decreasing ($^{86}Sr/^{43}Ca$, $^{138}Ba/^{43}Ca$) up until age two, a pattern consistent with current understanding of Kemp's ridley sea turtle life history. Values at age two and older were significantly different from those at age zero ($p < 0.01$, LMM), whereas values at age one were intermediate. Intrapopulation variation in $\delta^{15}N$ values was high, although values were temporally consistent within individuals after age two. A similar pattern has been observed previously in loggerhead and green sea turtles. The integration of skeletochronology and multiple biogeochemical analyses provides a valuable tool to understand intrapopulation variation of sea turtle life history.

1:15 – Preliminary predation patterns of cougars and wolves in an area of sympatry

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Expanding gray wolf (*Canis lupus*) populations and interspecific competition with sympatric cougars (*Puma concolor*) presents new challenges for management of multiple carnivore effects on ungulate populations (e.g., elk, *Cervus elephus*; mule deer, *Odocoileus hemionus*) in the western United States. We examined wolf and cougar predation patterns before (2009-2012) and after (2014-2016) wolves recolonized the Mt. Emily Wildlife Management Unit in northeast Oregon. We identified 1,213 and 541 prey items utilized by cougars in the pre- and post-wolf periods, respectively. We identified 158 prey items utilized by wolves. Cougar diet was similar between the pre- and post-wolf time periods. Cougar preyed predominantly on deer (mule deer and white-tailed deer, *O. virginianus*; 58% and 57% of all ungulate kills pre- and post-wolf, respectively) and primarily killed fawns (53% and 44% of all deer kills, pre- and post-wolf,

respectively). When cougar preyed on elk, they primarily preyed on calves pre – (77%) and post-wolf (71%) recolonization. Wolves preyed predominantly on elk (63%) and primarily the calf age class of elk in summer (83%) and winter (49%), but used adult elk nearly as often as calves in winter (46%). Before wolves recolonized Oregon, low recruitment and reduced elk population growth rates were linked to high density cougar populations and strong selective predation of elk calves. Continued selection of elk calves by cougars coupled with wolf predation may intensify the effects of carnivores on elk populations. Conversely, wolves may ultimately decrease cougar densities such that effects on elk populations remain relatively unchanged in this multi-predator system.

1:30 – Influence of flower native status, color, and morphology on visiting preferences of bees in riparian areas of eastern Oregon

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Effectively restoring or conserving bee habitat requires a better understanding of the complex relationship between bees and flowering plants, but information about bee preferences is currently lacking. The purpose of this study was to examine bee-plant associations in a riparian area of Starkey Experimental Forest and Range (Starkey) in eastern Oregon. Our objectives were to determine which blooming plants were most attractive to bees, and examine whether the species composition of bee visitors differed depending on a plant's flower color, morphology, or status as native or non-native. This research was part of a larger, multidisciplinary project evaluating the effectiveness of riparian restoration within Starkey. We found that different plant species were associated with different communities of bee visitors, but neither native status nor flower color significantly affected visiting bee species composition. The average number of bees visiting native and introduced plant species also did not differ significantly. However, flower morphology did influence the types of bees visiting each plant species. Bilaterally symmetrical flowers, with nectar and pollen typically more difficult to reach, tended to be associated with larger bees with longer tongues. In contrast, small, easily accessible flowers in the Asteraceae family attracted smaller bees with shorter tongues. Our results suggest that certain plants will be particularly useful for supporting an abundant and diverse bee community and that providing diversity in the morphology of blooming plants is a key factor to consider when restoring riparian areas for bee pollinators.

1:45 – Hints of residency: A preliminary investigation into blue whale population structure and ecology in New Zealand

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Despite recent documentation of a blue whale foraging ground in the South Taranaki Bight (STB) region of New Zealand (NZ), blue whales remain listed as 'Migrant' under the NZ threat classification system due to minimal knowledge of their ecology and distribution. The STB is the site of NZ's largest offshore oil and gas extraction operation including active drilling and exploration, shipping traffic, and proposed seabed mining. This industrial presence and potential space-use conflict warrants further investigation into blue whale population structure, abundance, and habitat use. To fill these knowledge gaps, we conducted vessel-based visual surveys in the STB in February 2014, 2016, and 2017. We recorded 64 sightings of 151 blue whales, photo-identified 90 individuals, and collected 43 tissue biopsy samples for genetic analysis. Photo-identification analysis found multiple resightings of individuals across years (maximum six years apart), and no matches were made to the >250 blue whales identified in Australian waters. Additionally, historical records of 553 blue whale sightings between 1980 and 2017 were examined, and included reports during every month of the year in NZ waters. These preliminary analyses indicate the possibility of a resident population of blue whales in NZ waters. Ongoing and future analyses include obtaining a population abundance estimate for the STB and NZ, comparing mtDNA haplotype frequencies to published data on Australian pygmy blue whales, and building a habitat model to assess blue whale space-use relative to industry. Our findings will be important to consider in the context of management, and may be used to update the threat classification accordingly.

