The University of Washington School of Aquatic and Fisheries Sciences presents

THE 29TH ANNUAL

GRADUATE STUDENT SYMPOSIUM

THURSDAY, NOVEMBER 15 2018

Oral Presentations

9am to 5pm in Anderson 207

Poster Presentations and Reception

5pm to 8pm in the FSH lobby

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

Program

The annual Graduate Student Symposium, now in its 29th year, is a highlight on the SAFS academic calendar. For almost 30 years, the GSS has given students across the School, as well as in Quantitative Resource Ecology and Management Program, an opportunity to present their past and ongoing work. There are many ways students can present their work within the School and to the broader scientific community, but this is the only time the entire School community is present.

The GSS should be seen in the broader context of the School itself, which is turning 100 in April 2019. The School has evolved from being focused on food production, and the biology and ecology of target species (salmon, halibut, herring and crab in the 1920s and 1930s; the first thesis that included "pollock" in its title was by Sukwoo Chang in 1974) to a School where conservation, genetics, and even corals and parasites are discussed as often as stock assessment and fisheries production.

The School will celebrate its 100th birthday in 2019 with series of events culminating in a 2.5 day symposium with sessions on biology and ecology, aquaculture, fisheries management, ecosystem considerations, and the future of Aquatic and Fishery Sciences. The speakers will include faculty, current students and friends of the School, but most of the speakers will be alumni, and many of them will have given presentations at the Graduate Student Symposium in previous years.

Our outstanding graduate students continue to pose and then address questions which will lead to a better understanding of how species, and marine and freshwater systems operate, and the impact of human activities on them. The talks and posters at this year's GSS once again cover a broad range of topics. I am particularly pleased to see so many talks from students mentored by our newest faculty – the future of SAFS is very bright indeed! This year's talks address key questions related to monitoring of species of conservation concern, modelling to support management, ecosystem-based management as applied to salmon populations in Alaska and the consequences of increased CO_2 levels. I was also pleased to see at least one talk that addresses how fisheries science impacts the health of communities, an issue that will become increasingly important 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 am proud to address you all as Director, and to continue to be part of this vital research community.

André E. Punt

Schedule

8:45 – 9:00 Coffee & light breakfast

9:00 WELCOME AND OPENING REMARKS
Forest Club Room, 207 Anderson Hall,
2018 GSS Coordinators
Dr. André Punt, Director, School of Aquatic & Fishery Sciences

9:15 – 10:15 Session I
Moderator: Davey French

10:15 – 10:35 MORNING BREAK

10:35 – 11:40 Session II
Moderator: Grant Adams

11:40 - 1:00 LUNCH

1:00 – 2:00 Session III
Moderator: Catrin Wendt

2:00 – 2:15 AFTERNOON BREAK I

2:15 – 3:15 Session IV
Moderator: Yaamini Venkataraman

3:15 – 3:30 AFTERNOON BREAK II

3:30 – 4:45 Session IV
Moderator: Marta Gómez-Buckley

4:45 CLOSING REMARKS

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

A chain covered in invertebrates, sea stars are surrounded by their favorite food, mussels
Photo: Lindsay Alma

Cover design: Melanie Davis

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

Presentations

SESSION I
Moderator: Davey French

9:15 Maia Kapur
Can the status of pelagic shark populations be determined using simple fishery indicators?

9:30 Zach Koehn
Connecting fishery science to health policies for diet-specific solutions in low-income low food access communities: a population health approach

9:45 Madison Shipley
Cooperation and Collaboration: The Tanner crab MSE story

10:00 Grant Adams
Sensitivity of multispecies statistical catch-at-age models to inclusion of annual recruitment and fishing mortality deviations as random effects.

10:15 – 10:35 MORNING BREAK

Walruses haul out on ice floes in the Beaufort Sea
Photo: Jenny Stern

Rachel Fricke filtering water for phytoplankton on the shore of Kulla Kulla Lake
Photo: Rebekah Stiling

SESSION II
Moderator: Grant Adams

10:35 Alex Lincoln
Managing salmon for wildlife: does harvest limit salmon consumption by brown bears?

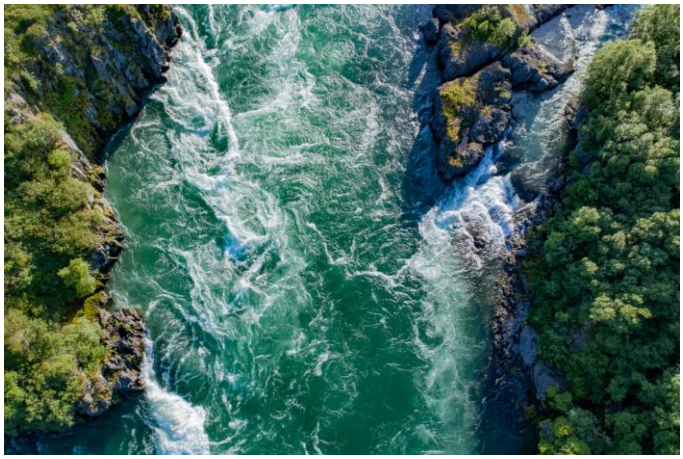
10:50 Martini Arostegui
Potential biological control of schistosomiasis by fishes in the lower Senegal River basin

11:05 Davey French
Geomorphic controls on organic carbon cycling in boreal rivers

11:20 Lindsay Alma
Scallops Under Stress: Climate related stressors affect molecules, microbes, mantle and everything in-between

Presentations

11:40 - 1:00 LUNCH BREAK



Newhalen River – Iliamna Lake, Alaska
Photo: Jason Ching

SESSION III

Moderator: Catrin Wendt

1:00 Rachel Manning
A new genus of Caribbean deep reef gobies

1:15 Jeremy Axworthy
Microplastic ingestion by thermally-stressed reef-building corals

