Change, Challenge, and Opportunity in Fisheries: Fishing for Solutions

Artwork by Marissa Amor

Alaska Chapter / Western Division

American Fisheries Society

43rd Annual Meeting **21 – 25 May, 2018**

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Table of Contents

Cover Art

Cover art was provided by Marissa Amor. Marissa is a self-taught artist and lifelong Alaskan. She currently lives in Sitka and studies Biology at the University of Alaska, Southeast. The beauty of Alaska's unique biodiversity inspires her to advocate conservation through art. Her vivid paintings depict Alaska's intricate tidal life & simplify nature's complex processes for all to appreciate.

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Facebook: marissa amor art

Letter of Welcome

Greetings Western Division Annual Meeting attendees and guests,

Welcome to the Last Frontier! We are pleased to have you join us for the 43rd annual meeting of the Western Division American Fisheries Society hosted by the Alaska Chapter. Anchorage is the heart of Alaska, a bustling metropolis yet surrounded by wilderness and minutes away from adventure in any direction. We hope you have set aside some time before or after the meeting to take in the scenery and enjoy the best Alaska has to offer.

The theme for this year's meeting is "Change, Challenge, and Opportunities in Fisheries: Fishing for Solutions". We will offer a high-quality and diverse set of 20 symposia that reflect the meeting theme and address current and future issues in the conservation and management of fisheries resources. These sessions will address our mission to improve conservation and sustainability of fishery resources and aquatic ecosystems by advancing fisheries and aquatic science and promoting development of fisheries professionals. We would like to thank all of the session organizers and presenters for their contributions.

We would like to express our utmost gratitude to the team of hardworking volunteers who made this meeting happen. If you run into them during the meeting, please say "Thanks!". The planning team has put together an amazing meeting that we are sure you will enjoy. From tasting some of Alaska's finest food and beverages at the Welcome Social at the 49th State Brewery, to a visual feast during the 2018 Alaska Fish Film Festival, to a memorable visit to the rolling, forested hills and rugged coastline of Cook Inlet at the Banquet at Kincaid Park – there is something for everyone!

The future of our society is in the excellent hands of our student and early career professional membership. There will be many of these folks in attendance, and most will provide volunteer time in exchange for travel assistance and waiver of registration fees. The planning team (including student representatives) has worked hard to be inclusive and promote professional development during the meeting. We will offer a student/early career professional panel session lunch, a student mentor social with fish trivia, and student awards for best papers and posters. Please consider striking up a conversation with one of our student or early career attendees, you won't regret it!

In closing, we thank you for attending this year's conference and sharing your expertise with our network of dedicated fisheries professionals. For those of you traveling from the "lower 48", we hope you enjoy Alaska's scenery and hospitality.

Sincerely,

Brian Missildine
President
Western Division AFS

Aaron Martin
President
Alaska Chapter AFS

Jackie Watson
President Elect
Western Division AFS

Jeff Falke
President Elect
Alaska Chapter AFS

Planning Committees

2018 Western Division of the American Fisheries Society Annual Meeting Planning Committees

General Meeting Organization
Brian Missildine – President, Western Division AFS
Jeff Falke – President - Elect, Alaska Chapter AFS

Awards
Jon Gerken - Co-chair
Cleve Steward – Co-chair

Arrangements and Accommodations
Hamachan Hamazaki - Chair
Bill Hauser
Sabrina Garcia

Budget and Finance
Lee Ann Gardner – Co-chair
Tracy Wendt – Co-chair

Socials and Entertainment
Bert Lewis – Chair
Leah Ellis
John Seigle
Jessica Johnson
Jessica Speed
Katrina Liebich
Erika Ammann

Event Management and Registration
Tyler Dann – Co-chair
Lee Ann Gardner – Co-chair
Chris Sergeant

Program
Mike Daigneault – Co-chair
Jackie Watson – Co-chair
Jeff Falke
Brian Missildine
Peter Westley
Lisa Stuby
Sara Miller
Matthew Varner
Aaron Martin
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Dan Dauwalter
Allison Matter