Session 2: Morphology and Acoustics

Agricultural Science Room (12:45-2:00)

12:45 – Cranial weapons, reanimated corpses, and Andy Serkins: how the sculpin got its spines back

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Defensive structures in fishes come in a wide variety of shapes and sizes, but are often derived from modifications of the bony elements of the fins into rigid spines (e.g., Siluriformes, scorpaenids) or modification of the scales into spines or scutes (e.g., Acipenseriformes, dasyatids). Another evolutionary source of material for defensive structures is the cranial bones which, especially in the fishes historically classified in Scorpaeniformes, may bear sharp, spiny processes. One group of fishes, the cottoids, possess modified preopercle bones, which bear at least one but often several large, sharp projections. Though remarkable in both their size and diversity, the function and deployment of these spines has historically received little scientific study. To characterize the mechanism(s) by which sculpins "flare" the preopercle bone, we used high-speed filming and dissection to develop a hypothesis of muscle activation and bone movement, then used 3D models of movement and placement of the bones, as well as electric stimulation of muscles to test our hypothesis. Our results show that the flaring of the preopercle can be achieved through contraction of the *levator arcus palatini* muscle. Flaring can also be achieved by retractive movement of the basibranchial bones, which apply lateral force to the preopercles via the hyoid series. Together with the infraorbital series, these bones form a rigid brace around the flared preopercle, which may serve to increase the structural integrity of its flared position, with clear implications for its putative use as a predation deterrent.

1:00 – Repeated cranial elongation in Piscivorous Characiform fishes

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Characiform fishes are one of most diverse lineages of freshwater fishes on the planet, with species exhibiting a remarkable amount of variation in phenotypes and ecologies. A recent study quantified body shape diversification of the order through geometric morphometric analysis and found that piscivorous lineages converged onto a single elongate body shape. However, this previous study focused exclusively on overall body shape variation and did not attempt to analyze the underlying changes in the axial skeleton, making it unclear if all piscivorous lineages elongate the same regions of their bodies. Our goal was to quantify the length of the jaw, head, precaudal and caudal

regions, as well body depth, through linear morphometric measurements to determine if piscivorous lineages elongate the same regions of their body indicating a general pattern of diversification. To test this, we performed linear morphometrics across 136 species for a total of 868 specimens. Using phylogenetic ANOVA, we found that piscivores head and jaw length was significantly larger, varying from twice to one third larger, than most other trophic groups. Within piscivores, 8 out of 10 lineages exhibited anywhere from a 2% to 8% increase in the length of their head compared to non piscivorous species in the same lineage. Our results found that piscivorous fishes primarily elongate their body by increasing the length of their jaw and head, with little to no structural changes occurring throughout the rest of the axial skeleton.

1:15 – The NOAA/NPS ocean noise reference station network: Monitoring long-term ambient noise trends in U.S. waters

Samara M. Haver[1]*, Jason Gedamke[2], Leila T. Hatch[3], Robert P. Dziak[4], Sofie Van Parijs[5], Megan McKenna[6], Jay Barlow[7], Catherine Berchok[8], Eva DiDonato[9], Brad Hanson[10], Joseph Haxel[1], Marla Holt[10], Danielle Lipski[11], Haru Matsumoto[1], Christian Meinig[11], David K. Mellinger[1], Sue Moore[12], Erin Oleson[13], Melissa Soldevilla[14], and Holger Klinck[1,15]
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The NOAA/NPS Ocean Noise Reference Station Network (NRS) is an array of 12 calibrated autonomous passive acoustic hydrophone moorings that are maintained by the U.S. National Oceanic and Atmospheric Administration (NOAA) and the National Park Service (NPS). The NRS network was first deployed between June 2014 and November 2016 to document baseline levels and multi-year trends in low-frequency ocean ambient sound within the United States exclusive economic zone (US EEZ). The multi-year network of identical autonomous passive acoustic hydrophones recorded underwater sound in the 10 to 2,000 Hz frequency range to capture anthropogenic, biological, and environmental contributions to the marine soundscape. Temporal and cross-network comparisons of these baselines will provide information on the relative presence of calling animals and prevalence of abiotic and human activities that make sounds. Implementation of the NRS significantly advances the passive acoustic sensing capabilities that exist within NOAA and NPS to address national issues dealing with monitoring protected areas and marine species (marine mammals, fish, and turtles), the effects of human sound sources associated with energy production (oil exploration, renewable energy development), and socioeconomic activity (commercial shipping, commercial fisheries, and watercraft for recreation and tourism). Initial analysis of the first year of available data from the NRS demonstrates variability of low-frequency sound levels across the entire NRS, as well as seasonal variability within each site. Continued data collection efforts will inform assessments of long-term low-frequency sound level trends within the US EEZ and the efficacy of soundscape management approaches addressing both protected areas and species.

1:30 – Autonomous vehicles as passive acoustic recorders

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Recent advances in passive acoustic monitoring technologies have led to development of mobile autonomous recording platforms (underwater gliders and deep-profiling floats) for recording marine mammals. These instruments may allow for greater spatial and temporal sampling than traditional towed or bottom-moored systems. However, as slow-

and vertically-moving platforms, they are subject to unique sampling biases and methodological considerations, including the effects of sound propagation and movement of animals relative to the instruments. Comparison of recording abilities of these instruments to traditional methods has yet to be performed. My dissertation aims to directly compare mobile autonomous platforms to traditional methods to identify the differences in recording abilities across platforms, quantify how to account for these differences when drawing conclusions about species presence and density estimation, and provide best practice recommendations for future implementation. I conducted two simultaneous deployments of acoustically equipped underwater gliders and deep-profiling floats off the coast of Southern California in 2016. I am using these two datasets to measure detection probabilities for both low-frequency and mid-frequency marine mammal vocalizations. These detection probabilities will feed into a framework for estimating animal density and abundance from slow-moving platforms, which will be tested with a final survey in summer 2018.