1:30 Calder Atta
Novelty or not? A new Red Sea reef fish community

1:45 Jennifer Gardner
Rolling the dice: diceCT methods for visualization of soft tissues

2:00 – 2:15 AFTERNOON BREAK I

SESSION IV

Moderator: Yaamini Venkataraman

2:15 Laura Spencer
Carryover effects of parental low pH exposure in the Olympia oyster (*Ostrea lurida*)

2:30 Natalie Mastick
Role specialization in bubble-net feeding humpback whales in the southern Gulf of Maine

2:45 Erica Escajeda
Interannual variability in the acoustic presence of fin whales (*Balaenoptera physalus*) in relation to environmental conditions in the Bering Strait

3:00 Catrin Wendt
Pumped up prevalence: Exploring drivers of *Ichthyophonus* disease in Pacfic herring

3:15 – 3:30 AFTERNOON BREAK II

Sockeye salmon take a break during their upstream migration
Photo: Alex Lincoln

Presentations

SESSION V
Moderator: Marta Gómez-Buckley

3:30 Stephanie Thurner
A mathematical theory for extinction risk from human exploitation

3:45 Sam May
Salmon homing in time and space: Factors influencing fine-scale structure in wild Alaskan sockeye salmon (*Oncorhynchus nerka*)

4:00 Lee Cronin-Fine
Comparing a numerical integration method for constructing size-transition matrix with other construction methods

4:15 Evan Fiorenza
It's a worm world: Meta-analysis reveals long-term change in the abundance of anisakid nematode parasites of marine fishes and invertebrates

4:30 Michaela Lowe
Evaluating geochemical tracers in fish fin rays: a non-lethal approach for threatened species

Alaska Salmon Program staff beach seine for juvenile fish on Lake Aleknagik, Alaska
Photo: Katie McElroy

POSTER SESSION

5:00 – 8:00 Poster Session & Reception at SAFS 2nd Floor Kitchen

Eileen Bates
Analyzing the accumulation of trace metals in mussels (*Mytilus trossulus*) under global climate change conditions

Grace Crandall
Effects of temperature change and *Hematodinium* spp.- infection (Bitter Crab Disease) on Tanner Crabs (*Chionoecetes bairdi*)

Jordan Healy
A novel method for ageing demersal fish of the Bering Sea, using Fourier Transformed Near-Infrared Spectroscopy (FT-NIRS)

Lily McGill
Estimating the spatial and temporal dynamics of water sources across a river network using stable isotopes

Hyejoo Ro
Impacts of a trematode parasite on the behavior of an invasive shore crab in the northwest Atlantic

Jennifer Stern
Assessing the timing and rate of fur growth in zoo polar bears

Abstracts

A bald eagle anxiously awaits its next meal – Dutch Harbor, Alaska, June 2018

Photo: Erica Escajeda

Researchers measure Chinook salmon – Dillingham, Alaska

Photo: Jason Ching

Abstracts

SESSION I

Maia Kapur, Ph.D

Major Professor: André Punt

Can the status of pelagic shark populations be determined using simple fishery indicators?

Calls to develop alternative methods of assessing the population status of pelagic shark populations have increased substantially in recent years. An interim solution has been the development of more subjective evaluation of data series (indicator-based analysis) rather than predictions from complex stock assessment models. This study examines the reliability of indicators for predicting population status (i.e. whether it has been overfished) and the fishing pressure (i.e. whether overfishing is occurring) of large pelagic sharks, based on these fishery indicator trends alone. We simulate a variety of large pelagic shark populations under different exploitation scenarios using life history parameters, and measurable fishery indicators information (catch-per- unit of effort - CPUE; and average length - AL). Our simulation results, designed to be generalized (via sampling of realistic distributions) but based loosely on the shortfin mako shark, showed that the reliability of fishery indicators for establishing population status is dependent upon the length of the time series analyzed. These caveats are critical to the proper evaluation of population trajectories that underlie the most important conservation decisions being made for sharks today.

Sleeping tagged northern fur seal female and her pup
Photo: Amanda Warlick

Zach Khoen, Ph.D

Major Professor: Ray Hilborn & Eddie Allison

Connecting fishery science to health policies for diet-specific solutions in low-income low food access communities: a population health approach

Fisheries will not alone feed the world's growing population. However high micronutrient density of seafood *will* play a critical role in alleviating health concerns among nutrient-deficient communities. After two decades of careful conservation-based management, US West Coast assessments indicate that many of its stocks have rebuilt from severe overfishing. Amidst these ecological successes, rural communities rank high among coastal regions for poverty and diet-based noncommunicable diseases (NCDs) to the detriment of wellbeing. This follows a pattern of inequity increasingly common across the development spectrum: households with low income and low access to healthy foods (LILA) incentivize residents to select more affordable, calorie-rich but nutrient-poor foods. Without developing a relational understanding of sustainable fisheries production, healthy diets and NCDs, it is impossible to consider how nutritional value of local fisheries might reconcile with the ecological and economic paradigms that dominate current management discourse. As a result, conservation decision-making may inadvertently ignore the potential for development of local seafood supply focused on health outcomes, and a benefit of marine science to contribute to public health is lost. This transdisciplinary research synthesizes place-based data from fisheries landings, socioeconomic and food access surveys, and public health information. We use a population health approach to identify where nutritious and underutilized fish are landed and evaluate whether this fish might become available to LILA households. In doing so we encourage equitable and inter-sectoral solutions to alleviate diet-based health concerns that respect the need for continued conservation of fisheries resources and livelihoods in coastal communities.

