Program

Welcome to the 30th Graduate Student Symposium. Last year I compared the topics on which the talks at the 29th GSS were to be based with those that were the focus of the School in the first decades of its history (mainly salmon, halibut, herring and crab, with little evidence for even pollock). However, the School has evolved even over the last five years. There are many topics such as salmon ecology and fisheries management that were the basis for presentations at the 25th GSS in 2014 (and many before that). However, 25th GSS made no reference to ocean acidification, coral reef ecosystems, and snailfishes in the Aleutian Islands, and I expect that the 35th GSS in 2024 will include a new set of topics, questions, analyses and solutions.

The talks at this year's GSS once again cover the range of questions that faculty, students and staff explore as we improve our understanding of ecosystems and how they operate, as well as questions that have direct relevance to how we manage anthropogenic impacts on ecosystems to best achieve societal goals. Today's presentations cover the full range of what constitutes SAFS. I see talks by first-year MS students as well as talks by PhD students who have been with us for several years. The talks include the results of fieldwork research and laboratory studies, as well as the outcomes from population dynamics modeling. As always, there are titles that catch my eye. This year it is how Seattle's seawall is changing juvenile salmon migration and whether it is possible to improve age estimation using near-infrared spectroscopy.

We are amongst the most prolific programs worldwide in terms of producing peer-reviewed papers, giving presentations at national and international conferences, and making the public aware of our science through social media. Just considering publications in the peer-reviewed literature, I found that SAFS graduate students were authors of 80 papers last year – that is almost a paper for each graduate student in the program! Graduate students were the primary authors of well over half of those papers. As I noted in my welcome earlier this quarter, graduate students are the primary authors of almost half of the papers whose primary authors are from SAFS. The papers authored by graduate students were published in top-of-the-top journals such as *Proceedings of the National Academy of Sciences* and well as highly ranked discipline-specific venues including the *Canadian Journal of Aquatic and Fishery Sciences, Fish and Fisheries* and *Polar Biology*. Several of the titles in the 2018 publications reminded me of the talks I heard at previous GSS events, and I would not be surprised to see some of today's titles appearing in highly ranked journals in the future.

Well done and thank you to the program committee for setting up an excellent program, to those contributing the goodies at the back of the room, and to everyone who is moderating and acting as judges. A special welcome to the alumni and friends who are joining us for GSS this year. Finally, thanks to the Skau family whose gift to the School makes this event possible each year.

I wish I could have attended GSS this year, but this was not possible owing to the need to attend a fishery management council meeting. However, based on past experience I am sure that GSS will once again be a tremendous success. Well done continuing to make SAFS the top program in the nation.

André E. Punt

Schedule

8:45 – 9:00 Coffee & light breakfast

9:00 WELCOME AND OPENING REMARKS
Forest Club Room, 207 Anderson Hall,
2019 GSS Coordinators
Dr. Steven Roberts, Assistant Director, School of Aquatic & Fishery Sciences

9:15 – 10:15 Session I
Moderator: Stephanie Thurner

10:15 – 10:30 MORNING BREAK

10:30 – 11:30 Session II
Moderator: Yaamini Venkataraman

11:30 – 12:30 Lunch Workshop I
12:30 – 1:15 Lunch Workshop II

1:30 – 2:30 Session III
Moderator: Davey French

2:30 – 2:45 AFTERNOON BREAK I

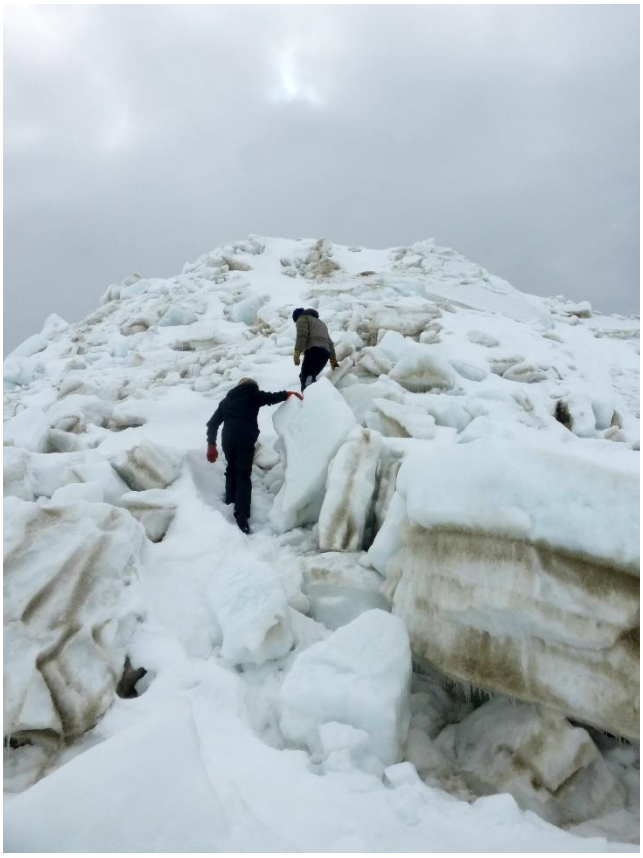
2:45 – 3:30 Session IV
Moderator: Kristin Privitera-Johnson

3:30 – 3:45 AFTERNOON BREAK II

3:45 – 4:45 Session V
Moderator: Marta Gomez-Buckley

4:45 CLOSING REMARKS

5:00 – 8:00 POSTER SESSION & RECEPTION
School of Aquatic & Fishery Sciences Lobby



Climbing an ice pile at the landfast ice edge in Kotzebue Sound, AK, April 2018
Photo: Jessica Lindsay

Cover design: Cathy Schwartz

This annual event is sponsored by the Skau Endowment, established in memory of Oscar Skau by his family and friends.

Presentations

SESSION I
Moderator: Stephanie Thurner

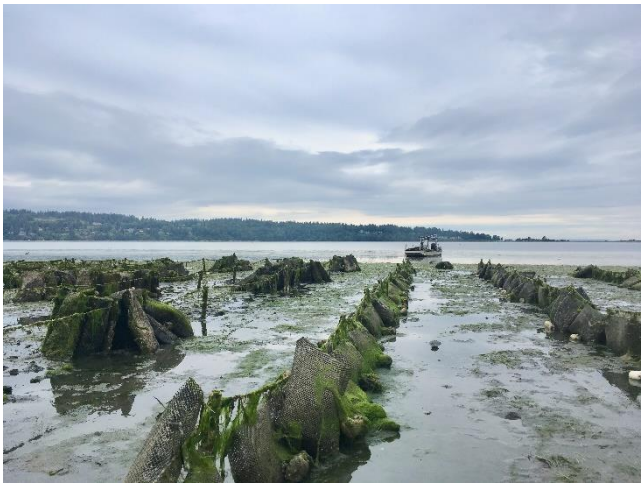
9:15 John Trochta
A Bayesian analysis of the utility of ecosystem information in a stock assessment model of Prince William Sound herring

9:30 Maia Sosa Kapur
Oceanographic features delineate growth zonation in the Northeast Pacific sablefish

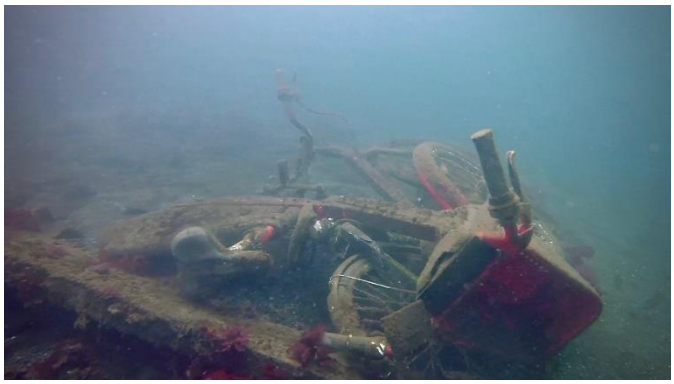
9:45 John Best
Parameterizations for Bayesian state-space surplus production models

10:00 Grant Adams
Estimates of time-varying natural mortality of groundfish in the Gulf of Alaska

10:15 – 10:30 MORNING BREAK



Collecting oysters in Blaine, WA.
Photo: Julieta Martinelli



Two bike shares now part of the underwater landscape off Pier 54, Seattle, WA.
Photo: Mike Caputo