1:45 – Variation in fin whale songs recorded near Hawaii

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Marine mammals use acoustics for many life functions, including communication. Male fin whales produce a call around 20 Hz and the pattern of a series of calls can vary based on the individual, geographic region, and season. I examined the variation between songs in fin whales. A glider was deployed southwest of Honolulu, HI in December 2014. It recorded passive acoustic data in the ocean for four weeks. There were 33 days with fin whales detected in the recordings but only 22 days had calls of measurable quality. In the 11 days that did not have distinct calls there was either many hours with the glider turned off or the calls were interspersed with background noise that masked them. Using Raven Pro, I looked through the entire data set and graded songs based on the amplitude and ability to differentiate the call from ambient noise. I then marked individual calls and recorded the inter-pulse interval (IPI) in each of the quality song bouts. I used the timing information to further classify the song pattern and make comparisons to other studies. From the seven days that I collected data, the most common IPIs were between 25-33 seconds. The mean IPI was 36.0 seconds and the median IPI was 30.1 seconds. The consistent patterns measured match previous fin whale songs recorded near Hawaii in December 2002 and 2005.

Session 3: Management

Agricultural Leaders Room (2:15-3:15)

2:15 – A model to evaluate barred owl (*Strix varia*) removal strategies for northern spotted owl (*Strix occidentalis caurina*) conservation

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In ecosystems throughout the world, lethal removal of one species is sometimes seen as necessary for the conservation of another. Modeling alternative removal strategies can inform decision-making so that resources are not directed towards ineffective or inefficient actions and, perhaps more importantly, to avoid culling animals using strategies with little to no conservation benefit for the species of concern. Lethal removal of barred owls has been proposed as a management option for the conservation of northern spotted owls. We developed an individual-based spatially explicit population model to compare the efficacy and efficiency of alternative barred owl removal strategies. The model evaluates how well an area can be maintained free of barred owls. We compared several basic approaches for implementation of removal to understand how spatial extent and distribution of removal areas influences removal dynamics. We also identified parameters of interest where further empirical field research could refine model predictions. The flexible nature of the model allows further development to answer more complex questions concerning barred owl removal as well as application to property-specific evaluation when landowners or managers propose or consider barred owl removals.

2:30 – Modeling the effects of control efforts on a population of common carp (*Cyprinus carpio*) in a shallow eutrophic desert lake

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The introduction of Common Carp (*Cyprinus carpio*; hereafter “carp”) into North American waterways has led to widespread destruction of aquatic ecosystems. An example of this destruction can be found in Malheur Lake, located on Malheur National

Wildlife Refuge (MNWR) in Southeastern Oregon. Invasion of carp in this system is believed to be responsible for the loss of aquatic vegetation and as well as declines in waterfowl productivity. Over the past 65 years, efforts to remove carp and restore the aquatic ecosystem have included eight rotenone treatments, each of which led to an immediate decline in the carp population, followed by a rapid rebound in the abundance of carp in subsequent years. In order to better understand the carp population and ensure future sustained reduction in carp biomass we developed a novel carp population dynamic model which was then used to explore the efficacy of alternative control measures. The alternative control measures that we evaluated were broken into two categories (active & passive) of removals, with active removals imposing mortality externally on multiple life stages (commercial harvest of adults, fyke net trapping of juveniles, and electroshocking eggs in the spawning areas) and passive removals via increased avian piscivore populations. Through these model simulations we determined that increases in the avian populations contributed to the suppression of carp, however were unable to alone reduce the carp biomass below the desired 50 kg/ha threshold (Vilizzi et al., 2015). Model results suggest that there is no single active removal method that would decrease the overall carp biomass below the desired threshold. Furthermore, a combination of two or potentially all three removal methods can reduce the carp biomass below the desired threshold due to the targeting of multiple life stages. Collectively, these results represent a realistic assessment of multiple factors that influence the success of carp control, and the ability to use carp control measures as a means of restoring the aquatic ecosystem.

2:45 – Understanding tribal stakeholder preference through valuation of environmental attributes

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Human dimensions are increasingly relevant in natural resource sciences as robust solutions require input from diverse stakeholder groups to maximize well-being of the environment and society. Many strategies exist to gain stakeholder perspectives, but quantifying these can be challenging. Discrete choice experiments were originally designed in the marketing and transportation sectors to create more refined products and services. In the past 20 years however, this tool has been increasingly relevant for valuation in the field or natural resources. This technique takes standard stated preference approaches, such as contingent valuation, one step further by providing more than one good or service to the respondent. This allows the researcher to understand how individuals trade-off environmental attributes, thus eliciting those of highest value. The Quinault Division of Natural Resources (QDNR) has stated their interest in understanding how tribal members trade-off management scenarios, particularly those related to wild salmon restoration and riparian timber harvest. To

understand these characteristics of the population a discrete choice method will be applied to elicit values for environmental attributes associated with salmon restoration and riparian timber management in and around the Quinault River. The population of interest is a representative sample of Quinault Indian Nation members residing on and off reservation. In addition, exploring how the potential cultural differences between the residence groups affect their preferences will also be explored through the addition of Likert-style questions to the survey. Results of the proposed research will inform structured decision making for the QDNR to help create robust management decisions.