Abstracts

Madison Shipley, MS

Major Professor: André Punt

Cooperation and Collaboration: the Tanner crab MSE story

Tanner crab, *Chionoecetes bairdi*, is one of several commercial crab fisheries in the Eastern Bering Sea. The Tanner crab fishery is cyclic in nature due to the highly variable recruitment and has historically had substantial fluctuation in abundance and biomass from year to year resulting in highly irregular catches. Crab stocks in the Bering Sea are managed under a Fishery Management Plan (FMP), with management shared between the National Marine Fishery Service (NMFS) and the Alaska Department of Fish and Game (ADFG). In 2015, there was a boom in Tanner crab abundance and a 20-million-pound fishery was opened, but the following year, due to an insufficient number of females, the fishery was closed. This prompted a re-evaluation of the Tanner crab harvest strategy. A Tanner crab steering committee was formed which included participants from NMFS, ADFG, Universities, and crab stake holders, working together to identify, harvest strategies and objectives to test in a Management Strategy Evaluation (MSE). This projection tool will allow the selection of a strategy that will serve the objectives of both managers and stakeholders. This level of collaboration is uncommon in management and allows for the best science to take place answering specific questions from managers necessary to create a useful tool, and answer stakeholder questions to give a comprehensive understanding of management decisions regarding catch limits.

Rough skinned newt (unsuccessfully) exhibiting defensive posture
Photo: Lennah Shakeri

Grant Adams, Ph.D

Major Professor: André Punt

Sensitivity of multispecies statistical catch-at-age models to inclusion of annual recruitment and fishing mortality deviations as random effects

The development of analytical tools that address ecosystem based fisheries management (EBFM) needs is essential for rationally managing fisheries resources in the face of changing climate and ecological processes. Multispecies statistical catch-at-age (MSCAA) models are one tool of particular value for providing both tactical and strategic EBFM advice by accounting for trade-offs among fisheries for multiple species. MSCAA links multiple single-species age-structured models via predator-prey interactions conditioned on bioenergetics and diet information. Within MSCAA models, annual recruitment and fishing mortality are commonly estimated as deviations away from a mean process. For most MSCAA models, penalized likelihood approaches have been used to constrain deviations away from zero. Such an approach requires the *a priori* selection of variance associated with each process. However, this can limit our understanding of the variation in both recruitment and fishing mortality and may also have an impact on estimates of biological reference points. Alternatively, recruitment and fishing mortality deviations can be treated as random effects, allowing for the estimation of variance terms. Using a MSCAA developed for groundfish in the Bering Sea (CEATTLE for climate-enhanced, age-based model with temperature-specific trophic linkages and energetics), I evaluate the sensitivity of MSCAA models to the incorporation of annual recruitment and fishing mortality deviations as random effects. This research addresses the need for a greater understanding of parameter uncertainty in MSCAA models prior to further implementation in fisheries management.

Abstracts

SESSION II

Alex Lincoln, MS

Major Professor: Thomas Quinn

Managing salmon for wildlife: does harvest limit salmon consumption by brown bears?

Ecosystem-based management (EBM) has received increased attention in recent decades, particularly in systems where human activity competes with other organisms for a resource. In particular, Pacific salmon (*Oncorhynchus spp.*) may benefit from EBM, given their economic and ecological importance to marine, freshwater, and terrestrial ecosystems. Salmon are a key component of brown bear (*Ursus arctos*) diet in coastal Alaskan populations, and so there is interest in managing salmon populations for both commercial fishing and to support bear populations. Salmon consumption is linked to increased bear productivity and population density, and so it has been suggested that increasing salmon escapement goals to allow more fish to reach spawning streams would increase bear population density through increased consumption of salmon. However, a saturating relationship exists between salmon abundance and the number killed by bears, and bears eat less tissue per fish as salmon abundance increases. Thus, the overall annual biomass of salmon consumed by a bear may not increase with the suggested increase in prey abundance, as previously assumed, but rather may remain stable or even decrease at very high prey abundance. Using decades of data from sockeye salmon (*O. nerka*) carcass surveys, we determined the relationship between salmon availability and salmon consumption across three systems in southwestern Alaska, and found a saturating relationship between biomass available and biomass consumed. From this relationship, we explored predicted consumption under various fisheries management scenarios. Our findings have implications in determining the sufficiency of current salmon management for wildlife needs.

Field station in Cordova, Alaska
Photo: Catrin Wendt

Martini Arostegui, Ph.D

Major Professor: Thomas Quinn

Potential biological control of schistosomiasis by fishes in the lower Senegal River basin

More than 200 million people in sub-Saharan Africa are infected with schistosome parasites. Transmission of schistosomiasis occurs when people come into contact with larval schistosomes emitted from freshwater snails in the aquatic environment. Thus, controlling snails through augmenting or restoring their natural enemies, such as native predators and competitors, could offer sustainable control for this human disease. Fishes may reduce schistosomiasis transmission directly, by preying upon snails or parasites, or indirectly, by competing with snails for food or by reducing availability of macrophyte habitat (i.e., aquatic plants) where snails feed and reproduce. To identify fishes that might serve as native biological control agents for schistosomiasis in the lower Senegal River basin – one of the highest transmission areas for human schistosomiasis globally – we surveyed the freshwater fish that inhabit shallow, nearshore habitats and conducted multivariate analyses with quantitative diet data for each of the fish species encountered. Ten of the sixteen fish species we encountered exhibited diets that may result in direct (predation) and/or indirect (food competition and habitat removal) control of snails. Fish abundance was low, suggesting limited effects on schistosomiasis transmission by the contemporary

Abstracts

fish community in the lower Senegal River basin in the wild. Here, we highlight some native species – such as tilapia, West African lungfish, and freshwater prawns – that could be aquacultured for local-scale biological control of schistosomiasis transmission.