SESSION II
Moderator: Yaamini Venkataraman

10:30 Mark Sorel
Incorporating juvenile life-history diversity in a life-cycle model for Endangered spring Chinook salmon

10:45 Marie Zahn
Beluga and Narwhal sonar beam directionality

11:00 Lukas DeFilippo
Benefits, risks, and best practices for using assisted evolution in coral conservation

11:15 Megan Feddern
Reconstructing a century of coastal productivity and predator trophic position in coastal Washington and the Salish Sea using archival harbor seal bone

Presentations

LUNCH WORKSHOPS

11:30 Workshop I
Organizer: Mark Scheuerell
Panel Discussion on Non-academic Careers in Science

12:30 Workshop II
Organizer: Isadora Jimenez
Grad Student Essentials: Caring for your Mental Health and Finding a Sense of Belonging

1:15 – 1:30 AFTERNOON BREAK I

SESSION III

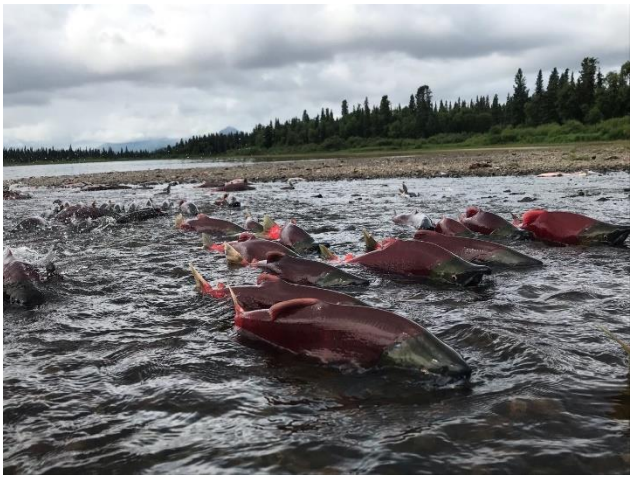
Moderator: Davey French

1:30 Grace Crandall
Effects of Bitter Crab Disease on the gene expression of Alaska Tanner Crabs

1:45 Yaamini Venkataraman
Influence of ocean acidification on Pacific Oyster (*Crassostrea gigas*) DNA methylation

2:00 Eileen Bates
Interactive effects of ocean acidification and warming on the survival and settlement of larval pinto abalone: implications for recovery

2:15 Sean Rohan
Do changes in the visual environment affect the reliability of stock assessment indices of abundance?



Sockeye salmon entering Hansen Creek, AK
Photo: Katie McElroy

2:30 – 2:45 AFTERNOON BREAK II

SESSION IV

Moderator: Kristin Privitera-Johnson

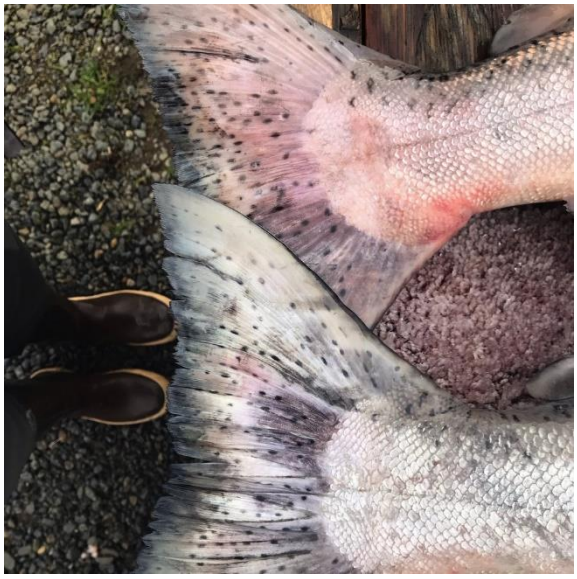
2:45 Colin Okasaki
Optimizing large-scale spatial surveys

3:00 Qi Lee
Life history changes and fisheries assessment performance: a case study for small yellow croaker in China

3:15 Marta Gomez-Buckley
Comparing eDNA and enclosed anesthetic stations sampling to detect cryptobenthic reef fishes from the Vava'u Archipelago, Kingdom of Tonga

3:30 – 3:45 AFTERNOON BREAK III

Presentations



Chinook salmon tails from set net sites on the Nushagak river, AK.
Photo: Katie McElroy

SESSION V

Moderator: Marta Gomez-Buckley

3:45 Rebekah Stiling
Determinants of resource use by rainbow trout in mountain lakes

4:00 Jordan Healy
Aging Pacific Cod (*Gadus macrocephlus*) at the molecular level with Near-Infrared Spectroscopy (FT-NIRs)

4:15 Kerry Accola
Do Seattle's seawall modifications influence juvenile salmon migration along the urban waterfront? An acoustic perspective

4:30 Katie McElroy
Can we evaluate the Marine Life Protection Act?

POSTER SESSION

5:00 – 8:00 Poster Session & Reception at SAFS Lobby

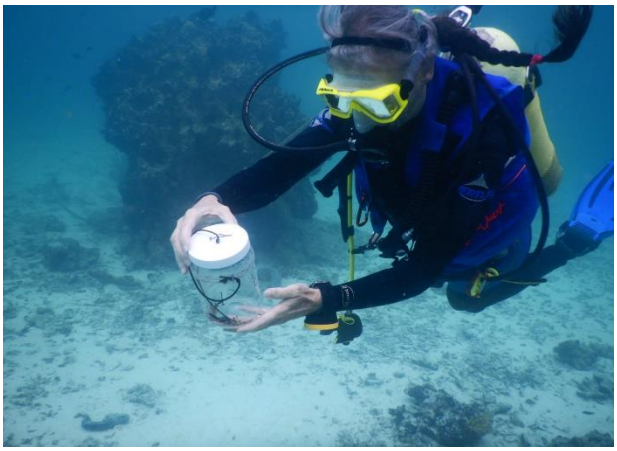
Jennifer Gardner
New species of snailfishes from the Aleutian Islands, Alaska

Sam Ghods
Evolutionary Development in Anglerfishes (Teleostei, Ceraioidei): An investigation into the phylogenetic economy of morphological parts

Madison Heller-Shipley
Risk avoidance – MSE collaboration for Bering Sea Tanner crab

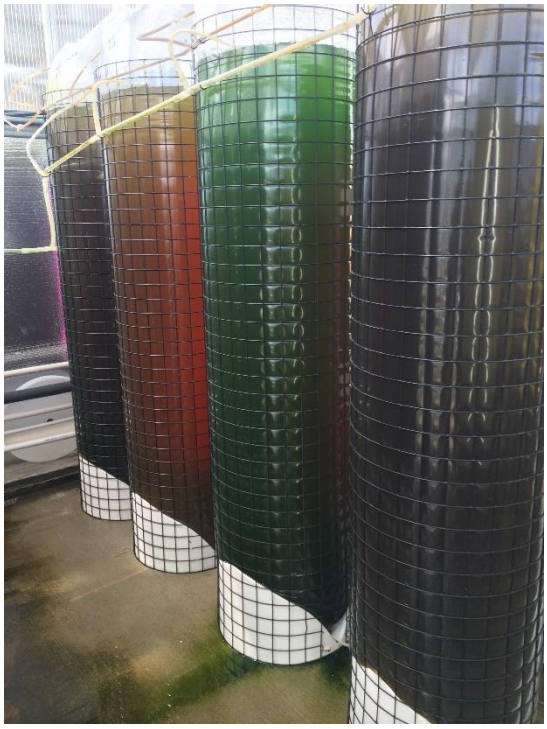
Bob Oxborrow
Epibenthic prey communities along an urban environmental gradient

Kylie Sahota and Regan Jarvis
Is table salt a viable alternative for the control of burrowing shrimp on shellfish beds in Washington state?