Publicity and Outreach
Jimmy Fox – Chair
Josh Ashline
Marshall Barrows
Tyler Dann

Website
Mary Beth Loewen – Co-chair
Joel Markis – Co-chair

Fundraising
Brian Missildine
Alaska Pacific University Student Subunit

Student Activities
Britta Baechler – Co-chair
Tessa Minicucci – Co-chair

Travel Grants
Erik Schoen – Co-chair
Dan Dauwalter – Co-chair
Paul Kusnierz

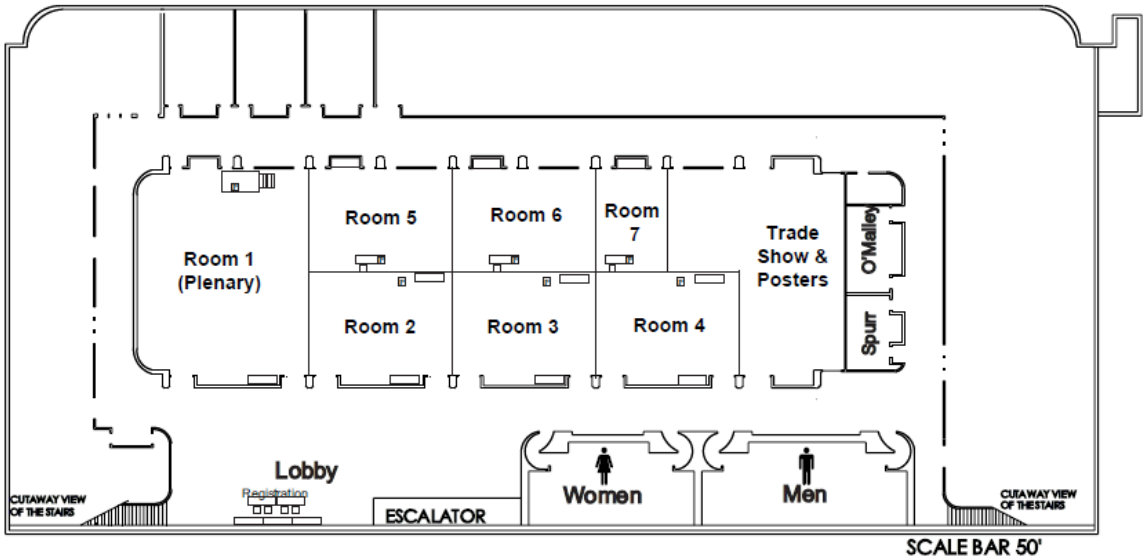
Trade Show
Kevin Foley – Chair
Jon Adsem

Tours, Transportation, Info
Dan Rinella – Chair
Jason Leppi
Becky Shaftel
Michael Winfree

Spawning Run
Kyle Shedd – Co-chair
Sue Mauger – Co-chair

Swag
Samantha Simpson

Maps: Egan Center, Downtown Anchorage



Egan Center - Lower Level
Summit Hall

Schedule at a Glance

Date/Time*	Activity	Location
Sunday May 20th		
10:00am – 5:00pm	Western Division ExComm Meeting	Hilton
Monday May 21st		
8:00am – 5:00pm	Registration Open	Egan Center
8:00am – 5:00pm	Workshops/Continuing Education	Egan Center: (Rooms 1, 2)
12:00pm – 1:20pm	Alaska AFS Past Presidents Lunch	Glacier Brewhouse
7:00pm – 9:00pm	Welcome Social	49th State Brewing
Tuesday May 22nd		
8:00am – 5:00pm	Registration Open	Egan Center
8:10am – 9:20am	Plenary Session	Egan Center (Room 1)
9:40am – 12:00pm[1]	Symposia and Contributed Paper Sessions	Egan Center: (Rooms 1-7)
12:00pm – 1:20pm	Student & ECP[2]/Professional Panel Lunch	Egan Center: (Room 1)
1:20pm – 5:00pm[1]	Symposia and Contributed Paper Sessions	Egan Center: (Rooms 1-7)
5:00pm – 6:00pm	AK AFS Environ. Concerns Comm. Meeting	Egan Center: (Room 2)
6:00pm – 8:00pm	Tradeshow and Poster Session	Egan Center: (Trade Show)
8:00pm – 11:00pm	Student & ECP[2]/Mentor Social – Fish Trivia	Port View Banquet Hall
8:00pm – 11:00pm	AK Fish Habitat Partnership Film Fest	AK Experience Theater
Wednesday May 23rd		
8:00am – 5:00pm	Registration Open	Egan Center
8:10am – 9:20am	Plenary Session	Egan Center: (Room 1)
9:40am – 12:00pm[1]	Symposia and Contributed Paper Sessions	Egan Center: (Rooms 1-7)
12:00pm – 1:20pm	Western Division Business Meeting	Egan Center: (Room 1)
1:20pm – 5:00pm[1]	Symposia and Contributed Paper Sessions	Egan Center: (Rooms 1-7)
6:00pm – 7:00pm	Spawning Run	Kincaid Park
7:00pm – 10:00pm	Banquet, Silent Auction, Raffle	Kincaid Park
Thursday May 24th		
8:00am – 5:00pm	Registration Open	Egan Center
8:10am – 9:20am	Plenary Session	Egan Center: (Room 1)
9:40am – 12:00pm[1]	Symposia and Contributed Paper Sessions	Egan Center: (Rooms 1-7)
12:00pm – 1:20pm	AK AFS Business Meeting	Egan Center: (Room 1)
12:00pm – 1:20pm	WD Native Fish Committee meeting	Egan Center: (Room 3)
1:20pm – 5:00pm[1]	Symposia Sessions	Egan Center: (Rooms 1-7)
5:00pm – 6:00pm	Closing Session – Best Student Paper Awards	Egan Center: (Room 1)
Friday May 25th		
9:00am – 5:00pm	Field Trips (Fishing, Eklutna, Turnagain Arm)	Meet at Egan Center
10:00am – 12:00pm	Hatchery Tour	W.J. Hernandez Hatchery
2:00pm – 5:00pm	Alaska Blackfish Viewing	Meet at Egan Center

[1]Tuesday-Thursday – two breaks (Morning - 9:20AM-9:40AM); (Afternoon – 3:00PM-3:20PM)
[2]Student and Early Career Professionals
[3]Buses will begin regular trips from the front of the Egan Center to Kincaid Park starting at 4:30pm

Monday, May 21

Continuing Education

INNOVATIVE DEVELOPMENTS IN THE USE OF PIT-TAG TECHNOLOGY: TECHNICAL AND MODELING CONSIDERATIONS

Course Date: Monday, May 21st, 2018; 9am-12pm
Class Location: Egan Center (Anchorage) Room 2
Instructor(s): Peter MacKinnon, Biomark Inc/Utah State University, pdmackinnon@gmail.com
Format: Presentation with discussion input from attendees. Equipment demonstration.

Description: Radio Frequency Identification or RFID was introduced into the realm of fisheries science in the Pacific Northwest in the mid-1980's with the introduction of the Passive Integrated Transponder (PIT) tag. Innovations such as multiplexing antenna readers, smaller high-performance tags, and larger more robust antennas have resulted in the widespread application of PIT-tag technology as a fisheries data collection tool. As the use of PIT-tag technology becomes more geographically widespread, the need for alternative detection techniques and methods has become apparent. Innovative new styles and types of fish detection antennas have been developed and tested, driven by the needs and ideas of biologists working with species having diverse life histories in diverse geographical regions. The goal of the continuing education course is to provide an overview of the uses of PIT tag technology in fisheries research, and to introduce relevant models for transforming raw detection data in useful information. The first part of the course will cover the basics of, and potential problems related to; site selection, system design, power sources, cost, remote data access, and continued system monitoring and maintenance. The second part of the course will cover how data from PIT tag antenna arrays can help answer specific research questions. This section will focus on mark-recapture models that are relevant for PIT tag data, with a brief hands-on introduction to using Excel to transform raw data into appropriate model format. The course will not teach users how to build PIT-Tag antennas or analyze their data. The course is intended for researchers and biologists who are considering using stationary or mobile passive interrogation arrays and are seeking an overview of current technology and data analyzing possibilities.

REPRODUCIBLE RESEARCH IN R

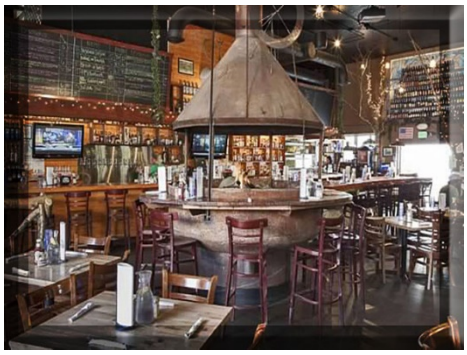
*Sponsored by the Alaska Chapter of the AFS and the Data Task Force at the National Center for Ecological Analysis and Synthesis, a part of the State of Alaska Salmon and People project.
Course Date: Monday, May 21st, 2018; 8am-4:30pm
Class Location: Egan Center (Anchorage) Room 3
Instructor(s): J. Clark, J. Cornejo-Donoso, M. Jones, M. Jovanovich, and J. Kibele

Description: This full-day workshop will provide students with an introduction to reproducible data science techniques using R, RStudio, Git, and GitHub. Intended to improve students' ability to communicate and share their analysis techniques more effectively with modern R packages such as those within Tideyverse. Attendees should be connected with an internet-capable laptop, and have the latest versions of R and RStudio installed. Instructions to do so will be provided in advance. Students need not be familiar with Git, but should have a basic knowledge of R. Topics covered include version control with Git, reproducible analysis using RMarkdown, and publication graphics using ggplot2, and tidy data with dplyr and tidyr. This workshop is structured with materials that students can follow along with hands-on instructor support using their own computers and take home to use with their own data. This collaboration is funded through the State of Alaska Salmon and People project, and supported by the National Center for Ecological Analysis and Synthesis Data Task Force.

Monday, May 21

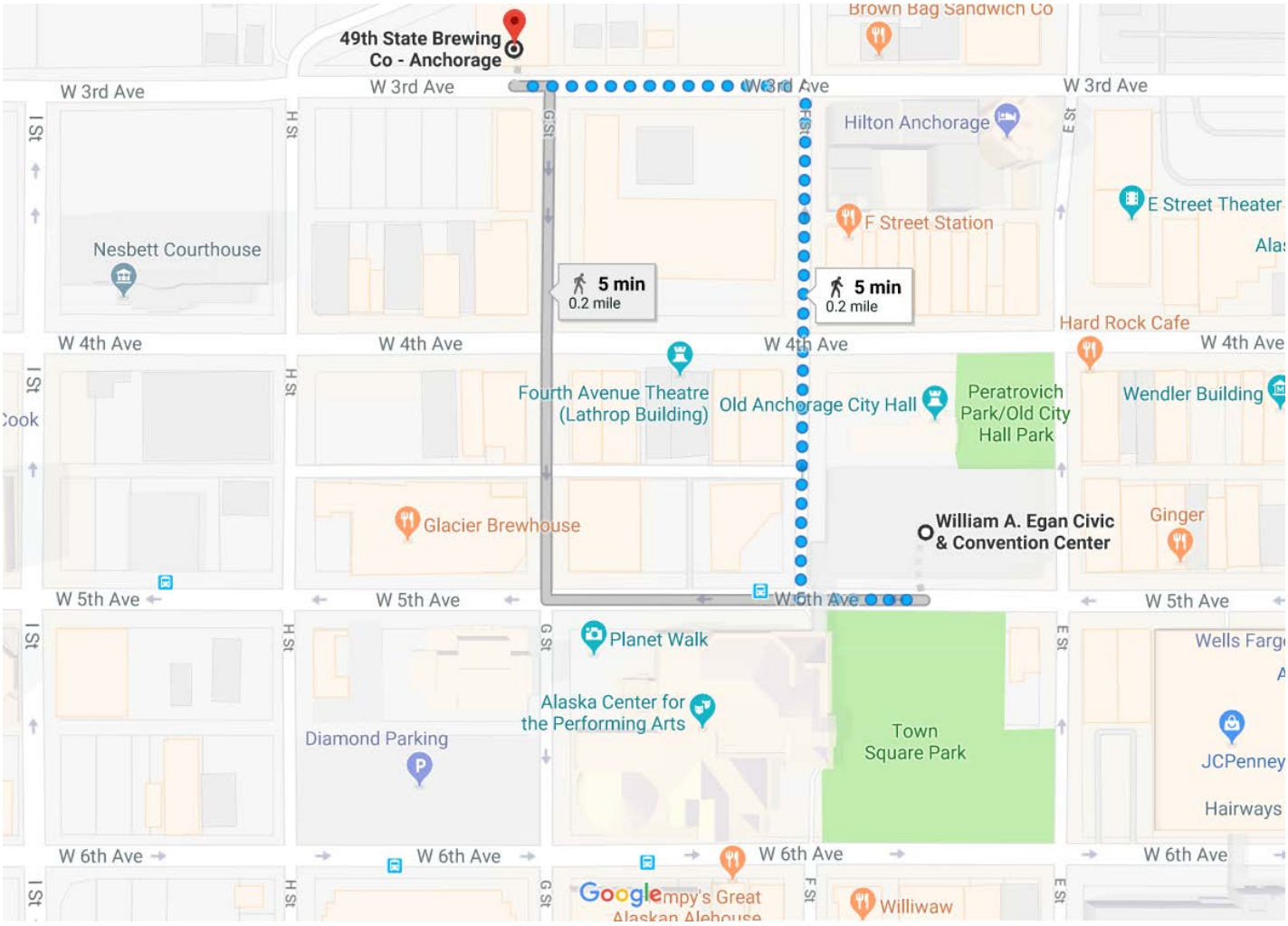
Welcome Social

7 – 9 PM, 49TH STATE BREWING COMPANY



Our welcome social will be held Monday evening May 21st 2018 at the 49th State Brewing Company located just a few blocks from the Egan Center and Hilton in downtown Anchorage. Come and enjoy visiting with your colleagues over small-batch handcrafted brews and a menu filled with freshly sourced Alaskan products. See you there!

www.49statebrewing.com/anchorage/



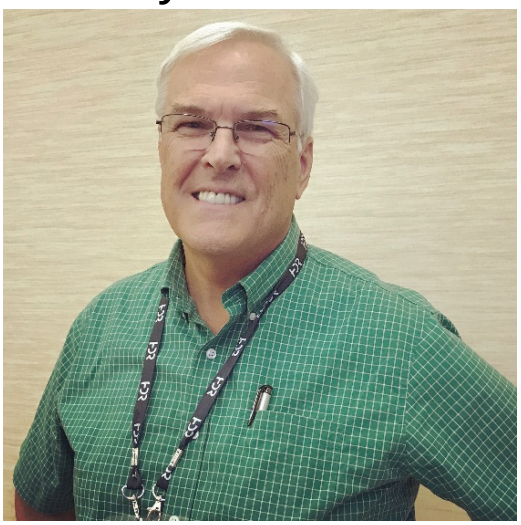
Tuesday, May 22

Welcome, Announcements, