ANNUAL REPORT

July 1, 2019–June 30, 2020

Washington Cooperative Fish and Wildlife Research Unit

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Unit Staff and Coordinating Committee Members back cover

Cover photo: Adrian Wolf

Message from the Unit Leader

As for everyone, the global Covid-19 pandemic and the long-overdue reckoning with racial injustice in the US have had major effects on our lives and our work here at the Washington Cooperative Fish and Wildlife Research Unit. Despite the many challenges, we are coming out of this year with meaningful progress on our goals.

The biggest news is that we have begun the search for a new AUL-Wildlife. Based on discussions with Cooperators, we have decided to seek a scientist with expertise in the human dimensions of wildlife management. Unlike any previous position in the WACFWRU, the AUL-Wildlife will be based 100% in the School of Environmental and Forest Sciences (SEFS). We're excited to strengthen the ties between the wildlife faculty in SEFS and the fisheries faculty in the School of Aquatic and Fishery Sciences (SAFS). We will be busy with this search in the coming academic year.

We continue to pursue WACFWRU priorities in three areas: Ensuring our Sustainability, Increasing Our Connection, and Serving Our Community. Ensuring Our Sustainability is about improving and sustaining WACFWRU operations. This year, Mark Scheuerell assessed the WACFWRU boat fleet in light of expected future needs. With funds made available by USGS, we were able to order a new boat to facilitate fisheries and limnology fieldwork in Puget Sound and larger lakes and rivers. We expect to take delivery in January. We also obtained USGS funds for a new SUV, which will be useful for towing the boat and transporting larger groups.

We continue to look for ways to streamline our administrative function, including development of an online survey for annual tracking of student and postdoctoral scientist support. The goal is to make tracking as easy as possible for Principal Investigators. In FY2020, we facilitated student support totaling 41 academic quarters and 11 summers at University of Washington (UW), and 9 academic semesters/6 summers at Washington State University (WSU). For postdoctoral scientists we facilitated 19 quarters/8 summers at UW and 7 semesters/5 summers at WSU in FY2020.

Increasing Our Connection is about strengthening the links between agencies and university faculty. One way we do that is through our annual Graduate Student Symposium. This year's symposium will be held online on October 28. While we will miss meeting in person, an online symposium will offer better access to agency staff and WSU faculty and students. We're excited to assess the format and use the experience to continue to refine this annual event.

This year, with so much need, we focused a lot of effort on Serving Our Community. Mark and I both participated in career webinars for graduate students and postdocs at UW. We also continued to sponsor the UW Fish and Wildlife Ecology Seminar series. Thanks to the lab groups led by Beth Gardner (SEFS) and Daniel Schindler (SAFS) for organizing the 2019–2020 seminar. In 2020–2021, Mark's lab and Laura Prugh's lab (SEFS) will be organizing the seminar, planned for winter and spring quarters.

The WACFWRU has also been involved in the new Diversity, Equity, and Inclusion Committee for the CRU program. I was a member of a small group who conceived of the committee and its structure, and Mark is serving on the inaugural committee. The committee's first task was to develop training on implicit bias, and we've already been able to share their work with the search committee for our new AUL-Wildlife.

My own research lab is thriving, with 3 postdoctoral scientists, 3 PhD students, and 3 MS students. Lab members are working as far away as Guam and as close as Puget Sound. In Washington, we are working on gray wolves, Chinook salmon, Streaked Horned Larks, and Pigeon Guillemots. I am incredibly lucky to work in beautiful places and with so many amazing early career scientists.

I thank Mark, our administrator Verna Blackhurst, our Coordinating Committee members, and the students, faculty, and agency staff we work with for making another successful year possible here at the WACFWRU.

—Sarah Converse, *Seattle, September 4, 2020*

Message from the Assistant Unit Leader–Fisheries

There is no doubt that this past year has been like no other. In January and February my family traveled to California and Mexico, but by mid-March we were sheltering at home and now my kids could write the user's guide for Zoom. Despite all of the stress and uncertainty owing to COVID-19 concerns, we all found a way to continue our research, teaching, mentoring, and outreach efforts. I am fortunate to be surrounded by talented and dedicated colleagues, staff, and students who graciously help me every day.