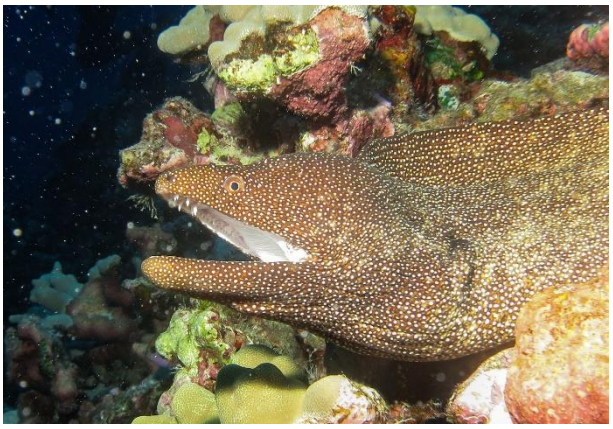


Marta Gomez-Buckley sampling for cryptobenthic reef fishes in Tonga
Photo: Marta Gomez Buckley

Abstracts



Food for filter feeding bivalves. Green and brown microalgae cultured in sterile silos at the Kenneth K. Chew Center for Shellfish Research and Restoration.
Photo: Lindsay Alma



Whitemouth moray eel foraging among the corals off the Big Island of Hawaii.
Photo: Thomas Quinn

Abstracts

SESSION I

John Trochta, PhD

Major Professor: Trevor Branch

A Bayesian analysis of the utility of ecosystem information in a stock assessment model of Prince William Sound herring

The failed recovery of Prince William Sound herring population following its collapse in the 1990s is poorly understood. Many hypotheses explaining reductions in annual recruitment and adult survival have been suggested, but little consensus on predominant drivers has been reached. Furthermore, much of the preceding hypothesis testing work is outdated in light of rapid ecosystem changes as well as improved statistical analysis techniques. Stock assessment models provide a unique tool for hypothesis evaluation because they statistically weight various sources of information to produce the best explanation of the data. We evaluate previous and new hypotheses with a recently developed Bayesian age-structured stock assessment model (BASA) for Prince William Sound herring. We take a novel approach to hypothesis evaluation by incorporating various types of uncertainty to determine the best predictive model(s) using a new efficient estimation algorithm. Factors from the physical environment and interspecific interactions are incorporated as covariates or latent variables in BASA. Models are compared using the Deviance and Watanabe-Akaike Information Criteria, and Posterior Predictive Loss. NPGO, walleye pollock spawning biomass, and Pacific cod effects on adult survival resulted in the best values of all selection criteria. Since these effects are representative of the Gulf of Alaska, our results suggest regional bottom-up and food web interactions likely have a key role in adult herring mortality and overall biomass dynamics. By using BASA to determine important ecological factors in herring dynamics, we also provide a robust framework for incorporating ecosystem information with uncertainty into biomass projections used by fisheries management.

Aerial view of the landfast ice edge in Kotzebue Sound, AK, May 2019
Photo: Jessica Lindsay

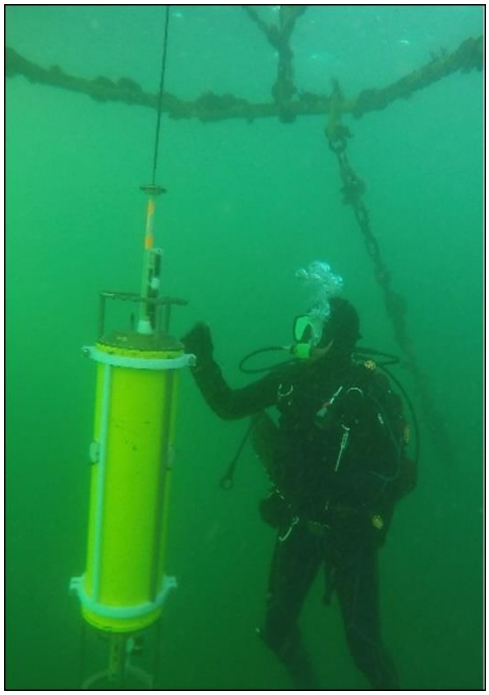
Maia Sosa Kapur, PhD

Major Professor: André Punt

Oceanographic features delineate growth zonation in Northeast Pacific sablefish

Renewed interest in the estimation of spatial variation in fish body size is a result of computing advances and the development of spatially-explicit management frameworks. However, many attempts to quantify spatial structure or distribution of traits utilize a priori approaches, which involve pre-designated geographic regions and thus cannot detect unanticipated trends. This study presents a new, data-driven method which evaluates the first derivative of the spatial smoothing term of a generalized additive model to identify spatial break points in fish length-at-age. We use simulation testing to illustrate the robustness of the method across a variety of spatially stratified age and length data, and apply it to survey data for Northeast Pacific sablefish (*Anoplopoma fimbria*). Preliminary results indicate that some parameters of the von Bertalanffy growth function show an increase with latitude in the NE Pacific, which is consistent with work from the western United States; simulation testing illustrates the robustness of the method across a variety of scenarios related to spatially complex growth data, including strict boundaries, overlapping zones and changes at the extreme of the range. This method has the potential to improve detection of large-scale spatial patterns in fish growth, and aid in the development of structured population dynamics models.

Abstracts



SCUBA diving beneath an oceanographic monitoring buoy in Puget Sound.
Photo: Lindsay Alma

John K. Best, PhD

Major Professor: André Punt

Parameterizations for Bayesian state-space surplus production models

Bayesian state-space surplus production models are commonly applied in fisheries stock assessment when the only information available is an index of relative abundance. However, even relatively simple models such as these can be computationally expensive to fit, and diagnosing poor fits can be difficult. The Stan software package provides an advanced Markov chain Monte Carlo sampler and diagnostics that are not available in other packages for fitting Bayesian models. Here the sampler diagnostics, efficiency, and posterior inferences are compared among multiple parameterizations of a state-space biomass dynamics model, using both Pella-Tomlinson and Schaefer dynamics. Two parameterizations that prevent predictions of negative biomass are introduced, one of which allows for errors in catch. None of the parameterizations used avoid diagnostic warnings using the default sampler parameter values. Choosing the appropriate parameterization of a model and paying attention to these diagnostics can increase computational efficiency and make inferences more robust.

Grant Adams, PhD

Major Professor: André Punt

Estimates of time-varying natural mortality of groundfish in the Gulf of Alaska

An assumption underlying most stock assessment methods is that natural mortality is constant through time, and changes in population status are due only to recruitment, growth, and/or fishing intensity. However, variability in the dynamics of exploited fish stocks has long been understood to be, in part, the result of variation in mortality from predation. Accounting for variation in predation mortality, a component of natural mortality, can be particularly valuable in stock assessment models if the biological realism of the assessment used for management is improved. Multispecies statistical catch-at-age analysis (MSCAA) is one modeling approach that links multiple single-species age-structured models by time-varying predation mortality and time-invariant residual mortality, representing components of natural mortality other than predation. We compare the outputs of single-species stock assessment models and a MSCAA developed for groundfish in the Gulf of Alaska (GOA), which support some of the most valuable fisheries in the region. Specifically, we fit the model to data for walleye pollock *Gadus chalcogrammus,* Pacific cod *Gadus macrocephalus*, Pacific halibut *Hippoglossus stenolepis*, and arrowtooth flounder *Atheresthes stomias*, species that are the most trophically connected in the GOA. Results demonstrate that recent increases in the biomass of arrowtooth flounder have led to increased mortality on juvenile pollock and cod. Predation mortality was larger for smaller individuals, and the proportion of predation mortality from each species varied through time. However, estimates of biomass are sensitive to the value of residual mortality. This represents a first step towards tactical ecosystem based fisheries management in the Gulf of Alaska.