3:00 – Using mental models to measure shared knowledge across fishers and stakeholders in response to the implementation of Belize's Managed Access Program

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The potential of an impending collapse of the fisheries sector around the world has placed countries on alert to develop efforts to mitigate such effects. In an effort to prevent against the collapse of its fisheries, Belize has implemented a catch shares program (Managed Access) to promote the sustainability of its fisheries sector. While the implementation of sustainable fisheries framework is essential, we must first be able to understand fishers' understanding of the new system and its influence on shifting their *modus operandi*. I endeavor to understand the mental models of fishers, managers and representatives of environmental NGOs around the implementation of the catch shares program. Through the use of Conceptual Content Cognitive Mapping (3CM), I aim to elicit the mental maps of these three groups and look for similarities and differences based on group membership and other characteristics. This research forms the first component of a larger project that will use the Reasonable Person Model (RPM) to understand how the implementation of the Managed Access Program influences the behavior of fishers to improve communication and decision making around fisheries management in Belize.

Session 4: Environmental Factors

Agricultural Science Room (2:15-3:15)

2:15 – Linking North Pacific chinook salmon habitat quality with fish production in a changing climate

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The U.S. Pacific Northwest is characterized by extensive upwelling and complex ocean dynamics. Large scale climatic patterns such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO) influence wind-driven upwelling and ocean temperatures, dissolved oxygen and salinity. These patterns largely determine habitat quality for species that use coastal waters for all or part of their lifespan. One such species is the Chinook salmon *Oncorhynchus tshawytscha,* which supports valuable recreational and commercial fisheries in the Pacific Northwest but is experiencing ecosystem-level declines. The goal of this study was to develop a dynamic index of habitat quality for Chinook salmon to examine and predict changes in habitat quality due to ENSO- and PDO-driven climate shifts. We compiled vertical profiles of water temperature, dissolved oxygen, and salinity from several sites in the Pacific Northwest. These data were used to calculate a dynamic habitat quality index based on bioenergetics-based growth rate potential (GRP) of adult Chinook salmon in the North Pacific between 1952 and 2013. An age-structured matrix population model for salmon was modified to incorporate habitat quality and used to generate a yearly index of population abundance. Commercial salmon landings were compared to the indices of habitat quality and population abundance, and all three time series were analyzed for evidence of regime shifts. Indices of habitat quality and population abundance were both correlated with annual catch rates of adult salmon. Salmon GRP decreased by 57 percent after the El Niño event in 1987-1988 as compared to the years before the event. This event heralded the transition from a strong warm phase to a strong cool phase in both the ENSO and the PDO, also corresponded to a decline in salmon landings. We suggest that GRP can be used to capture the variability in climatic forcing of ecosystems, and is a measure of habitat quality that can be used directly to predict fishery production. An integrated, dynamic definition of habitat quality, such as GRP, is necessary to understand the impacts of climate oscillations on fishery production.

2:30 – Effects of elevated CO_2 on the behavior of speckled sanddab (*Citharichthys stigmaeus*)

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Ocean acidification (OA) studies with marine fishes suggest that elevated CO_2 may affect behavior by interfering with an important brain neurotransmitter. OA effects on fish behavior are understudied in fishes from temperate and boreal regions such as the California Current. Flatfishes are a notable component of these food webs and support important regional fisheries. In laboratory experiments, I first examined speckled sanddab (*Citharichthys stigmaeus*) behavioral responses to potential predation cues (predator odor, damaged skin cues from injured conspecifics, and sight of a predator) under ambient CO_2. Sanddab reduced conspicuousness and foraging at the sight of a predator, but increased these responses when exposed to damaged skin (DS) cues. I then examined the effects of elevated CO_2 on posture, activity, and foraging of sanddab, and if CO_2 altered their responses to DS cues. CO_2 treatments reflected present-day levels (~400 µatm) and those predicted to occur over the next 150 years (~1,000 µatm and ~1,600 µatm). While there was no major effect of CO_2 on sanddab behavior, there were non-significant trends of fish from the medium CO_2 treatment exhibiting the lowest posture and activity scores, longest feeding latencies, and fewest feeding strikes. Results suggest that aspects of speckled sanddab behavior might be resistant to OA. It is also possible that prolonged exposure to elevated CO_2 enabled sanddab to compensate, mitigating the effects observed in other fishes following shorter-term exposure. Studying ecologically relevant behaviors across diverse species assemblages is necessary to evaluate the impact of ocean acidification on marine food webs.

2:45 – Mangrove ecosystems productivity of the Mahakam Delta, East Kalimantan, Indonesia

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The Mahakam Delta which was one of the densest mangroves in Indonesia had undergone severe deforestation and conversion into aquaculture ponds resulting in high carbon emissions to the atmosphere. To understand the carbon dynamics of mangrove ecosystems, we quantify the net primary production (NPP) and net ecosystem production (NEP) of mangroves and abandoned shrimp ponds in the Mahakam Delta, East

Kalimantan, Indonesia. NPP was obtained by summing aboveground growth, belowground growth and litterfall production for a year, while NEP was calculated by subtracting NPP from the heterotrophic soil respiration. We found that the mean aboveground NPP for mangroves and abandoned shrimp ponds were 13.5 ± 1.1 Mg C ha^{-1} yr^{-1} and 0.8 ± 0.4 Mg C ha^{-1} yr^{-1} respectively. The NEP of mangroves (8.8 ± 1.9 Mg C ha^{-1} yr^{-1}) was significantly higher than the abandoned shrimp ponds (–1.4 ± 0.3 Mg C ha^{-1} yr^{-1}). Our results showed that the mangroves of the Mahakam Delta are significant net carbon sinks, while abandoned shrimp ponds are large carbon sources to the atmosphere.

3:00 – Carbon dynamics in response to land cover change in tropical coastal peatlands, West Kalimantan, Indonesia

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Tropical peatlands cover as much as 439,238 km^2 which is about 11% of all peatlands of the world. Land use and land cover change (LULCC) has shifted peatland ecosystems from carbon sinks into huge sources of greenhouse gases. Yet, much is unknown about how LULCC may alters the carbon (C) stocks, net primary productivity and net ecosystem productivity of peatland ecosystems. The objectives of this study was to quantify the impacts of LULCC on ecosystem C stocks, potential C emissions, net primary productivity (NPP) and net ecosystem productivity (NEP). Tropical peat forests likely contain the largest total C stocks among terrestrial ecosystems on earth. Their stocks ranged from 2,515 Mg C ha^{-1} to 5,591 Mg C ha^{-1}. Degradation and conversion of intact peat forests may result in carbon emissions as high as 4,259 Mg CO_2-e ha^{-1}. Peat forest was among the most productive terrestrial ecosystems on earth. Our estimates of peat forests' NPP (i.e., 46.8 Mg CO_2-e ha^{-1} yr^{-1}) exceed that of many tropical rain forests and are equal to mangrove ecosystems. Logged forest and oil palm were net carbon sources; they have negative NEP values (-6.5 Mg CO_2-e ha^{-1} yr^{-1} and -25.1 Mg CO_2-e ha^{-1} yr^{-1}, respectively). In contrast, intact forest was net carbon sinks (10.8 Mg CO_2-e ha^{-1} yr^{-1}). The large carbon stocks and high rates of ecosystem productivity coupled with the extensive rates of degradation, and high greenhouse gas emissions points to the relevance for inclusion of PSF in appropriate climate change mitigation and adaptation strategies.

Poster Presentations

Construction and Engineering Hall Hallway (Official Session 4:30-5:30)

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1 – Heritability and genomic basis for variation in thermal tolerance of the coral holobiont in *Orbicella faveolata*

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Sea surface temperatures are predicted to rise 1-2°C by the end of the century, and thermally sensitive organisms like reef-building corals will require substantial adaptive responses in order to persist well into the future. Genetic variation that might support adaptive responses has been documented in larval stages of some corals, but the contribution of genetic variation of adult corals and its functional basis remains unclear. In this study, we focus on mechanisms that may enable long-term adaptation by investigating heritable variation in thermal tolerance and its genomic basis in *Orbicella faveolata*, a dominant reef-builder in the Caribbean. Thermal stress experiments were conducted at the Smithsonian Tropical Research Institute in Bocas del Toro, Panama, using coral fragments collected from natural populations. Bleaching responses were quantified and combined with genome-wide SNP genotyping to estimate heritability (h^2=0.85) and test for associations between thermal tolerance and genotypes. Using the linkage map and draft genome assembly for this species, we searched for genomic regions underlying variation within more thermally tolerant phenotypes and found loci associated with bleaching. In addition, we profiled transcriptional responses in the same corals, to evaluate whether genomic regions associated with tolerance include genes differentially expressed in heat-tolerant and susceptible genotypes. Integrating genomic and transcriptomic data with quantitative genetic analysis provides a new perspective on the mechanistic basis for thermal tolerance phenotypes and the potential for adaptation to rising ocean temperatures.

2 – Mobile autonomous passive acoustic monitoring of marine mammals in the Catalina Basin

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Traditional visual survey methods for marine mammals can only detect a fraction of the animals present. Even if the animal can be observed from the surface, visual limitations such as time of day and weather conditions can impede this ability. Recent advances in passive acoustic monitoring technologies have led to the development of mobile autonomous platforms for recording marine mammals. These instruments may allow for improved monitoring of species presence through greater spatial and temporal sampling capabilities. We deployed two types of commercially available platforms in the Catalina Basin in late July through early August 2016. The QUEphone, based on the APEX float (Teledyne Webb Research, Falmouth, MA, USA), is a buoyancy-driven device that dove to 1,000 m where it drifted horizontally with the currents. The Seaglider (Kongsberg Underwater Technology, Lynwood, WA, USA) is also buoyancy-driven, but repeatedly dove down to 1000 m and traversed back and forth across the survey area. Using MATLAB based software Triton, (Scripps Whale Acoustics Laboratory, La Jolla, CA), and Raven (Cornell Lab of Ornithology, Ithaca, NY) programs, I analyzed the acoustic data both visually and aurally using long term spectrogram analysis. The most prevalent species were unidentified delphinids, with 240 of 313 hours containing calls. Marine mammal detections also included unidentified otariid, Risso's dolphins, and blue, humpback, minke, and Cuvier's beaked whales. These data will be used to compare the detection capabilities of the QUEphone and Seaglider, contributing to the advancement of the use of these instruments in marine mammal surveys.