I have been busy engaging with various researchers in the region, many of you included, wrapping up existing projects and forging new collaborations. Our dialogues have included projects related to the effects of shellfish aquaculture on fish habitat use, the effects of habitat restoration and climate change on native salmonids, and updating the status assessment for Puget Sound rockfish. As Sarah mentioned, I'm excited to get our new boat to facilitate this research.

This past spring I taught Analysis of Ecological and Environmental Data (QERM 514) to 19 graduate students from four different units at UW. Teaching this course for the first time, and doing so remotely, was indeed challenging, but the students were rather patient and understanding. Sarah generously provided me with all of her materials from when she last taught the course, which allowed me to adapt the course information to a publicly accessible website that has now been used by many people beyond our UW community.

I'm very excited to now have two new graduate students in my lab. Kelly Mistry is a master's student in the Quantitative Ecology and Resource Management (QERM) program, and she will be working with some of our NOAA colleagues to improve spatiotemporal models used for groundfish assessment in the Gulf of Alaska. Markus Min is a master's student in SAFS whose first task will be updating the status assessments for three rockfish species in Puget Sound. In January I also expect to welcome another master's student as well as a post-doc.

Last fall I organized a discussion panel on Alternative Careers in Environmental Science at the SAFS 30th Annual Graduate Student Symposium. Seven women from the Seattle area, many of whom were UW graduates themselves, spent an hour discussing the pros and cons of their careers in NGOs, state and federal agencies, and consulting. I also organized a special session on developments in open and reproducible science for the June meeting of the Association for the Sciences of Limnology and Oceanography and the Society for Freshwater Science, but the conference was ultimately cancelled due to COVID concerns.

This spring and summer I committed myself to improving social justice at UW and beyond. I participated in several facilitated workshops focused on issues around equity, diversity, and inclusion. I'm particularly excited about working with the Students Exploring Aquatic Science (SEAS) program in SAFS to improve our outreach and recruitment efforts, with the goal of increasing the participation of BIPOC students in fisheries and aquatic science.

Next year I hope to report that business is "back to normal" and the WACFWRU is forging ahead with new directions in research, teaching, and outreach. I anticipate continued work involving collaborations with our cooperating agency partners, to whom I'm grateful for their support and encouragement.

Mark Scheuerell, *Seattle, September 8, 2020*

Unit Award Recipients

The Gilbert B. Pauley Award

Awarded annually for best student presentation at the Annual Student Symposium

2019 Winner—Cassandra Doll

Department of Biology, Washington State University–Vancouver; advised by Cheryl Schultz

Cassandra Doll presents her Pauley award-winning seminar, *Evaluating herbicides as a restoration tool for Oregon silverspot*, at the 2019 WACFWRU Annual Student Symposium.

The John Pierce Outstanding Graduate Student Award

Awarded annually to the graduate student who best embodies the spirit and mission of the WACFWRU

2019 Winner—Taylor Ganz

School of Environmental and Forest Sciences, University of Washington; advised by Laura Prugh

Taylor Ganz accepted the John Pierce Outstanding Graduate Student Award at the 2019 WACFWRU Annual Student Symposium.

The Unit Leader's Service Award

Awarded occasionally to those who provide exemplary service to 5the WACFWRU

2019 Winner—Richard Bigley, PhD

Washington Department of Natural Resources, retired

Richard Bigley addresses students, faculty, and agency cooperators after accepting the Unit Leader's Service Award in recognition of his 19 years of service on the WACFWRU Coordinating Committee.