Abstracts

SESSION II

Mark Sorel, PhD

Major Professor: Sarah Converse

Incorporating juvenile life-history diversity in a life-cycle model for Endangered spring Chinook salmon

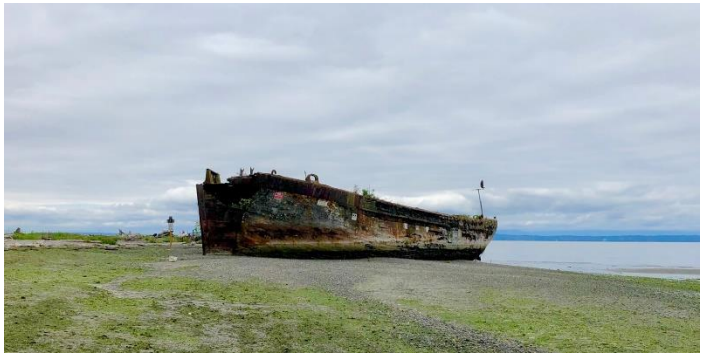
Life-cycle models are a common tool for recovery planning and status assessment of threatened anadromous salmonids. To be most useful for the management of spring Chinook salmon in the interior Columbia River, whose juveniles rear in freshwater for an entire year during which survival is thought to limit population growth and recovery, they need to account for the relationship between juvenile survival and habitat, climate, and management actions. Juvenile monitoring is often conducted using downstream-migrant traps, and in the Wenatchee River basin these traps capture juveniles emigrating from their natal streams as subyearlings throughout the year and as yearling smolts migrating directly to the ocean in spring. Incorporating these data into a life cycle model will be challenging due to the diversity of emigration timing (juvenile life-histories), however, doing so will allow us to utilize the available information on density-dependent processes, fish-habitat relationships, and life-history diversity. As a first step toward this, we fit functional relationships between spawner densities and the number of juveniles expressing four different life histories from 1996 to 2018. We find evidence for positive density-dependent migration through summer, and negative-density dependent survival or residency through fall and winter. These results are consistent with the current paradigm that summer rearing capacity limits the productivity of natal-stream-rearing juvenile anadromous salmonids, and raises questions about the fate of downstream-rearing juveniles. We plan to add additional management-relevant covariates into these relationships and incorporate them within a full life cycle model to be used as a decision-support tool.

Marie Zahn, MS

Major Professor: Kristin Laidre

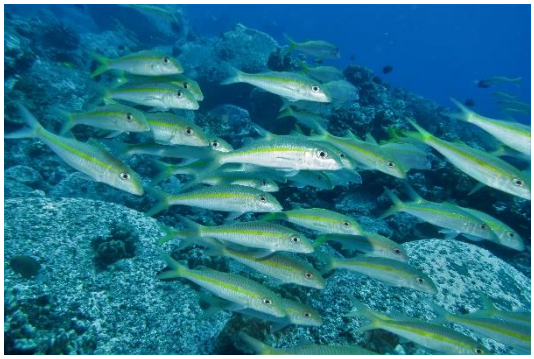
Beluga and Narwhal Sonar Beam Directionality

This presentation will outline my proposed master's thesis research on beluga (*Delphinapterus leucas*) and narwhal (*Monodon monoceros*) passive acoustics. Recordings of both narwhals and belugas were collected in 2013 from the pack ice of Baffin Bay, West Greenland. The narwhal recordings were analyzed and published, but the beluga data have yet to be evaluated. My thesis will investigate two leading questions with these recordings: 1) What are characteristic sonar parameters of belugas, including apparent source level, spectral composition, and directionality? 2) How do these results quantitatively compare to those of narwhals? Beluga and narwhal echolocation clicks were measured using a 16-channel hydrophone array that allows for acoustic localization and subsequent analysis for specific sonar characteristics. Results will provide fundamental sonar parameters for these two species that will contribute to acoustic monitoring in the Arctic. As the Arctic becomes more ice-free and vessel traffic and underwater noise are expected to increase, passive acoustic monitoring is becoming increasingly important to mitigate any negative impacts to marine mammals.



Grounded ship on beach at Shipwreck Point, Edmonds WA.
Photo: Mike Caputo

Abstracts



School of yellowstripe goatfish above coral reef off the Big Island of Hawaii.
Photo: Thomas Quinn

Lukas DeFilippo, PhD

Major Professor: Daniel Schindler

Benefits, risks, and best practices for using assisted evolution in coral conservation

There is growing interest in developing conservation strategies to restore and maintain critical ecosystem function of coral reefs in the face of mounting anthropogenic stressors. One such approach is to captively propagate corals and transplant them to degraded reef areas to augment habitat for reef-dependent fishes and invertebrates, prevent colonization from competing macroalgae, and enhance coral reproductive potential. In addition to these demographic and ecological benefits, it is thought that manipulating the thermal tolerance of out-planted corals through selective breeding or genetic engineering may enhance the evolutionary capacity of corals for adapting to a warming climate. While there has been considerable investment into developing the means to implement such restoration strategies, scientific assessments of their expected performance are scarce. I used an eco-evolutionary simulation approach to identify the levels of restoration intensity at which conservation benefits may be realized at the reef scale, and the potential benefits, risks, and best practices of using 'propagate-and-transplant' restoration as a vehicle for assisted evolution. These results indicate that the levels of restoration needed to affect coral cover are substantial, but that outcomes can be enhanced by selecting for greater thermal tolerance in out-planted corals. However, the outcomes of assisted evolution are highly sensitive to assumptions about the natural evolutionary capacity of corals and the spatial design of restoration strategies, and may even be deleterious in certain circumstances.

Megan Feddern, PhD

Major Professor: Gordon Holtgrieve

Reconstructing a century of coastal productivity and predator trophic position in coastal Washington and the Salish Sea using archival harbor seal bone.

Following the passage of the Marine Mammal Protection Act of 1972, pinniped populations along the west coast of North America experienced exponential population increases following historic lows in the 1970's. In the Salish Sea, this increase in pinniped abundance also corresponded to large scale changes environmental condition (i.e. Pacific Decadal Oscillation; PDO) and declines of prey species (forage fish, salmon), creating new challenges and tradeoffs for fisheries management in the region. The objective of this research is to understand how an abundant top predator, harbor seals, respond to bottom up forces in the system such as shifts in primary productivity and prey availability.
140 archival bones were sampled from specimens curated at institutions in the US and British Columbia, representing individuals from 1928 to 2014. Samples were analyzed for the 15N/14N of 11 individual amino acids (AAs), including both trophically fractionated (trophic) and trophically conserved (source) amino acids. Source amino acids are reflective of the 15N/14N of the base of the food web and can be used as an indicator of overall system productivity. When combined with the 15N/14N of trophic amino acids, the 15N/14N of source amino acids can also be used to calculate trophic position from historic samples. By comparing source and trophic position stable isotope data with environmental and ecological (prey abundance) time series we have identified bottom up forces, specifically environmental condition, are important drivers in harbor seal trophic position and productivity in the Salish Sea over the last 100 years.

Abstracts

LUNCH WORKSHOPS

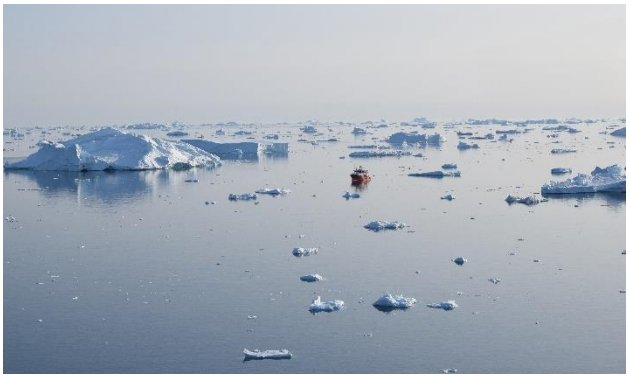
Workshop I

Organizer: Mark Scheuerell

An introduction to non-academic careers in environmental science.

We recognize that it can be difficult for graduate students to navigate the various career options available to scientists with advanced degrees in the environmental sciences. Due to the very nature of academic environments, most students have a pretty good idea of what it's like to be a professor by the time they graduate, but relatively few students have an equal appreciation for the array of alternative career possibilities. Furthermore, although academic careers continue to be a preferred path for some individuals, those jobs are increasingly rare and extremely competitive, and hence more graduates are pursuing non-academic careers. This panel discussion is therefore intended to introduce graduate students to the spectrum of non-academic career options in environmental science, and highlight their importance to society at large.

Each panelist will be given 6 minutes to describe her background and the nature of her current position, including its pros and cons. Panelists are also allowed one slide that exemplifies "a day in the life". Afterward, we will have a moderated Q&A session with audience members.