3 – Characterizing seasonal estuary fish assemblages and environmental conditions at tide-gate locations in the Coos Bay Estuary

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Seasonal fish assemblage composition in estuaries reflects individual life history needs that are linked to predictable patterns of environmental conditions. As these conditions change into the future, effects on native fish abundance and composition are uncertain. This research explores seasonal patterns of fish assemblage structure over time with environmental conditions that are predicted to change (i.e. salinity, tidal height, and temperature). To explore these relationships, fish were sampled with beach seines at three locations in the Coos Bay Estuary on a seasonal rotation from 2014 – 2017 at both low and high tide. Sample locations were selected to complement ongoing research exploring freshwater/estuary linkages for salmonids in tide-gate systems. Two of the sites occur in the upper Coos system in an inlet draining lowland watersheds, with the remaining site located off Coos Bay proper. Sites differ in terms of upslope river characteristics, and estuary habitat composition. Fish data collection included counts of fish (identified to species) and individual length and weight measurements.

Environmental data documenting salinity, and temperature were recorded over time. Tidal height at the time of fish sampling was recorded. Fish assemblage composition was characterized using species diversity and relative abundance per sampling effort (two seine hauls define a sample). We found differences in abundance and species diversity among seasons across sites. Winter seining was characterized by the lowest species diversity and abundance, consistent with life history diversity and nursery habitat needs of marine-dependent species. Juvenile salmonids were found in every season at low abundance. More fish and greater fish diversity were generally associated with the low tide seine. In many studies, seining is conducted by boat at high tides. Our results show the importance of sampling at low and high tide. Further, these results point to the importance of recording tidal height and season as a critical element for comparing data among sites over time. Our work furthers understanding the linkages of fish assemblages and their connection to environmental conditions in the Coos Bay Estuary. This can inform conservation planning and support future research to better understand effects of changing environments.

4 – Inclination angle and intensity of magnetic fields in hatchery environments

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During migration, salmonids derive positional information from elements of the Earth's magnetic field (inclination angle and total field intensity), and they actively use this geomagnetic signature to change their global orientation relative to their destination. In the study by Putman, Meinke, and Noakes (2014), juvenile steelhead trout (*Oncorhynchus mykiss*) reared in a distorted magnetic field were unable to differentiate between magnetic fields occurring at the extremes of their oceanic range. Here, we quantified the magnetic fields juvenile salmonids may experience throughout their development in a hatchery environment. Using a magnetometer, we measured the inclination angle and total field intensity at multiple locations within the Oregon Hatchery Research Center. Our results indicate that hatchery rearing environments can significantly alter the magnetic field that juvenile salmonids experience. Based on our findings, as well as the results from previous studies, we suggest that hatchery rearing environments can alter the magnetic field and thus the subsequent orientation of salmonids, which could have implications for their ability to navigate effectively.

5 – Identification of feeding behaviors of Caribbean reef fishes through underwater videos

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A functional trait is a behavioral, morphological, physical or biochemical characteristic of an organism that helps with its survival. Information on functional traits of reef fishes is generally poor in the Caribbean area. In this study, we documented presence of behaviors related to the trophic function of fishes in coral reefs of the Caribbean. We identified fish behaviors by using underwater videos recorded in spawning areas of Caribbean groupers off of the southwest coast of Puerto Rico between 2011 to 2015. The observed behaviors were compared to a data base of functional traits for 274 reef fish species in the U.S. Caribbean to identify new trophic traits. Preliminary results showed new behaviors related to the feeding position in the water column for ten reef fish species, and new social feeding behaviors for five species. In addition, we recorded known feeding positions for five species and social behaviors for nine species that agreed with existing literature. Our study shows the practical use of underwater videos to increase the basic ecological knowledge of reef fishes to improve data needed for functional diversity studies in Caribbean coral reef areas.

6 – Development of a water sampling protocol for monitoring and management of *Ichthyophthirius multifiliis* in the Klamath River

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Ichthyophthirius multifiliis (Ich) is a ciliated protozoan that infects freshwater fishes in aquaria, hatcheries, and wild rivers. Ich infections have contributed to mortality events of pre-spawning salmon in the Klamath River, CA. The long term goal of this project is to describe and mitigate the occurrence of Ich outbreaks in the Klamath River through the development of an improved monitoring protocol. Currently Ich is monitored through lethal sampling of migrating adult salmon. This method is time intensive and imprecise. Ich has a waterborne infective stage, and so should be detectable in filtered water samples: an approach we have used successfully with another salmon parasite with a waterborne infective stage present in the Klamath River, *Ceratonova shasta*. Molecular quantification of Ich in water samples using qPCR could be an effective method for early detection of parasite levels above a disease threshold. At this point in the project we have demonstrated that Ich can be detected in 1L water samples collected in the Klamath River. We have begun to establish the relationship between the levels of Ich detected in water samples and observed salmon infection levels. This work is being

undertaken in collaboration with Yurok tribal biologists and the CA-NV Fish Health Center, USFWS.