Photos: Dan DiNicola

Annual Student Symposium

The 2018 WACFWRU Annual Student Symposium was held in conjunction with the WACFWRU annual meeting on October 17 at the Center for Urban Horticulture on the University of Washington campus. The full lineup included:

Photo: iStock.com/Vince Barnes

WASHINGTON COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

WACFWRU

Annual Student Symposium

Wednesday, October 23, 2019, 4:00–6:00 pm

School of Aquatic & Fishery Sciences, 1122 NE Boat St, Seattle, WA 98105

depts.washington.edu/wacfwru/category/symposium/

4:00 pm **Welcome**
Sarah Converse & Mark Scheuerell, *Washington Cooperative Fish and Wildlife Research Unit*

4:10 pm **Snowshoe hare population ecology in lynx-occupied areas of Washington**
Paul Jensen, *School of the Environment, Washington State University (WSU)*

4:19 pm **Identification of cougar feeding sites from GPS data**
Lauren Satterfield, *School of Environmental and Forest Sciences (SEFS), UW*

4:28 pm **Strategies for estimating abundance and reproductive success for an unmarked seabird population in Puget Sound, WA**
Amanda Warlick, *School of Aquatic and Fishery Sciences (SAFS), UW*

4:37 pm **Spawn timing of wild Chinook salmon is advancing in a complex watershed**
Catherine Austin, *SAFS, UW*

4:46 pm **Using high resolution mass spectrometry to investigate contaminants in fish tissue**
Dave Wark, *Center for Urban Waters, UW Tacoma*

4:55 pm **Importance of the early environment on amphibian physiology and behavior: applications for captive rearing and trans-location programs**
Bernie Traversari, *School of the Environment, WSU*

5:04 pm **Optimally allocating survey resources for common loon occupancy analysis**
Hannah Sipe, *Quantitative Ecology and Resource Management Graduate Program, UW*

5:13 pm **Forensic identification of predators to improve wildlife conservation**
Taylor Ganz, *SEFS, UW*

5:22 pm **Juvenile recruitment and life history expression in an endangered spring Chinook salmon population**
Mark Sorel, *SAFS, UW*

5:31 pm **Comparing the nutritional and habitat niche of sympatric mule deer and white-tailed deer in eastern Washington**
Anna Staudenmaier, *School of the Environment, WSU*

5:40 pm **Assessing the status of South Puget Sound streaked horned larks with integrated population models**
Abby Bratt, *Quantitative Ecology and Resource Management Graduate Program, UW*

5:49 pm **Evaluating herbicides as a restoration tool for Oregon Silverspot**
Cassandra Doll, *School of Biological Sciences, WSU Vancouver*

5:58 pm **Awards presentation**
Sarah Converse & Mark Scheuerell

Disability Accommodations: Contact the Disability Services Office at 206-543-6450 (voice), 206-543-6452 (TTY), 206-685-7264 (fax) or dso@uw.edu for accommodation requests.

USGS science for a changing world · W · U.S. Fish & Wildlife Service · Washington Department of Fish and Wildlife · Wildlife Management Institute, Established in 1911 · Washington Department of Natural Resources · WSU · Department of Ecology, State of Washington

Research Projects

The WACFWRU Cooperative Agreement facilitated $7,022,141 in project funding at UW in 2019–2020, including $3,042,648 in new dollars. At WSU, the WACFWRU Cooperative Agreement facilitated $2,962,026 in project funds ($2,742,065 in new dollars). The WACFWRU staff and cooperating faculty at UW and WSU worked with 6 federal agencies in addition to our 3 state cooperating agencies. All funded projects led by WACFWRU staff are listed by funder, including project title and dates, with student and postdoctoral scientist support listed below the project title. For cooperating faculty, projects are listed by university and funder, including project title, principal investigator, department, and project dates, along with student and postdoctoral scientist support.

Sarah Converse, WACFWRU Unit Leader

Department of the Navy—Joint Region Marianas

- Evaluating and mitigating the effects of brown treesnakes on Guam's birds
  Staci Amburgey, *postdoctoral scientist*
  Hannah Sipe, *PhD student*

National Oceanic and Atmospheric Administration

- Developing an integrated Bayesian population viability analysis model for cetaceans
  Amanda Warlick, *PhD student*
- Integrating data sources to characterize demographic responses of Columbia River salmon and steelhead to threats and management actions
  Mark Sorel, *PhD student*
- Public benefits of Cook Inlet Beluga Whale recovery actions: the integration of population viability analysis and species valuation models
  Amanda Warlick, *PhD student*

National Park Service/U.S. Geological Survey

- Long-term seabird monitoring data analysis to update Channel Islands National Park seabird inventory and monitoring program and inform management and conservation
  Amelia DuVall, *MS student*

U.S. Fish and Wildlife Service

- Evaluating sea duck detectability in the Puget Sound winter ambient monitoring program

U.S. Geological Survey

- Restoration tools for Oregon silverspot butterfly
  Cassandra Doll, *MS student (advised by Cheryl Schultz, Department of Biology, Washington State University)*
- Early detection and rapid response: choosing monitoring targets to promote management effectiveness
  Brielle Kwarta, *MS student (co-advised by Julian Olden, School of Aquatic and Fishery Sciences)*
- Assessing the precision of estimates of population vital rates for polar bears in Alaska
  (co-PI Eric Regehr, *Applied Physics Laboratory*)
  Nathan Hostetter, *postdoctoral scientist*

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Photo: iStock.com/Karel Bock

Photos, l to r: iStock.com/DaveAlan, iStock.com/Lynn_Bystrom

Washington Department of Fish and Wildlife

- Assessing the fish community in the Chehalis River with occupancy models
  Mark Sorel, *PhD student*
- Constructing a modeling tool for wolf status review in Washington
  Lisanne Petracca, *postdoctoral scientist*

Other

- Integrated abundance and movement models for marine mammals (*supported by North Pacific Research Board*)
  Nathan Hostetter, *postdoctoral scientist*
- Integrated population model for Maine black bears (*supported by Maine Department of Inland Fisheries and Wildlife*)
  Nathan Hostetter, postdoctoral scientist (co-PI)
- Integrated population modeling for evaluating status and effects of management actions in Streaked Horned Larks (*supported by Washington Cooperative Fish and Wildlife Research Unit*)
  Abby Bratt, *MS student*
- Integrated population models that account for the effects of environmental variability on abundance and demographic rates for species with complex life histories (*supported by National Science Foundation Graduate Research Fellowship*)
  Amanda Warlick, *PhD student*
- Seabird ecology and conservation at Tetiaroa, French Polynesia
  (co-PIs Beth Gardner, *School of Environmental and Forest Sciences*, and Julia Parrish, *School of Aquatic and Fishery Sciences*; *supported by private donors to University of Washington*)
  Olivia Sanderfoot, *PhD student* (*advised by Beth Gardner*)
- Summarizing current knowledge of the factors influencing juvenile salmonid susceptibility to avian predation in the Columbia River Basin (*supported by Real Time Research, Inc.*)
  Nathan Hostetter, *postdoctoral scientist*
- Synchrony of seabird survival, March 2017–2020 *(supported by Swedish Academy of Sciences*)
  Martina Kadin, *postdoctoral scientist*

Photos, l to r: Gael Kurath, iStock.com/KGrif

Cooperating Faculty, University of Washington

Bureau of Reclamation

- Quantitative diet reconstruction of the food webs supporting juvenile suckers in the Upper Klamath Basin using fatty acid based mixing models
  PI: Michael Brett, Department of *Civil and Environmental Engineering*
  Julie Schram, *postdoctoral scientist*

National Oceanic and Atmospheric Administration

- To monitor the health and status of abalone populations in southern California: an examination of withering syndrome pathogen prevalence and future risk
  PI: Carolyn Friedman, *School of Aquatic and Fishery Sciences*
  Kahana Pietsch, *undergraduate*
- Rockfish remotely operated vehicle—MESA video review
  PI: Terryl Ross, *College of the Environment*
  Morgan Arrington, *MS student*
  Sean Rohan, *PhD student*
  Omar Abdirahman, *undergraduate*
  Melinda Carr, *undergraduate*

U.S. Fish and Wildlife Service

- Adaptation of IHN virus to Pacific Northwest Chinook salmon and impacts on other salmonids
  PI: Kerry Naish, *School of Aquatic and Fishery Science*
- Evaluating environmental DNA technology to streamline protection of anadromous habitat
  PI: Daniel Schindler, *School of Aquatic and Fishery Sciences*
  Sarah O'Neal, *PhD student*
- Inferring habitat use and migratory behavior of bull trout in the White River using microchemistry
  PI: Daniel Schindler, *School of Aquatic and Fishery Sciences*
  Michaela Lowe, *MS student*
- Lateral and longitudinal occupancy of Chehalis floodplain habitats to guide restoration and conservation
  PI: Julian Olden, *School of Aquatic and Fishery Sciences*
  Thiago Couto, *PhD student*

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Photos: Abby Bratt

PROJECT IN THE SPOTLIGHT

Integrated population modeling for evaluating status and effects of management actions on streaked horned larks

Principal Investigator: Sarah J. Converse, *Washington Cooperative Fish and Wildlife Research Unit, University of Washington*

Student: Abby Bratt, *Quantitative Ecology and Resource Management, University of Washington*

Funder: College of the Environment, University of Washington; Washington Cooperative Fish & Wildlife Research Unit; Center for Natural Lands Management

Partners: Washington Department of Fish and Wildlife, Joint Base Lewis-McChord

Streaked horned larks are a federally threatened subspecies of horned lark found in prairie-oak and grassland habitats in Washington and Oregon. Among other threats, habitat loss and fragmentation have led to significant declines. Today, Joint Base Lewis-McChord (JBLM) supports 80% of streaked horned larks breeding in the South Puget lowlands. Streaked horned larks have been monitored on JBLM since 2002 in a collaboration between JBLM Fish & Wildlife, the Washington Department of Fish & Wildlife, and the Center for Natural Lands Management. To restore ecosystem structure and function, prescribed burns and invasive plant controls are critical components of restoration on lowland prairies. However, the impacts of these management activities on lark habitat selection, demographic rates, abundance, and population viability are not well understood. We are using an integrated population model that combines data from several sources to estimate the impacts of these management actions on streaked horned larks in the South Puget lowlands. Our population model for streaked horned larks integrates three data sources: 1) nest monitoring data, which inform estimates of nest success and fledgling survival; 2) count data, which inform estimates of population size; and 3) mark-resight monitoring (i.e., when larks are captured, marked with colored leg bands, released, and resighted) data, which inform estimates of adult survival and movement. Crucially, our mark-resight model accounts for individuals that lose some of their original bands. Leveraging all available data sources will provide important insights about the effects of prairie-oak habitat management on South Puget lowland streaked horned lark population dynamics and alternative management strategies.

U.S. Geological Survey

- Crossing the divide: inundation drives hotspots of carbon flux
  PI: David Butman, *School of Environmental and Forest Sciences*
- Factors influencing productivity of native adfluvial salmonids in mainstem Skagit River reservoirs
  PI: Julian Olden, *School of Aquatic and Fishery Sciences*
  Rachelle Johnson, *MS student*
- Ichthyophonus in Pacific herring
  PI: Chelsea Wood, *School of Aquatic and Fishery Sciences*
  Catrin Wendt, *MS student*
- Tracing the age of wetland and aquatic carbon emissions across northern latitudes
  PI: David Butman, *School of Environmental and Forest* Sciences
- Transgenerational impacts of endocrine disrupting chemicals on innate immunity
  PI: Ram Savan, *Department of Immunology*

Washington Department of Ecology

- Washington Department of Ecology auto chemicals scoping and alternatives
  PI: Edward Kolodziej, *School of Interdisciplinary Arts and Sciences, UW Tacoma*
  Zhenyu Tian, *postdoctoral scientist*

Washington Department of Fish and Wildlife

- Assessing and minimizing genetic risks of hatchery production of native species for aquaculture
  PI: Kate Litle, *Washington Sea Grant*
- Ecology of non-native fish
  PI: Julian Olden, *School of Aquatic and Fishery Sciences*
- Improving preseason forecasts for U.S. coho salmon management units by accounting for spatially structured temporal variation in age-at-maturity
  PI: Daniel Schindler, *School of Aquatic and Fishery Sciences*
  Lukas DeFilippo, *PhD student*
- Investigating the impacts of peak flows on the performance, design, and cost of water crossing structures in the Chehalis Basin to guide comprehensive fish passage restoration
  PI: Erkan Istanbulluoglu, *Department of Civil and Environmental Engineering*
  Zach Johnson, *postdoctoral scientist*
- Marine bird and mammal hot and cold spots in Washington's marine waters
  PI: Beth Gardner, *School of Environmental and Forest Sciences*
- Nonnative finfish marine aquaculture–EHB 2957 implementation
  PI: James Seeb, *School of Aquatic and Fishery Sciences*
- Prioritizing sea level rise exposure and habitat sensitivity across Puget Sound
  PI: Kate Litle, *Washington Sea Grant*
- Protection and restoration of shoreline process: training, integration of green shores for homes, and shore friendly
  PI: Kate Litle, *Washington Sea Grant*

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Photo: Amelia DuVall

Photos, l to r: Shane Siers, Peter Larramendy, Amelia DuVall

- Shoreline monitoring toolbox—protocol implementation and data management
  PI: Kate Litle, *Washington Sea Grant*
- Skagit River Chinook spawning phenology and multispecies salmonid distribution
  PI: Tom Quinn, *School of Aquatic and Fishery Sciences*
  Catherine Austin, *PhD student*
- Ungulate-predator dynamics in northern Washington
  PIs: Beth Gardner/Laura Prugh/Aaron Wirsing, *School of Environmental and Forest Sciences*
  Sarah Bassing Linch, *PhD student (advised by Beth Gardner)*
  Taylor Ganz, *PhD student (advised by Prugh)*
  Lauren Satterfield, *PhD student (advised by Aaron Wirsing)*
- Washington Sea Grant green crab management
  PI: Kate Litle, *Washington Sea Grant*

Washington Department of Natural Resources

- Long-term monitoring and focus studies in shoreline biota in Puget Sound: 2019–20 data analysis and 2020–21 data collection
  PI: Megan Dethier, *Department of Biology*
  Margaret Turner, *PhD student*
- Research and advising: external-facing components to DNR's agency-wide climate resilience plan
  PI: Crystal Raymond, *Climate Impacts Group*
- Riparian extensive vegetation monitoring, model transferability testing
  PI: Monika Moskal, *School of Environmental and Forest Sciences*
- Roads prescription scale effectiveness monitoring project
  PI: Erkan Istanbulluoglu, *Department of Civil and Environmental Engineering*
  Amanda Manaster, *PhD student*
- Supplement to support dynamically downscaled projections for fish passage planning and design
  PI: Guillaume Sadler Mauger, *Climate Impacts Group*
- UW-DNR restoration treatment need and monitoring
  PIs: Jonathan Bakker/Brian Harvey, *School of Environmental and Forest Sciences*
  Don Radcliffe, *PhD student* (*advised by Brian Harvey*)
- Work plan for the University of Washington in managing and facilitating a scientific review process for the Cooperative Monitoring, Evaluation, and Research Committee by the independent scientific peer review program
  PI: Dan Vogt, *School of Environmental and Forest Sciences*

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PROJECT IN THE SPOTLIGHT

Using eDNA to monitor beaver relocations and associated transmission of aquatic pathogens and invasive species

Principal Investigators: Jonah Piovia-Scott, *School of Biological Sciences, Washington State University–Vancouver*
Caren Goldberg, *School of the Environment, Washington State University–Pullman*

Student: Jesse Burgher, *MS student, School of Biological Sciences, Washington State University–Vancouver*
Alexandra Kahler, *MS student, School of the Environment, Washington State University–Pullman*