View from Fisher Island in NW Greenland of the R/V Sanna.
Photo: Jenny Stern

Panel:

Dr. Neala Kendall*
Research Scientist, WA Department of Fish and Wildlife

Ms. Jennifer Scheuerell*
Owner, Sound Data Management

Dr. Amanda Stanley
Executive Director, COMPASS

Dr. Jodie Toft*
Deputy Director, Puget Sound Restoration Fund

Dr. Sacha Vignieri
Deputy Editor for Research, Science

Dr. Melissa Poe
Social Science Program Lead, Washington Sea Grant

Dr. Beth Sanderson
Ecosystem Analysis Program Lead, Northwest Fisheries Science Center, National Marine Fisheries Service

*denotes SAFS alumni

Workshop II

Organizer: Isadora Jimenez

Speaker: Dr. Andrea Salazar-Nuñez
Staff Psychologist at the University of Washington Counseling Center

Grad Student Essentials: Caring for your Mental Health and Finding a Sense of Belonging

A workshop on guidance to maintaining mental health and creating a sense of belonging while in graduate school. The speaker may provide a tool kit to assist students with their self-care.

Abstracts

SESSION III

Grace Crandall, MS

Major Professor: Steven Roberts

Effects of Bitter Crab Disease on the Gene Expression of Alaska Tanner Crabs

Alaska Tanner crabs (*Chionoecetes bairdi*) are a coldwater crab species found in the Bering Sea, along the Gulf of Alaska, and southeastern Alaska. The southern stocks supported a $21 million fishery in 2014, but warming waters and disease have been threatening their numbers as well as the industry's profits. Bitter crab disease is caused by a parasitic dinoflagellate of the genus *Hematodinium*, and is considered to be the "principal threat" to crab stocks by the Alaska Department of Fish and Game. Aside from its causing the crabs to become lethargic, among other signs, it renders their meat bitter and chalky. Due to this, the crab industry has been suffering from the loss of marketable product. It is not known how the disease is transmitted, or if it is fatal. It would be useful to have a better grasp of how the parasite affects its host on a molecular level, which is what our study set out to do. We held infected and uninfected crabs in tanks over the course of 2.5 weeks at ambient (8˚C), cold (4˚C), and warm (10˚C) temperatures, sampling their hemolymph at three time points. From these samples, we identified crab genes involved in immune response and temperature response. We were also able to characterize the parasite's transcriptome. These data will provide important insight into the linkages between bitter crab disease, climate change, and pathogenicity.

Yaamini Venkataraman, PhD

Major Professor: Steven Roberts

Influence of Ocean Acidification on Pacific Oyster (Crassostrea gigas) DNA Methylation

As negative effects of ocean acidification are experienced by coastal ecosystems, there is a growing trend to investigate the effect of ocean acidification has on multiple generations. For example, temporarily exposing adult Pacific oysters (*Crassostrea gigas*) to low pH prior to gametogenesis affects larval abundance. The documented effect on Pacific oyster larval abundance indicates a potential role for epigenetic modifications, specifically DNA methylation, in response to ocean acidification. To assess how ocean acidification affects the oyster epigenome, DNA was extracted from adult oysters exposed to either low pH (7.31 ± 0.02) or ambient pH (7.82 ± 0.02) conditions for seven weeks. Whole genome bisulfite sequencing was used to identify methylated regions. The predicted function of genes containing differentially methylated loci location suggests a role for DNA methylation in acclimating to adverse conditions. Understanding a possible mechanism for phenotypic plasticity and acclimation across generations is valuable when considering organismal ability to persist in the face of environmental change.

Eileen Bates, MS

Major Professor: Jacqueline Padilla-Gamiño

Interactive effects of ocean acidification and warming on the survival and settlement of larval pinto abalone: implications for recovery

From 1992 to 2017 pinto abalone (*Haliotis kamtschatkana*) experienced a 97% decline in Washington waters. As the only abalone species native to the Salish Sea, their decline is a loss for indigenous tribes, recreational divers, and the health of rocky reefs and kelp beds. Puget Sound Restoration Fund and Washington Department of Fish & Wildlife are working to restore populations in the San Juan Islands. As this restoration occurs, however, climate change is causing ocean acidification (OA) and warming in the northeast Pacific, further threatening pinto abalone recovery. The purpose of this research was to inform best hatchery practices for restoration and to better understand the tolerance and physiological flexibility of wild abalone larvae under future climate change scenarios. We exposed abalone post-fertilization to four treatments for ten days: 1) ambient pH + hatchery rearing temperature, 2) low pH + hatchery rearing temperature, 3) ambient pH + high temperature, and 4) low pH + high temperature.

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Abalone in the ambient pH + hatchery rearing temperature treatment had the best survival, those in the low pH + high temperature treatment had the worst survival, and those in the two single-stressor treatments had survival in between. This indicates an additive effect of the stressors. While temperature appeared to have a minor effect on settlement, pH was the dominant stressor determining settlement success, with higher settlement rates under ambient pH treatments (both temperatures). Our results demonstrate the interacting effects of warming and OA on the vulnerable early life stages of pinto abalone.

Sean Rohan, MS

Major Professor: Tim Essington

Do changes in the visual environment affect the reliability of stock assessment indices of abundance?

Bottom-trawl gear leverages threat-avoidance behaviors to catch fish. Because vision plays a prominent role in threat detection, changes in the visual environment affect behavioral reactions of fishes to bottom-trawl gear, affecting the efficiency of bottom-trawl gear. Consequently, changes in the visual environment may cause bias and uncertainty in bottom-trawl survey density estimates, which are used as a basis to derive indices of abundance for fisheries stock assessment, identify species-environment relationships using species distribution models, and monitor changes in stock distribution using spatial abundance indices. However, due to historical limitations of technology, there is limited understanding of how much variation occurs in the visual environment of marine ecosystems and whether changes in the visual environment affect bottom-trawl survey density estimates. To begin addressing these knowledge gaps, I conducted a virtual species simulation using a novel visual environment data set from the eastern Bering Sea. Using the simulation, I asked whether variation in the visual environment affects stock density estimates from bottom-trawl stock assessment surveys, the reliability of bottom-trawl survey abundance indices, and the accuracy of spatial indices.

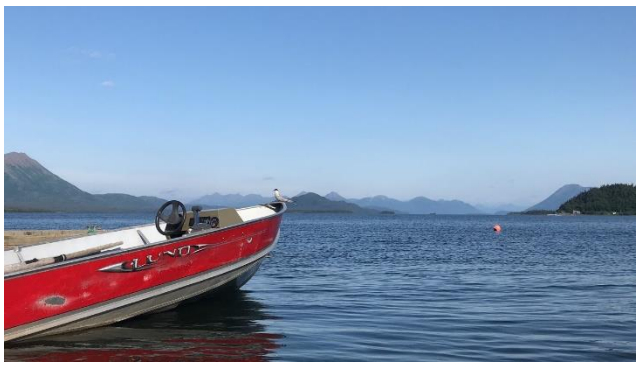
SESSION IV

Colin Okasaki, MS

Major Professor: Andrew Berdahl

Optimizing Large-Scale Spatial Surveys

Large-scale spatial surveys are rife with logistical considerations. Routing, field-base construction, road construction, fuel consumption, and equipment deployment are just a few of the factors that can add costs to a survey. These costs limit the number and quality of measurements that may be taken. Few survey design methodologies are capable of directly incorporating complex constraints. Even fewer are capable of doing so for the large, complex spatial surveys that are most heavily constrained by logistics. By incorporating spatial statistical models directly into a mixed integer-linear program, and taking advantage of the computational efficiency of sparse precision matrices, we propose a methodology to optimize spatial surveys subject to logistical constraints.