Davey French, MS

Major Professor: Daniel Schindler

Geomorphic controls on organic carbon cycling in boreal rivers

Major uncertainties in transport and processing of organic carbon (OC) and nutrients in rivers limit our ability to understand watershed responses to perturbations such as climate change and land development. Boreal rivers in particular drain vast, carbon-rich landscapes subject to twice the warming rate of lower latitudes. Watershed geomorphology shapes the spatial configuration of stream networks and influences the composition and quantity of OC delivered to streams by governing land cover, hydrologic regimes, and soil and organic matter accumulation and residence times. The timing, magnitude, and spatial distribution of OC and instream nutrient availability shape the base of aquatic food webs. We used recently developed spatial stream network models coupled with GIS-derived geomorphic watershed characteristics to examine controls on riverine OC across multiple spatial scales in the Kuskokwim river, Alaska. We also compare the behavior of OC with conservative and biologically reactive streamwater constituents to evaluate instream processing versus passive transport.

Lindsay Alma, Ph.D

Major Professor: Jacqueline Padilla-Gamiño

Scallops under stress: Climate related stressors affect molecules, microbes, mantle, and everything in-between

Despite increasing research efforts, there are still many gaps in our knowledge to understand the mechanisms involved in the organism's responses to multi-stressors associated with CO_2. This project is the first to explore the interactive effects of high pCO_2 and temperature on the acclimation and acclimatization potential of the purple-hinge rock scallop (*Crassadoma gigantea*). Scallops were exposed to variable pCO_2 and temperature treatments to test acclimation potential in the lab. Subsequently, scallops were placed in the field at variable depths to assess acclimatization potential in their natural habitat. Thermal stress was the primary driver for increased short-term oxygen consumption rates, growth, and changes in the microbiome. A combination of factors including temperature, pCO_2, and other oceanographic variations (in field experiments), additively or synergistically affected scallop's shell morphology, total lipids, and fatty acid content. Results demonstrate that thermal stress is the primary source for fluctuations in phenotypic plasticity, however combinations of stressors further disrupt homeostasis and may have long term consequences for *C. gigantea* fitness, the ecosystem they support, and their emerging presence in the aquaculture industry. Furthermore, this project highlights the importance of using dynamic marine environments as a natural lab to predict future acclimatization potential of a species as global change continues.

SESSION III

Rachel Manning, MS

Major Professor: Luke Tornabene

A new genus of Caribbean deep reef gobies

Resultant from the Smithsonian's Deep Reef Observation Project (DROP) and UW submersible expeditions on Western Atlantic mesophotic deep reefs from 2011 to present, both published literature and additional preliminary phylogenetic analyses identified an undescribed monophyletic group of Caribbean deep reef gobies (Teleostei: Gobiidae). Seven to eight putative new species are believed to compose this undescribed monophyletic group in the Gobiid *Priolepis* lineage. Presently, this putative new genus appears to be most closely related to several other Gobiid genera including *Lythrypnus, Trimma, Paratrimma, Trimmatom, Feia, Priolepis,* and *Egglestonichthys*. I will be conducting phylogenetic

Abstracts

and morphologic analyses of specimens collected across 5 Caribbean localities (Bonaire, Curacao, St. Eustacius, Dominica, and Roatan) from submersibles *Idabel* and *Curasub* to test the validity of this monophyly. If validated, this study will result in a new genus and new species descriptions, along with phylogenetic placement of the genus within family Gobiidae.

Herring spawn on eel grass
Photo: Eleni Petrou

Jeremy Axworthy, MS

Major Professor: Jacqueline Padilla-Gamiño

Microplastic ingestion by thermally-stressed reef-building corals

Reef-building corals are increasingly threatened by a suite of stressors including rising sea temperatures and pollution. In response to thermal stress, corals can bleach and decrease autotrophic energy acquisition. When bleached, some coral species are thought to shift more towards heterotrophy to acquire energy from zooplankton. However, this may consequently lead to increased ingestion of other particles in the water such as microplastics (MP). We tested whether thermally stressed corals are at greater risk of MP ingestion by comparing MP and *Artemia* nauplii feeding rates in two Hawaiian coral species, *Montipora capitata*, and *Pocillopora damicornis*. Preliminary results show that *P. damicornis* ingested MP more readily than *M. capitata*, but *P. damicornis* only ingested MP when food was present. Under thermal stress, both species fed less on *Artemia* than when in ambient temperatures, contradicting previous studies on the role of heterotrophy in *M. capitata*. These results provide evidence that MP ingestion can vary considerably among coral species and suggest that some corals are at greater risk of MP pollution. Furthermore, these result challenge our current understanding of the role of heterotrophy in thermally-stressed corals, highlighting the need to continue research in this important aspect of coral biology in a changing world.

Calder Atta, MS

Major Professor: Luke Tornabene

Novelty or not? A new Red Sea reef fish community

Al Wajh lagoon in the Northern Red Sea contains a remote coral reef system that likely supports a novel fish community. The large (1500km^2), shallow (< 40m) lagoon experiences greater temperature and salinity fluctuations, and higher turbidity than most other Red Sea reefs. Since these conditions often influence coral communities and introduce physiological challenges, changes in reef-associated fishes are expected. We present much needed baseline data on fish biodiversity and benthic composition for this region. Underwater visual census of conspicuous fishes and standardized collections of cryptobenthic fishes were combined to provide a comprehensive assessment of these fish communities. We documented 153 fish species and operational taxonomic units, within 24 families, on a reef dominated by hard coral and soft sediment (39% and 32% respectively). The most diverse and abundant families were the Pomacentridae and Gobiidae, which contain several candidates for new species descriptions. Bray-Curtis dissimilarity distances for each site suggest a distinctive fish

Abstracts

community within the lagoon, and coefficients of variation for each species show high variation in distribution across the lagoon. Species accumulation curves predict that additional sampling would document many more species throughout Al Wajh. Our findings provide the most extensive biodiversity survey of fishes from this region to date, provide a foundation for studying reef ecology in environments with high stressors on coral, and record the condition of the reef prior to major coastal development occurring in the near future.