7 – Characteristics of 20 Hz fin whale vocalizations in the Northeast Pacific

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Fin whales (*Balaenoptera physalus*) are known to sing in the NE Pacific Ocean. Both 20 Hz and 40 Hz fin calls can be observed in this area, but separated temporally with 20 Hz calls being predominant in the winter. A Seaglider™ (Konsberg Underwater Technologies) and two Apex floats (Teledyne Webb) outfitted with hydrophones were deployed in the area of the Southern California Offshore Range from 22 December 2015 through 4 January 2016. Fin whales were present and 20 Hz vocalizations recorded throughout the deployment. The objectives of this study were to: 1) classify fin whale songs, 2) identify any diel patterns in 20 Hz fin whale calls and 3) gain experience working with an acoustic dataset. Fin songs were classified by measuring the inter-pulse intervals (IPIs) of 20 Hz calls. Song "bouts" were graded and selected to minimize error of accidently measuring IPIs between multiple whales. 1362 pulses were measured in the 18 "bouts" chosen for a total of 9.3 hours of recorded data. The measured IPIs had a bimodal distribution with means around 18.6 and 22.4 seconds. Diel patterns were assessed by randomly selecting 10 minute portions of every hour of recorded data. No diel patterns were observed in this data set, which is not surprising as fin whales in the Pacific are known to feed during both night and day.

8 – Spatial and vertical distribution of the invasive European green crab in a temperate estuarine system.

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The European green crab, *Carcinus maenas*, is a generalist predator that has established invasive populations throughout the world, including the west coast of North America. In Oregon, strong cohorts of green crabs recruit only during major El Niño events. The goals of this study are to: 1) compare the abundance and growth of the recent 2014-2015 El Niño cohort to that of the strong 1997-1998 El Niño in Yaquina Bay, Oregon, and 2) explore the spatial and vertical distribution of *C. maenas* and how it

relates to that of the native red rock crab, *Cancer productus*. An abundance and size distribution similar to the 1997-98 cohort was observed, indicating favorable current patterns and growing conditions brought on by the strong El Niño. We did not find a correlation between the spatial distribution of *C. productus* and *C. maenas*, however it is possible that the distribution is related to the dynamics of the bay or microhabitat preference. Our data suggests a negative correlation in the vertical tidal distribution of the two species, supporting the hypothesis that *C. productus* sets the vertical lower limit of *C. maenas*. Observations of the interactions of the two species in the same trap support this hypothesis. Future studies should follow the 2015 year class and its effects on the local ecosystems. These data could prove a valuable tool in making predictions on the indirect effects of El Niño or the establishment of a self-sustaining *C. maenas* population in Yaquina Bay.

9 – Comparing avian diversity with human disturbance in Puerto Rico

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Human disturbance often negatively affects wildlife species due to increasing habitat destruction, poaching and invasive species introduction. Many areas that have a high amount of human disturbance have less balanced ecosystems. Puerto Rico is a model system and has converted much of the natural habitat to monoculture and polyculture agricultural systems. These disturbed areas support a limited number of wildlife species. Native wildlife species in Puerto Rico also experience negative effects from invasive species such as West Indian Mongoose and the Green Iguana. We investigated if there were more avian species present in more pristine areas (areas with low amount of human disturbance) such as El Yunque National Forest and Cabo Rojo National Wildlife Refuge. Eight areas were sampled that were categorized into three groups: low (1), medium (2) and high (3) amount of human disturbance. An observational survey was conducted with five-minute stationary bird counts. A total of 303 birds and 40 species were observed. There appears to be an inverse relationship between the level of human disturbance and the number of avian species observed, even though the data were not statistically significant. Additional research need to be conducted to determine if significant relationships between disturbance level and number of avian species can be documented. In the future, agriculture and wildlife systems need to work together since they provide many mutualistic relationships. Many stray cats and dogs were observed. Avian species observed may have been influenced by dog and cat overpopulation resulting in increased amounts of predation and stress.

10 – Distribution and abundance or myrtle and Audubon's warbler during migration and winter

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Yellow-rumped Warbler (*Setophaga coronata)* is one of the most abundant and widespread warbler in North America. It is recognized by the American Ornithologists' as four recognized subspecies. The two that occur commonly in Western North America, Myrtle and Audubon's warbler, both lack sufficient information regarding to their proportions during the migration and wintering ranges. It is likely that the recognition of the two as one species; which were separate at one point, has influenced the lack of data. A ten-year 2007-2016 bird survey data set from western Oregon was used to assess the seasonal patterns and proportional representation of the two subspecies. The study emphasizes a large portion on the western-central Willamette Valley, where near-daily bird surveys were conducted. Yellow-rumped Warblers were identified down to subspecies using diagnostic differences in call and plumage. Across the ten years of the study, 8,799 Yellow-rumped warblers were identified down to subspecies in western Oregon. A near 60% were Myrtle Warblers and 40% of Audubon's. A fraction of Myrtle warblers was consistently higher than Audubon's warbler, with the exception of spring migration, where Audubon's Warbler proportions remained higher. It is suggested that Audubon's warbler take separate routes than Myrtle warbler and during the spring, Audubon's move northward in greater numbers through western Oregon. Many other possibilities are being explored, but it is recommended for others to begin recognizing the two subspecies, as there is a possibility of both subspecies having separate wintering habitats, as well as migration routes.