Arctic tern on Lake Aleknagik
Photo: Katie McElroy

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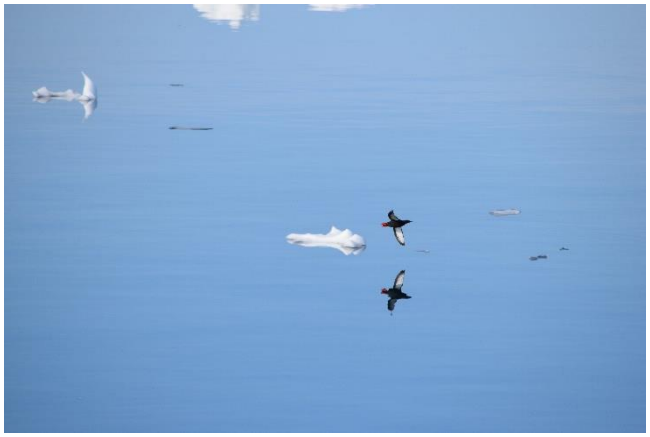

A black guillemot flies over the calm water in Melville Bay, Greenland.
Photo: Jenny Stern

Qi Lee, Ph.D

Major Professor: André Punt & Ray Hilborn

Life history changes and fisheries assessment performance: a case study for small yellow croaker in China

Many intensely-exploited fish stocks have experienced changes in trophic structure and environmental conditions, resulting in non-stationary population processes. We evaluate the ability of assessment methods to estimate quantities used in management (like target biomasses and fishing mortalities) when life history processes are non-stationary and comprehensive data are not available. We use the small yellow croaker (*Larimichthys polyactis*) fishery in the East China and Yellow Seas as a case study. We simulate age-structured populations with time-varying fishery and life history characteristics similar to that of the small yellow croaker in China based on historical studies that demonstrate changes in life history. We then fit surplus production and statistical catch-at-age models to simulated catch and index data from these populations. Given our assumptions, both estimation models yielded biased quantities important to management. The production model estimated reference points associated with target biomass with less bias than the age-structured model, while the latter outperformed the former when estimating reference points associated with target fishing mortality. The age-structured model also better captured relative population trends and provided flexibility to consider impacts of life history changes over time. We suggest that assessments of similar stocks consider the potential of life history variation impact management quantities.

Marta Gomez-Buckley, PhD

Major Professor: Luke Tornabene

Comparing eDNA and Enclosed Anesthetic Stations Sampling to Detect Cryptobenthic Reef fishes from the Vava'u Archipelago, Kingdom of Tonga

Cryptobenthic reef fishes (CRF) are an important and often overlooked faunal component of coral reef ecosystems. Their cryptic nature and very small size (average < 20 mm TL), makes them very difficult to assess using visual transect methods. The current method to determine the species composition of CRFs is to enclose limited areas of habitat to collect the fishes after an ichthyocide or anesthetic is applied. This study is the first to do comparative collections of underwater eDNA and corresponding samples of the actual fishes collected from the area of enclosed habitat. The objective of this study was to determine if the DNA sequences from eDNA sampling would reflect the CRF species composition from anesthetic collections. Assessing CRF species composition using eDNA water samples would be a faster and non-lethal method to detect CRF species composition. A total of 596 CRF were collected from 23 shallow (2-5 m) anesthetic stations using quinaldine solution as fish anesthetic, and an underwater airlift sampling device. Before CRF collections, modified 200 ml syringes were used to extract water samples from the coral microhabitats enclosed for anesthetic sampling. Analyses of eDNA samples, including use of bioinformatics, detected a total of 20 fish families, with 35 identified to species level. Only two families (four species) of all the fishes detected from eDNA samples belonged to the targeted CRF group in contrast to the approximate 40 species of CRFs collected from the anesthetic stations. Refinement of the extraction methods, and development of more specific primers for CRF species may make it possible to detect a larger number of CRF species in future eDNA explorations.

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SESSION V

Rebekah Stiling, MS

Major Professor: Julian Olden & Gordon Holtgrieve

Determinants of resource use by rainbow trout in mountain lakes

Basal sources of carbon to lake food webs flow from terrestrial, pelagic, and littoral habitats. It is well established that aquatic consumers acquire carbon from across these habitats in varying proportions, yet the factors that influence this variability are not well understood. Here, we leverage the moderately similar food webs, yet varying bathymetries, of mountain lakes to address the question of how the relative availability of habitat determines resource use by rainbow trout. We collected samples of rainbow trout, pelagic seston, benthic-littoral periphyton, and terrestrial organic matter across 16 mountain lakes in western Washington. Samples were analyzed for the stable isotope ratios of carbon and nitrogen.

Jordan Healy, MS

Major Professor: Luke Tornabene

Aging Pacific Cod (Gadus macrocephalus) at the Molecular Level with Near-Infrared Spectroscopy (FT-NIRs)

For decade's age structured stock assessment has been a key component of managing Pacific Cod (*Gadus macrocephalus*) and other such fisheries stocks, placing a high demand on precise age estimates. However, traditional fish aging techniques are expensive. Furthermore, subjectivity among age analysts makes repeatability challenging, resulting in difficult to quantify bias and imprecision of age estimates. In an effort to reduce cost and improve the repeatability of aging fish, we investigated an alternative approach using Fourier Transformed Near-Infrared Spectroscopy (FT-NIRs) and Partial Least Squares regression (PLSr) models. The primary objectives of the study were to 1) ascertain the precision with which this method can estimate ages for *G. macrocephalus*, 2) investigate if such an approach should include annual updates to a model structured on multiple years of data (Multiyear Model) or if models should be re-fitted and run independently for each year, and 3) estimate the efficiency (time saved) of using this approach. PLSr models were fitted to three years of survey data (2010, 2016, and 2017). Leave-One-Out Cross Validations (LOOcv) of models yielded high precision relative to reference ages (r^2 = 0.888 – 0.868). Percent Agreement (PA) between model age estimates and reference ages (PA = 71% – 65%) was comparable to between reader agreement (PA = 70% – 63%). Model estimates consistently had slight negative bias in older fish (< 7 years). After models are fitted, this method has the ability to estimate up to 120 ages per hour, compared to the approximately 10-15 ages per hour produced by age readers.

Kerry Accola, MS

Major Professor: John Horne

Do Seattle's seawall modifications influence juvenile salmon migration along the urban waterfront? An acoustic perspective

Seattle's waterfront is a key migration route for three species of juvenile Pacific salmon including: Chinook (*Oncorhynchus tshawytscha*), pink (*Oncorhynchus gorbuscha*), and chum (*Oncorhynchus keta*). The hardwired tendency of salmon to migrate in nearshore waters results in close association with coastline urbanization, including piers and seawalls. Seattle's seawall was replaced in 2017 with modifications intended to aid juvenile Pacific salmon in their migration. Modifications include: light-penetrating glass blocks in the overhanging sidewalk to light the water below, marine mattresses along the seawall restore shallow water depths, and textured seawall and shelves for invertebrate colonization. The objective of this research is to study the influence of the seawall modifications on juvenile salmon migrations. A high-frequency acoustic camera quantifies salmon and other fish population densities as they move along the urban waterfront through modified and original seawall habitats. Acoustic surveys at set transects during April-August 2019 compared salmon distributions and densities 1) between modified and original seawall habitat,

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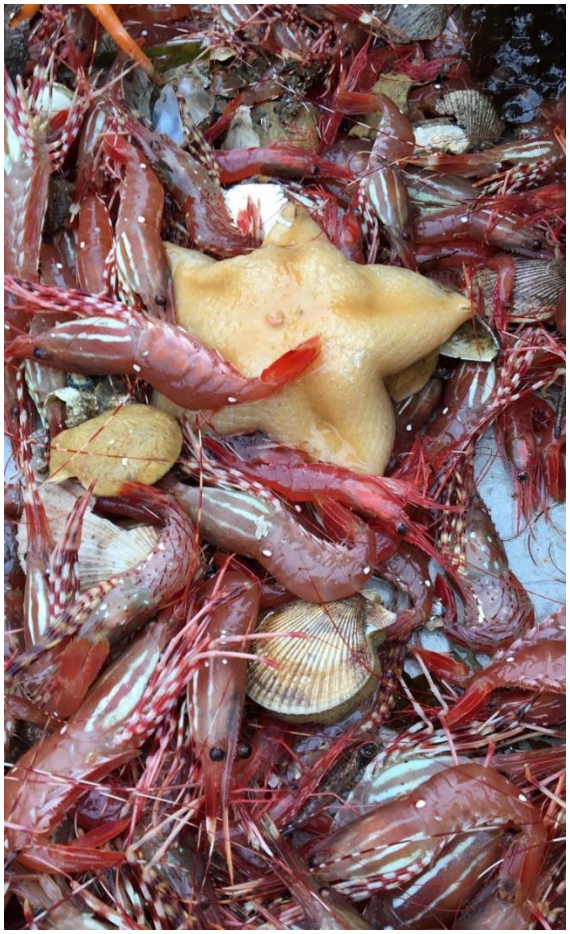
2) during day and night, 3) by overhead structures with varying ambient light, and 4) compared to snorkeler fish count densities. Initial acoustic results suggest that higher salmon densities occur in modified seawall habitat, at night than during the day in modified habitat, and that some salmon migrate around pier ends to avoid overhead structures. Results from this study can be used to evaluate the cost-benefit of fish-friendly coastal armoring for the next phase of Seattle's seawall and at similar sites throughout the world.