Funder: Washington Department of Fish and Wildlife

Translocation of the American beaver (*Castor canadensis*) has emerged as a possible strategy to protect and restore freshwater aquatic systems across the western United States. Through the construction of dams, beavers have been shown to slow stream flows, increase ground water storage, delay summer drying, and provide habitat for sensitive aquatic species. Aquatic restoration via beaver translocation is a developing management tool that has been increasingly implemented across the west since 2005. However, the movement dynamics of translocated beavers vary widely and are not well understood. Translocation failures are common and post-translocation monitoring is difficult and expensive. Additionally, beaver translocations may unintentionally transport aquatic pathogens and invasive species from capture to release sites. In this project, we are using environmental DNA to develop methods for monitoring translocated beaver and evaluate their potential as fomites by 1) pairing eDNA sampling with radio-tracking-based location data of translocated beaver to evaluate eDNA sampling strategies, and 52) sampling beaver for aquatic pathogens and invasive species throughout the capture, holding, and movement process. Data collection for this project began in August 2020 and will continue through 2021.

Photo: Jonah Piovia-Scott

Photo: John McMillan

PROJECT IN THE SPOTLIGHT

Improving short-term recruitment forecasts for coho salmon using a spatiotemporal integrated population model

Principal Investigator: Daniel Schindler, *School of Aquatic and Fishery Sciences, University of Washington*
Mark Scheuerell, *Washington Cooperative Fish and Wildlife Research Unit, University of Washington*

Student: Lukas DeFilippio, *PhD Student, School of Aquatic and Fishery Sciences, University of Washington*

Funder: Washington Department of Fish and Wildlife

Partner: Pacific Salmon Commission

Fishery managers often rely on forecasts of future population abundance to determine allowable harvest quotas or exploitation rates. While there has been substantial research effort devoted to identifying environmental factors that can predict future recruitment, such correlations typically degrade over time and have limited utility for management. Conversely, examining multiple stocks at once to detect shared, spatially structured patterns can offer insights into their population dynamics that are advantageous for forecasting. Here, we develop a forecast model for wild coho salmon (*Oncorhynchus kisutch*) stocks in Washington state that leverages spatial and temporal autocorrelation in marine survival to improve one-year-ahead forecasts of adult returns. Executed in a Bayesian hierarchical and integrated modelling framework, our spatiotemporal approach incorporates multiple data types and shares information between populations to estimate key biological parameters that are informative for forecasting. Retrospective evaluation of one-year-ahead forecast skill indicated that the spatiotemporal integrated population model outperforms the existing method currently used for forecasting Washington state coho salmon returns, as well as several other plausible alternatives. Our results add to a growing body of work that demonstrates the utility of spatiotemporal and integrated modelling approaches for studying and predicting population dynamics, and the model developed here has broad applications to the assessment and management of coho salmon stocks in Washington state.

Cooperating Faculty, Washington State University

Washington Department of Ecology

- 2020 Columbia River supply demand forecast
  - PI: Jennifer Adam, *Department of Civil and Environmental Engineering*
  - Rojina Desar, *MS student*
- BEACH Program in Snohomish County
  - PI: Jonathan Robinson, *Washington State Extension*
- Identification of safer alternatives to per- and polyfluorinated substances in plant fiber-based food packaging
  - PI: Donna Riordan, *Washington State Academy of Sciences*
- Skagit Basin supply and demand analysis
  - PI: Jonathan Yoder, *School of Economic Sciences*
  - Siddharth Chaudhary, *postdoctoral scientist*
  - Navdeep Singh, *postdoctoral scientist*
- Waste to fuels technology partnership
  - PI: Georgine Yorgey, *Center for Sustaining Agriculture & Natural Resources*
  - Neda Khosravi, *PhD student (advised by Tom Jobson)*
  - Sohrab Mood, *PhD student (advised by Manuel Garcia-Perez)*
  - Nathan Stacey, *postdoctoral scientist (advised by Doug Collins)*
  - Ruifeng He, *postdoctoral scientist (advised by David Gang)*
  - Xiaochao Xiong, *postdoctoral scientist (advised by Shulin Chen)*
- WSU Beachwatchers 13
  - PI: Chrys Bertolotto, Washington State Extension

Washington Department of Fish and Wildlife

- Beaver relocation research project
  - PI: Caren Goldberg, *School of the Environment*
  - Jesse Burgher, MS student
  - Alexandra Kahler, *MS student*
- Northern leopard frog population assessment and modeling, disease surveillance, and headstart optimization
  - PI: Caren Goldberg, *School of the Environment*
- Snowshoe hare density
  - PI: Daniel Thornton, *School of the Environment*
  - Paul Jensen, *MS student*
- The influence of fuel reduction treatments on the nutritional ecology of mule and white-tailed deer in northeastern Washington
  - PI: Lisa Shipley, *School of the Environment*
  - Anna Staudenmaier, *MS student*

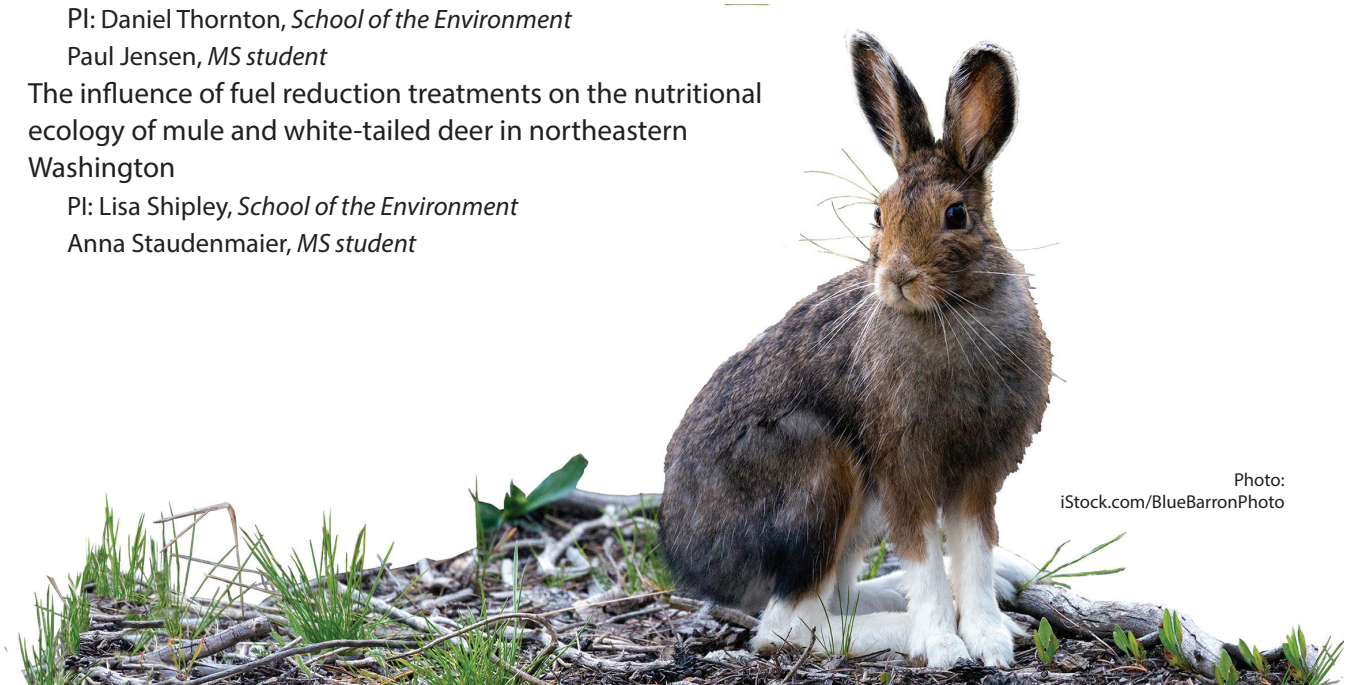

Photo:
iStock.com/BlueBarronPhoto

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