11 – Caspian tern (*Hydroprogne caspia*) response to managed reductions in nesting habitat: preliminary results

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Conflicts between Caspian terns (*Hydroprogne caspia*) and restoration efforts for anadromous salmonids (*Oncorhynchus* spp.) throughout the Columbia Plateau region

have resulted in the development of a management plan to reduce avian predation on juvenile salmonids. This plan calls for the elimination of Caspian tern nesting at the two largest colony locations within this region. Management was implemented at Goose Island in Potholes Reservoir during the 2014-2016 nesting seasons and at Crescent Island in the Columbia River near Pasco, WA in the 2015 and 2016 nesting seasons. To understand the response of Caspian terns to these managed reductions in nesting habitat, and infer potential benefits to salmonid populations, I monitored Caspian tern nesting across the Plateau region during the two years of management implementation at both colony locations (2015-2016). Caspian terns were successfully dissuaded from nesting at both colony locations. Terns continued to nest at other historical colony locations, however; a previously small colony within the Blalock Islands in the Columbia River near Boardman, OR grew to 4-5 times larger than previously recorded. Three previously unknown colony locations developed during years of management implementation (2014-2016). In 2014 and 2015, the total number of nesting pairs and nesting success for Caspian terns throughout the Columbia Plateau region were below historical averages. In 2016, the number of Caspian tern nesting pairs was the lowest recorded for the region since comprehensive monitoring began in 2000. Nest predation and fluctuating reservoir water levels were the primary limiting factors for Caspian tern nesting success.

12 – An evaluation of blooming vegetation variation on crab spider (Thomisidae) abundance and diversity in Eastern Oregon grasslands

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In Eastern Oregon, there have been a number of attempts to restore grassland environments. Grassland vegetation provides foraging habitat, breeding habitat and shelter for many types of invertebrates including spiders. Crab spiders (Thomisidae), for example, forage in grassland blooms that attract pollinators that the spiders predate on. The objective of this study was to evaluate the relationship between blooming grassland vegetation and spider abundance and diversity, with special attention to the Thomisidae family. Blooming vegetation and spider data were collected during the 2015 summer season (June-August). In this study, native, restored and degraded grassland habitats were compared at three different locations: The Nature Conservancy Boardman Grasslands and Zumwalt Prairie, and the Umatilla National Wildlife Refuge (UNWR). Blooming vegetation data were collected using transects and quadrats, and spiders were collected using pitfall traps. Preliminary analyses indicate that the Boardman Grasslands has the highest abundance of *Thomisidae* (134 individuals), with a floral species richness of 16 species and 4,548 blooms. The Zumwalt Prairie has the highest floral species richness (50 species) and the highest total number of blooms (13,946

blooms). However, only 5 Thomisidae spiders have been identified in the samples from the Zumwalt prairie so far. The UNWR shows the lowest floral species richness (14 species) and the lowest total number of blooms (2,517 blooms) but has a moderate abundance of crab spiders (28 individuals). This study will provide more information about the effectiveness of grassland restoration on crab spider communities and beneficial invertebrate-plant relationships.

13 – Consumer influence on stream metabolic rates

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Stream metabolism is being used as an indicator of stream health because it integrates responses of the aquatic community across space and time. Respiration and Net Primary Production (NEP) both respond to changes in light and nutrients, but less is known about how they are affected by the structure and composition of the aquatic community. In the summer of 2016, we sought to answer this question at the H.J. Andrews Experimental Forest. We utilized recirculating chambers and incorporated aquatic consumers Cutthroat trout (*Oncorhynchus clarkii*) and common macroinvertebrates to quantify their respective influence on stream metabolic rates.

14 - Large wood impacts on stream geomorphology and fish habitat: does stream size matter?

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Engineered large wood (LW) jams have long been implemented as a stream restoration strategy to create fish habitat. However, their effectiveness in streams of different sizes is rarely studied. The goal of this study is to assess the success of LW introduction over a range of stream sizes in an Oregon Coast Range basin. The Mill Creek basin will serve as a natural laboratory to quantify scale-dependent effects on stream geomorphic change and grain size distribution after the addition of LW, and to correlate stream geomorphic change with biological salmon habitat indicators. Seven restoration sites draining 3.9-22 km^2 and with similar LW jams were selected. Indicators to be examined include grain size distribution, stream topography and width, frequency of pools, and

LW movement. We will assess the relative change among sites of different sizes to determine which site experiences the most geomorphic change. We expect that this will be primarily influenced by the upstream drainage area of the site and the amount of contact between LW and the channel. We hypothesize that the most geomorphic change will occur in sites of intermediate drainage area and bankfull width, where the equilibrium between LW-channel contact and discharge (driven by drainage area) is maximized. By identifying which size category experiences the most change after the introduction of LW, and linking this change to salmon habitat metrics, we will provide information to optimize future LW stream restoration efforts that focus on stream reaches likely to experience the most increase in fish habitat.

Notes

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- Workshops: Jenna Curtis, Lauren Smith, Andrew Olsen
- Abstract/Program: Brittany Schwartzkopf, Ryan Baumbusch
- Brown Bag Lunch: Jenna Curtis, Lauren Smith, Kate Self, Eric Wade, Lizz Schyler
- Fundraising/Auction: Olivia Bailey, Aimee Massey, Angie Munguia
- Catering: Brittany Schwartzkopf
- Outreach/Advertising: Kate Self, Samara Haver, Jane Doliver, Kerrick Robinson
- Volunteers/Faculty judges: Selene Fregosi, Jane Doliver, Dawn Barlow

A special thanks to our FWGSA Co-Presidents, Brittany Schwartzkopf and Lauren Smith

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The RAFWE Organizing Committee would like to thank all of our faculty judges, undergraduate and graduate student volunteers, and the LaSells Center staff for making our symposium a success.

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