Katie McElroy, PhD

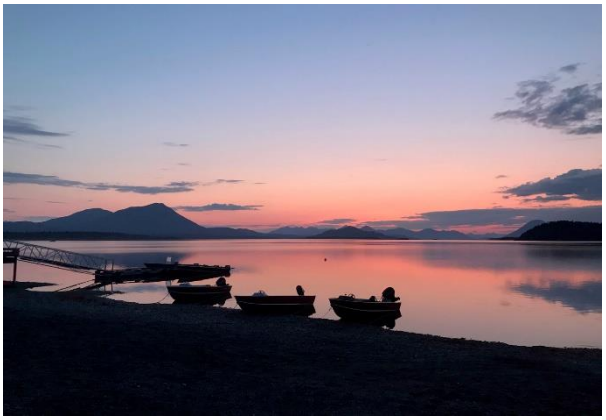
Major Professor: Ray Hilborn & Thomas Quinn

Can we evaluate the Marine Life Protection Act?

The coast of California hosts one of the largest experiments in the use of Marine Protected Areas (MPAs) in the world. In 1999, the Marine Life Protection Act (MLPA) established 124 MPAs along the California coast, creating a "network" of protected areas, and specified six goals to guide the establishment, enforcement, and monitoring of these areas. For over 20 years, multiple agencies, universities, and non-profit organizations have been involved with monitoring and science in these protected areas. Leveraging these 20 years of data, we now ask if the goals of the MLPA can be evaluated, a crucial first step to understanding if the MLPA is doing what it was designed to do. We reviewed the legislation governing the establishment of the MLPA, and the scientific literature resulting from the implementation process and follow-up evaluations. We completed 18 interviews with key participants and identified what data have been collected, and what evaluations have been done. Ultimately, we found that current reports do not robustly evaluate the economic or ecologic impact of the MLPA. While an incredible amount of data has been collected on MPA and reference sites on the California coast, ambiguous goals, inadequate financial and human resources, insufficient years of baseline studies, and problems in experimental design make the MLPA unevaluable in its current state.



Slime star, spot prawns, and pink scallops. Contents of a bottom trawl conducted at Friday Harbor Labs.
Photo: Lindsay Alma



Sunset from field camp at Lake Aleknagik
Photo: Katie McElroy

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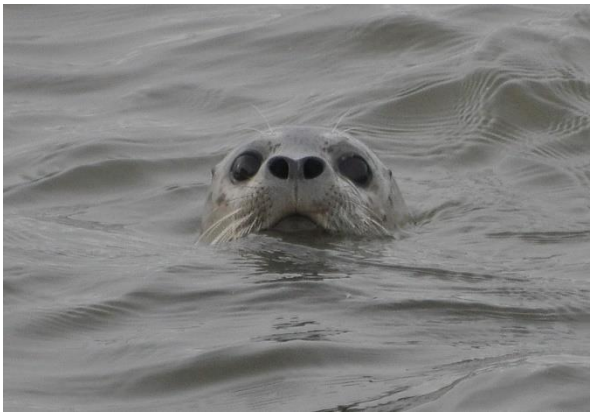
POSTER SESSION

Jennifer Gardner, MS

Major Professor: Luke Tornabene

New Species of Snailfishes from the Aleutian Islands, Alaska

Worldwide, over 430 species of liparids have been described and allocated to about 32 genera. The diversity in the North Pacific is particularly high, with more than 150 species of snailfishes in 17 genera. *Careproctus* is the most specious genus in the region, containing over 60 species, though it has been shown to be paraphyletic both globally and locally in the North Pacific. Three species of *Careproctus* from the Aleutian Islands, Alaska, all with variegated coloration have been described recently. These species (*C. comus, C. faunus,* and *C. staufferi*) were recovered in a well-supported clade with *Careproctus* (*Temnocora*) *candidus* in recent molecular phylogenetic hypotheses and prompted our reevaluation of the status and diagnosis of *Temnocora*. Presently recognized as a subgenus of *Careproctus*, the monotypic genus *Temnocora* had been primarily diagnosed by the presence of a lobed dorsal fin and a slitted pupil, characters that these species lack. Here we will describe some new species from the Aleutian Islands that appear most similar to *C. candidus* in having a variegated coloration, a slit pupil, and a partially lobed dorsal fin. They differ based on vertebral counts, morphometrics, and characteristics of the dorsal fin. We discuss the resurrection of the newly diagnosed genus *Temnocora* and the allocation of these species to the genus. The description of new species related to *C. candidus* and the potential resurrection of *Temnocora* will provide important steps to resolving the paraphyly of *Careproctus*, the most diverse genus within a diverse marine fish family.



Spotted seal at the waterfront in Kotzebue, AK, October 2018
Photo: Jessica Lindsay

Sam Ghods, MS

Major Professor: Luke Tornabene

Evolutionary Development in Anglerfishes (Teleostei, Ceratioidei): An investigation into the phylogenetic economy of morphological parts

This project aims to describe differences in the development and specialization of skeletal elements in male deep-sea anglerfish (Suborder Ceratioidei). While some studies have investigated the origin and development of the characteristic lure of the female anglerfish, few to no studies have examined the homologous elements or lack thereof in males of this group. Specifically, I am interested in describing which elements in male anglerfish of the genus Melanocetus are adapted to form the specialized jaw by which he bites and latches into the female during reproduction. My aim is to CT scan and subsequently clear and double-stain a complete developmental series of Melanocetus johnsonii and examine the metamorphosis of the upper jaw from larvae to sexually mature adult. The ultimate goal of this project is to describe the origin and development of the specialized denticular apparatus in male anglerfishes and how this relates to female development. I will examine mainly skeletal development and also conduct histological dissections to describe the structure of the denticular teeth and bones.

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Madison Heller-Shipley, MS

Major Professor: André Punt

Risk avoidance – MSE collaboration for Bering Sea Tanner crab

Eastern Bering Sea Tanner crab (*Chionoecetes bairdi*) is one of the State of Alaska's more variable fisheries and experiences large fluctuations in annual abundance, which has led to multiple closure years since its establishment. In 2014 to 2015, Tanner crab harvest went from 20 million pounds to 0, and uncertainty surrounding the performance of the current harvest control rules (HCR) lead to interest in modifying them to better account for stock status and potentially reduce large-scale changes in catch. Management Strategy Evaluation (MSE) accounts for assessment error and process error in population dynamics, involving simulating a managed system to provide information for decision-makers tasked with selecting a management strategy for implementation. MSE performed without stakeholder input may fail to address key issues. A collaborative workshop featuring stakeholders, university affiliates, and managers was convened where MSE based on the current Tanner crab assessment model was deemed the most appropriate way to test candidate HCRs. To ensure a cooperative and transparent development process, there has been substantial communication among industry representatives, managers, and scientists. Objectives of the MSE and corresponding performance statistics were determined collaboratively to report results in terms meaningful to decision makers while considering stakeholder input on risks to the fishery and trade-offs. This project represents a case study in collaboration, highlighting how concerted interactions with industry, managers, and scientists can distill highly technical processes into coherent and tractable results.

Bob Oxborrow, MS

Major Professor: Charles Simenstad

Epibenthic prey communities along an urban environmental gradient

Seawalls and piers impact out-migrating juvenile salmon by deepening nearshore water and shading the environment. Previous studies along Seattle's waterfront have shown that small epibenthic crustaceans such as amphipods and harpacticoid copepods are greatly reduced by pier shading and that juvenile salmon occurring there feed less on these types of prey. A large section of Seattle's seawall needed to be replaced due to damage caused by wood-boring isopods and an earthquake in 2001. To reduce the impacts of these structures on out-migrating salmon and increase epibenthic prey availability, the new section of seawall includes three habitat enhancements including a raised bench to reduce shoreline water depths, a textured seawall to increase habitat diversity, and a glass paneled walkway to allow photosynthetically active radiation to penetrate to the water below piers. The objectives of this study are to determine the impacts of the new seawall on the epibenthic prey community and to determine if any affects are reflected in juvenile chum salmon diets. We sampled the epibenthic community in 2018 to examine differences along the raised bench and the seawall between and underneath the piers and in 2019 on the seawall at five sites along an environmental gradient including the old and new seawalls and un-armored reference sites. Juvenile chum salmon were also collected to determine gut contents at the same sites. We expect the epibenthic community along the enhanced seawall to be more like the reference sites than to the unenhanced seawall and that this change will be reflected in the diets.

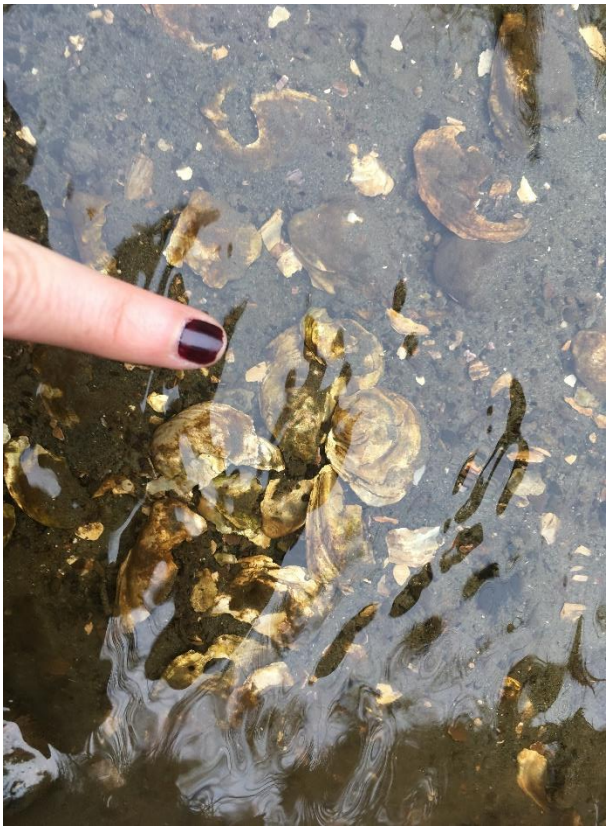
Abstracts

Kylie Sahota, Undergraduate
Raegan Jarvis, Undergraduate

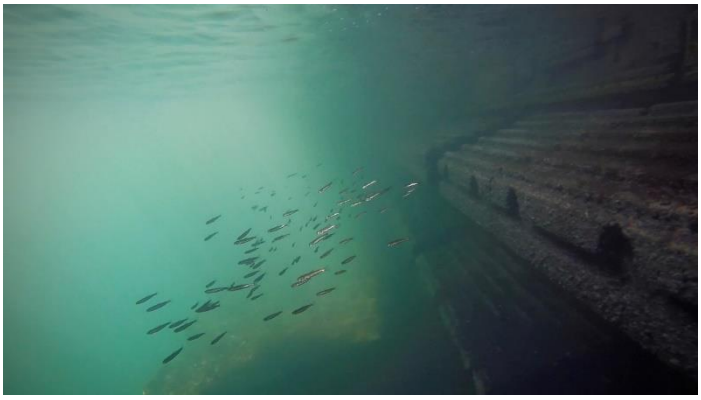
Major Professor: Christian Grue

Is table salt a viable alternative for the control of burrowing shrimp on shellfish beds in Washington state?

Imidacloprid (IMI), a neonicotinoid insecticide, is being sought by shellfish growers to control burrowing shrimp (ghost shrimp, *Neotropea californiensis*) in Willapa Bay and Grays Harbor, Washington. The shrimp destabilize sediments resulting in poor survival and low yields of the commercially harvested Pacific oyster (*Crassostrea gigas*), threatening the local shellfish industry. A permit for the use of IMI has been denied by the State, Pacific County has declared an economic emergency, and the outcome of an appeal by the growers remains uncertain. We have undertaken studies to determine if un-iodized table salt may be an alternative to IMI, specifically targeting juvenile shrimp (recruits) inhabiting the upper 10-15 cm of the sediment. Studies in 2018 indicated that a 2-3-fold increase in salinity resulted in 100% mortality when juveniles were exposed in artificial seawater. In 2019, we exposed juveniles (3 replicates, 5 shrimp each) within 10 cm of native sediment to five different salt solutions to achieve sediment pore water salinities of 25 (ambient, control), 35, 50, 70, and 100 ppt. Salt solutions were prepared with native seawater, added on top of the sediment (depth = 2 cm), and allowed to percolate through the sediment column for 6 h (low tide). At 6 h, 2 cm of ambient seawater (25 ppt) were added to simulate tidal inundation and allowed to remain on the surface for 12 h (low-high + high low tide) with two subsequent drawdowns and tidal inundations at 25 ppt (total test duration = 48 h). The sediment was then sieved to remove the shrimp and determine mortality. Average survival of controls (25 ppt) was 73.3% whereas none of the shrimp exposed to elevated salinities survived. Additional tests are underway to examine different exposure scenarios. Results to date suggest table salt may be a viable and greener alternative to IMI.



Collecting subfossil Olympia oysters in Lynch Cove, Hood Canal.
Photo: Julieta Martinelli



A school of juvenile chum salmon along the seawall in Seattle, WA.
Photo: Mike Caputo

Acknowledgements

The success of the 30th Annual School of Aquatic and Fishery Sciences Graduate Student Symposium is due to the efforts of many dedicated students, faculty, and staff. Thank you for contributing your time, ideas, and energy. Each of you has played a key role in creating this year's event and your hard work has resulted in a wonderful showcase of our school's current graduate student research.

We would like to specifically thank the following volunteers:

Mark Scheuerell	Workshop Organizer
Isadora Jimenez	Workshop Organizer
Sean Rohan	A/V Coordinator
Megan Feddern	Judge Coordinator
Natalie Mastick	Food Coordinators
Rebekah Stiling	Food Coordinators
Anonymous student, post-doc, and faculty judges.	

Thank you to the volunteers helping with set-up, clean-up, baked goods, session moderation, and ballot counting for making this day run smoothly. These volunteers include Davey French, Kristin Privitera-Johnson, Grace Crandall, Lindsay Alma, Laura Spencer, Lee Qi, Stephanie Thurner, Marta Gomez-Buckley, Corinne Klohmann, Yaamini Venkataraman, Jeremy Axworthy and several more who volunteered after the program was complete.

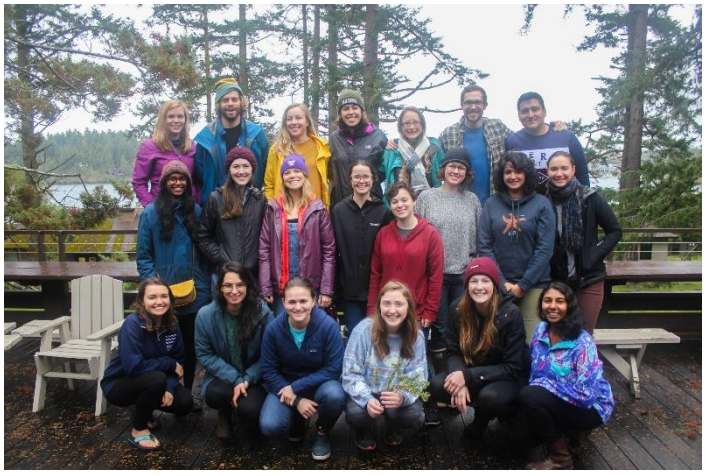
Thank you to all the graduate students contributing oral and poster presentations for being eager to share your research.

The Graduate Student Symposium is funded through contributions from the Skau Endowment. We offer sincere thanks to the friends and family of Oscar Skau for your generous gifts to School of Aquatic and Fishery Sciences.

We acknowledge the Coast Salish peoples of this land, the land which touches the shared waters of all tribes and bands within the Suquamish, Tulalip, and Muckleshoot nations.

We appreciate your attendance at the 30th Annual School of Aquatic and Fishery Sciences Graduate Student Symposium and we hope you enjoy your time with us.

Sincerely,
Jennifer Gardner, Sean Rohan, and Eileen Bates
2019 GSS Coordinators



Group photo from the 2019 Graduate Student Retreat
Photo: Yaamini Venkataraman