Julian Olden and Rachel Fricke navigate a waterfall on their approach to Upper Tuscahatchie Lake
Photo: Rebekah Stiling

Jennifer Gardner, MS

Major Professor: Luke Tornabene

Rolling the dice: diceCT methods for visualization of soft tissues

The oVert Thematic Collections Network is an NSF funded endeavor to produce publically available 3D scans across the vertebrate tree of life via X-ray computed tomography (CT). To date, CT scans of fishes typically capture dense structures such as bone, but diffusible iodine-based contrast enhanced CT (diceCT) can produce 3D scans of soft tissues. The majority of scans produced by oVert will be skeletons, but production of diceCT scans of select taxa are also an important component of this initiative. This method has been especially useful for projects focused on soft tissues, like looking at brain evolution across vertebrate lineages. While published works referencing diceCT from many different vertebrate taxa, including fishes, currently exist, published protocols or guidelines for iodine staining of fishes are lacking. The work presented here tests protocols for staining fishes, specifically snailfishes of the family Liparidae. Snailfishes from multiple genera (*Liparis* and *Careproctus*) were stained using different formulations (aqueous versus in ethanol), and rinse methods to determine the optimal protocol for a range of sizes of liparids. The methods developed here focus on the tradeoffs between optimizing visualization of tissues, minimizing degradation of specimens (including desiccation and long-term stain retention), and minimizing overall cost (including time required and chemicals used). From making specimen selection easier by detailing specimen condition before and after staining, to removing some of the guesswork around time of stain diffusion based on specimen size, this work aims to make future diceCT scanning of other fishes simpler, more efficient, and more easily repeatable.

SESSION IV

Laura Spencer, MS

Major Professor: Steven Roberts

Carryover effects of parental low pH exposure in the Olympia oyster (Ostrea lurida)

A broadening body of work indicates that low pH negatively affects fertilization and early life stages of many marine invertebrates. Oysters may, however, contain a unique capacity to keep pace with rapidly shifting climate stressors via genetic variation, epigenetic plasticity, or a combination of the two. To examine the transgenerational carry-over effects of ocean acidification on *Ostrea lurida,* the only oyster native to the United States' west coast, larval production, larval survival, juvenile growth, and juvenile survival in a natural setting were measured following adult-only exposures. First-generation hatchery reared broodstock from three sub-populations in the Puget Sound estuary in Washington State were exposed to elevated dissolved CO2, then conditioned and induced to spawn. I will present results on gonad development after pH exposure and subsequent fecundity, as well as survival to metamorphosis and juvenile stages, growth after nine months for a subset of the progeny, and survival during a deployment in four bays

Abstracts

within Puget Sound. Initial findings suggest a negative effect on juvenile size, but positive effect on survival during the deployment.

Natalie Mastick, Ph.D

Major Professor: Chelsea Wood

Role specialization in bubble-net feeding humpback whales in the southern Gulf of Maine

In many species, group foraging increases the ability of group members to find and exploit patchy prey. In one manifestation of group foraging, cooperative by-product mutualism, individuals obtain greater energetic gain by feeding together than they would alone. Humpback whales (*Megaptera novaeangliae*), which forage in groups by performing bubble-net feeding, are one of the few baleen whale species that use coordinated foraging. I used multi-sensor archival tag data from 26 whales from the southern Gulf of Maine to analyze individual bubble-net feeding behaviors. Linear mixed effects models assessed differences in dive behaviors as a function of group size. The results indicate that individuals were largely consistent in their bubble-net feeding behaviors regardless of group size, but that overall complexity of foraging dives decreased with increasing group size, when group members used a specific behavior, the upward spiral. These results suggest that individuals use specific roles, or stereotyped foraging behaviors, in group feeding events with different functional consequences for the collective fitness of the group. This suggests that there is a division of labor and role specialization among whales.

Erica Escajeda, Ph.D

Major Professor: Kristin Laidre

Interannual variability in the acoustic presence of fin whales (Balaenoptera physalus) in relation to environmental conditions in the Bering Strait

Fin whales (*Balaenoptera physalus*) are common visitors to the Alaskan Arctic during the summer, migrating through the Bering Strait and into the southern Chukchi Sea to feed on seasonally-abundant prey. The abundance and location of fin whales in the Chukchi Sea exhibits high interannual variability and may reflect varying environmental conditions. Using acoustic recordings from three moored hydrophones in the Bering Strait region, we identified fin whale calls during the open-water season (July–November) from 2009–2015 and investigated environmental drivers of interannual variability in fin whale presence. Detections of fin whale calls were highest in 2012 and 2015, and the majority of detections (96%) were recorded at the mooring located at the confluence of the nutrient-rich Anadyr and Bering Shelf water masses, ~35 km north of Bering Strait (site A3). Interestingly, the two years with the highest fin whale detections had very different environmental conditions. Colder temperatures, low salinities, and slow water speeds prevailed in 2012 while high temperatures and salinities, faster water speeds and thus higher transport through the Bering Strait prevailed in 2015. The disparity between 2012 and 2015 suggests there may be multiple combinations of environmental factors that draw fin whales into the Alaskan Arctic. There also may be other contributing factors to variability in fin whale presence that we did not examine. The results of our study corroborate previous observations of interannual variability in the presence of fin whales and contribute to our understanding of environmental influences on fin whale presence in the Chukchi Sea.

Researchers conduct beach seine surveys – Lake Aleknagik, Alaska
Photo: Jason Ching

Abstracts

Sockeye salmon migrating past a beaver dam – Iliamna Lake, Alaska
Photo: Jason Ching

Catrin Wendt, MS

Major Professor: Chelsea Wood

Pumped up prevalence: Exploring drivers of Ichthyophonus disease in Pacific herring

Following the 1989 *Exxon Valdez* Oil Spill and subsequent crash of the local herring fishery, the herring population in Cordova, Alaska has failed to recover. One possible mechanism preventing the recovery of the population is infectious disease, including ichthyophoniasis. *Ichthyophonus hoferi* is a protistan parasite that has been reported in more than 80 species of marine and freshwater fishes. It is one of the most economically and ecologically important pathogens of wild marine fishes. I used existing data on the monthly prevalence of Ichthyophonus infection was assessed in age zero Pacific herring (*Clupea pallasii*) at index locations including Cordova Harbor, AK (2015) and collected new data on prevalence at many sites in the Salish Sea, WA (including Port Angeles Harbor, Port Ludlow Harbor, and Admiralty Inlet) during 2018. A marked temporal increase in infection prevalence occurred in Cordova Harbor; however, analogous increases have not yet been detected from the other sampling locations. In this talk, I will discuss possible drivers of these differences in infection prevalence and outline a plan for testing these hypotheses in 2019.

SESSION V

Stephanie Thurner, MS

Major Professor: Trevor Branch

A mathematical theory for extinction risk from human exploitation

As human pressure on natural systems increases, there is an urgent need for general predictions of extinction risk caused by human exploitation. Because of the inherent complexity of a large combination of biological, economic, and social factors, we still lack a firm mathematical foundation for a general understanding of extinction risks. I am developing a multispecies mathematical model of extinction by human exploitation that identifies factors that most influence extinction risk from exploitation. During preliminary simulation runs, I have found that multi-species extinction pathways increase the overall extinction risk of both the target and non-target species when compared to the extinction risk predicted by single-species pathways. Additionally, simulations show that relative price, ease of catch, and animal location appear to be the most important factors in predicting extinction risk. As my simulation framework expands, I will continue to test the impact of these three factors on extinction risk

Sam May, MS

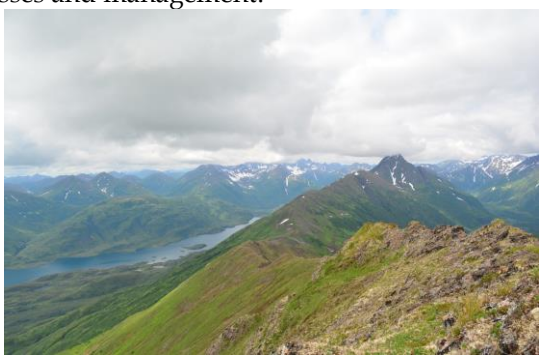
Major Professor: Kerry Naish

Salmon homing in time and space: Factors influencing fine-scale structure in wild Alaska sockeye salmon (Oncorhynchus nerka)

Population structure in freshwater salmonids contributes to a diverse portfolio of locally adapted, semi-isolated subpopulations, which buffer metapopulations and species and against decreases in productivity in any one subpopulation. However, the extent of population structure within individual small creek populations is unclear, primarily due to weak genetic structure. Addressing the scale and interactions of geographic and temporal structure has important implications for rates of inbreeding,

Abstracts

the extent of local adaptation, and the amount of gene flow within populations. Here we aim to use relatedness measures to infer fine-scale population structure within individual sub-populations of sockeye salmon (*O. nerka*) in the upper Wood River System, Bristol Bay, Alaska. We apply a genetic spatial autocorrelation analysis using entry-date and daily measures of in-creek location to determine if related individuals cluster together in fine-scale space and time. We demonstrate significant positive spatial autocorrelation and conclude that population structure exists within creeks at small geographic and temporal scales. We discuss how variation in behavior, life-history, and environment may contribute to structure. Finally, we discuss the implications of fine-scale structure for evolutionary processes and management.



Church Mountain and Little Togiak Lake, Alaska
Photo: Emily Iversen

Lee Cronin-Fine, Ph.D

Major Professor: André Punt

Comparing a numerical integration method for constructing size-transition matrix with other construction methods

Stock assessment methods for many invertebrate stocks, including crab stocks in the Bering Sea and Aleutian Islands region of Alaska rely on size-structured population dynamics models. A key component of these models is the size-transition matrix, which specifies the probability of growing from one size-class to another after a certain period of time. Size-transition matrices can be defined using three parameters, the growth rate (k), the asymptotic height (L_∞), and the variability in the size increment. Most assessments use mark-recapture data to estimate these parameters and assume that all individuals follow the same growth curve. Unfortunately, not accounting for individual variation in growth can result in biased estimates of growth parameters. It is also unrealistic to assume that every individual has the same k and L_∞. However, a method is now available that allows k and L_∞ to vary among individuals. This technique is compared to two other methods for creating size-transition matrices, each with different assumptions about individual variation in growth. The first assumes all individuals follow the same growth curve. The second assumes individuals follow one of three growth curves through the "platoon" method. This method divides the population into separate platoons, each with their own growth curve and size transition matrix. We conducted a simulation study comparing the performance of the three construction methods under a variety of scenarios such as whether individuals in the simulated growth population have their own growth parameters, and the number of mark-recapture data points to determine which performs best overall.

Evan Fiorenza, MS

Major Professor: Chelsea Wood

It's a wormy world: Meta-analysis reveals long-term change in the abundance of anisakid nematode parasites of marine fishes and invertebrates

The Anthropocene has brought substantial change to ocean ecosystems, but whether this age will bring more or less marine disease is unknown. In recent years, disease has devastated a diverse suite of marine species, including sea stars, abalone, urchins, and fishes. Is this apparent increase in disease due to increased observation and sampling effort, or to an actual rise in the abundance of parasites and pathogens? We examined the literature to track long-term change in the abundance of two parasitic nematode genera: *Anisakis* spp. and *Pseudoterranova* spp. These nematodes are occasionally transmitted to humans and can cause gastrointestinal ailments in people who accidently ingest worms in raw or undercooked fish and squid. A total of 123 papers published between 1967 and 2017 met our criteria for inclusion, which resulted in 939 data points (552 for *Anisakis* spp. and 387 for *Pseudoterranova* spp.) .

Abstracts

Meta-analysis revealed a global 90-fold increase in *Anisakis* spp. abundance (average number of worms / fish) over a 53-year period from 1962 to 2015 and 1.5-fold increase in *Pseudoterranova* spp. average abundance over a 37-year period from 1978 to 2015. These global shifts in of *Anisakis* and *Pseudoterranova* spp. abundance may have important implications for human health, marine mammal health, and fisheries profitability.

Michaela Lowe, MS

Major Professor: Daniel Schindler

Evaluating geochemical tracers in fish fin rays: a non-lethal approach for threatened species

Many freshwater and anadromous fish species have life histories that involve large-scale migrations among a variety of habitats. While historical fish ecology has emphasized long distance movements as a strategy used by adult fish during their spawning migrations, we now know that most fishes use extensive networks of habitat over their entire lives. A major challenge in the conservation of migratory fishes is to quantify the extent and locations of the habitat networks different populations use to complete their life cycles. Bull trout (*Salvelinus confluentus*) native to the Puyallup River basin rely on connectivity in rivers that span habitat from the alpine to the coastal plain. The conservation of this federally threatened species depends on protecting and restoring the networks of habitats necessary for completing its life-cycle; information that is currently unknown. Using geochemical tracers archived in fish fin rays, we are working to reconstruct the migration patterns of bull trout throughout this river network. The natural variation of strontium in river waters, dictated by geologic heterogeneity, is reflected in calcified structures of fish, and is a known reliable tracer used to reconstruct migratory patterns. Currently, strontium signatures in otoliths are predominantly used to reconstruct life history patterns, and require lethal sampling. To circumvent mortality, we use a technique that extracts sections of fin rays to evaluate geochemical tracers. This project evaluates variation in isotopic and elemental tracers of river waters and fish fin rays to infer movement patterns among different habitats.

POSTER SESSION

Eileen Bates, MS

Major Professor: Jacqueline-Padilla Gamiño

Analyzing the accumulation of trace metals in mussels (Mytilus trossulus) under global climate change conditions

Global climate change causes ocean acidification (OA), warming, and decreased dissolved oxygen (DO) in coastal areas, each of which can cause physiological stress to shellfish species. Compounding these changes, shellfish in Puget Sound face local pressures: waters with naturally low pH, regions that are seasonally hypoxic, and a growing coastal human population. Similar industrialized areas with high river discharge have been associated with high trace metal pollution. Changes in seawater pH can affect the solubility and speciation of metals, increasing their availability to marine organisms. Higher tissue concentrations of metals—most notably lead, arsenic, cadmium, and copper— may negatively impact shellfish. It is critical that we determine the combined effects of pH, temperature, and DO on trace metal bioaccumulation and its implications for shellfish health and human safety in Puget Sound. In our study, we aim to investigate the accumulation of trace metals in shellfish under climate change conditions. We will expose mussels from Puget Sound to four treatments: 1) ambient, 2) high temp, 3) low DO+low pH, and 4) high temp+low DO+low pH, for two months. After establishing a protocol to prevent trace metal contamination during sample preparation, we will use IPC-MS to analyze trace metal concentrations in the mussel tissue and associated water samples from before and after exposure to the treatments. Results from this study will reveal the effects of climate change on bioaccumulation of trace metals and provide the methodological groundwork for research on the physiological effects of increased trace metal concentrations on shellfish species.

Abstracts

Grace Crandall, MS

Major Professor: Steven Roberts

Effects of temperature change and Hematodinium spp. – infection (Bitter Crab Disease) on Tanner crabs (Chionoecetes bairdi)

Increasing CO_2 released into our atmosphere is warming the world's oceans. For most species, the magnitude of the impact, potential for adaptation to future temperatures, and mechanisms for adaptation are unknown. Features of parasite/disease ecology are predicted to change as oceans warm, including susceptibility of hosts to disease, host ability to combat disease once infected, and alterations in pathogen virulence. Alaskan southern Tanner crab stocks, supporting fisheries worth $21 million in 2014, are expected to be significantly impacted directly and indirectly by warming temperatures. The Alaska Department of Fish and Game considers bitter crab disease, caused by a parasitic dinoflagellate, *Hematodinium*, to be the 'principle threat' to Alaskan Tanner crab stocks. Infection rates in the Bering Sea and southeast Alaska range from 2-5% and 0-100%, respectively. In heavily infected hosts, the meat is soft and chalky with a bitter taste, rendering the crabs unmarketable. The disease is believed fatal, although recent research indicates it may be a chronic disease; time from infection to death remains uncertain. We postulate that increased temperature in the North Pacific will physiologically stress Tanner crabs and also lead to increased occurrence of *Hematodinium* infections, either of which may lead to increased mortality in Tanner crabs. We held healthy and *Hematodinium*-infected Tanner crabs under different temperature regimes to test for genetic responses to infection and temperature. Our research will provide insight into the underlying mechanistic linkages between potential effects of climate change and important processes such as recruitment, growth and natural mortality on Alaskan Tanner crab stocks.

A handful of tagged Olympia oysters
Photo: Lindsay Alma

Jordan Healy, MS

Major Professor: Luke Tornabene

A novel method for ageing demersal fish of the Bering Sea, using Fourier Transformed Near-Infrared Spectroscopy (FT-NIRS)

Fish age estimation has been integral to modeling for stock assessment as well as research to better understand growth, life history, recruitment and productivity dynamics in market valued ground fish fisheries, such as eastern Bering Sea (EBS) walleye pollock (*Gadus chalcogramma*). EBS Pollock stocks support the most valuable fishery in Alaska, with an annual catch biomass and revenue of over 2.0 M tons and $1.0 billion, respectively. This study investigates the use of Fourier Transformed Near-Infrared Spectroscopy (FT-NIRS), as a method for measuring light absorbance signatures in organic substances, to derive ages from fish otoliths. Model age estimations are derived by first relating specimen ages to a spectral matrix of absorbances (elements) with an otolith specimens (objects) by wavenumbers (descriptors) structure, using Partial Least Squares Regression (PLS). The resulting model is then validated against aged otoliths not used in the model's development. From this, several model performance statistics can be generated. The primary advantage of FT-NIRS ageing over traditional methods is the speed and repeatability with which age estimates are generated. In this study, validation of the FT-NIRS derived PLS model for EBS Pollock against the traditionally derived ages (best age produced between two age readers), yielded high

Abstracts

performance (r^2 = 0.90). Furthermore, this approach can be expected to predict fish age within ± 1.0 year of age 67% of the time (RMSEP = 0.96), in a fraction of the time that traditional aging is conducted. However, results from this study suggest that sample stratification during model development, in terms of biological, spatial, and temporal variability in the population, may result in increased precision in model performance. Future work will seek to apply this method to more species in the Bering Sea and Alaskan Gulf, while seeking to elucidate the underlying variability in the spatial and temporal biology of the fisheries that might explain unexplained spectral variability, therein producing more precise age estimations.

Lily McGill, MS

Major Professor: Gordon Holtgrieve

Estimating the spatial and temporal dynamics of water sources across a river network using stable isotopes

A detailed understanding of the spatial and temporal dynamics of water sources across river networks is central to managing the impacts of climate change. Because the stable isotope composition of precipitation varies geographically, variation in surface-water isotope signatures indicates the volume-weighted integration of upstream source water. We monitored the isotope composition of river water across the Snoqualmie River, WA throughout the year. Within the basin, the majority of the variation in small tributary streams was explained by mean elevation of the catchments, while seasonal variation was negligible. However, water in the mainstem Snoqualmie and the major tributaries had distinct isotopic seasonal patterns that occurred as a result of changes in source water. River isotope values were lowest in September during baseflow, and highest in April during snowmelt. We fit a spatial stream network model to generate continuous river isoscapes and employed a mixing model approach to estimate the contribution of river water from high elevation snowmelt. We found that water source varied across both time and space.

Hyejoo Ro, Undergraduate

Major Professor: Chelsea Wood

Impacts of a trematode parasite on the behavior of an invasive shore crab in the northwest Atlantic

Numerous trophically-transmitting endoparasites can increase transmission likelihood in their definitive host by manipulating behaviors of their intermediate host(s). An example is the trematode Microphallus similis that infects non-native European green crabs (Carcinus maenas) in the northwest Atlantic. There is limited knowledge regarding how this parasite may alter crab behavior, which may ultimately influence life cycle transmission. Our project aimed to assess how infection by M. similis influenced behavioral shifts in green crabs across a temporal scale: prior to infection and at 4 other time points post-infection (72 hours, 1 week, 2 weeks, and 3 weeks). Behavior in infected and uninfected crabs was measured using righting response and an established ethogram that recorded numerous behavioral types, including those that may affect conspicuity to predators. We found that there was minimal influence of infection on behavior, and that individual crab behaviors remained resilient through time. An exception was a slight decline in conspicuity in the 72 hour post-infection time point, which may suggest that M. similis has the potential to decrease predation risk during parasite development in its new host. Future work will include in-depth analyses for specific behaviors and investigations into infection burden.

Dario dario from personal tank
Photo: Sicheng Wang

Abstracts

Jennifer Stern, MS

Major Professor: Kristin Laidre

Assessing the timing and rate of fur growth in zoo polar bears

Polar bears are experiencing rapid loss of sea ice habitat across the Arctic. In some subpopulations, this is associated with declines in body condition, survival, and abundance. Because polar bears range over large, remote areas, most scientific information is based on sampling and deployment of satellite collars during a short spring field season. During this time, a suite of samples is collected from bears, such as blood, fat, and hair. These samples can be used to assess how sea ice loss is affecting the physiological status of individuals across subpopulations, in combination with other threats such as contaminants. Hair is a useful tissue because it can also be collected outside of spring using hair snares or harvest samples and reflects bear diet, stress levels, and contaminant exposure. However, inference from hair has been limited by a lack of data on the timing of the molt and hair growth rates throughout the molt. We have initiated a collaborative study between zoos and polar bear field researchers to quantify hair growth rates and thereby better understand the ecology and health of polar bears from wild samples. We have identified a visual and biochemical approach proven safe for humans and other animals to quantify the rate and timing of hair growth at body locations commonly sampled in wild-caught polar bears. This methodological information is essential to make full use of polar bear hair samples and in predicting the implications of continued sea ice loss and informing conservation and management decisions for polar bear.

The USCGC Healy moves through the ice on the Beaufort Sea
Photo: Jenny Stern

Biologists fill a fall-out trap with water to catch marsh invertebrates
Photo: Melanie Davis

Acknowledgements

The success of the 29th 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:

Catherine Austin	A/V Coordinators
Sean Rohan	A/V Coordinators
Hannah Bassett	Judge Coordinator
Eleni Petrou	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, Katie McElroy, Grace Crandall, Erica Escajeda, Jessica Lindsay, Amanda Warlick, Stephanie Thurner, Michaela Lowe, Lily McGill, Rebekah Stiling, Jenny Stern, Mark Sorel, Martini Arostegui, Yaamini Venkataraman, Jessica Hale 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 29th Annual School of Aquatic and Fishery Sciences Graduate Student Symposium and we hope you enjoy your time with us.

Sincerely,
Megan Feddern, Melanie Davis, and Jennifer Gardner
2018 GSS Coordinators

View onto the fur seal rookery from the cliff above on St. George Island, Alaska
Photo: Amanda Warlick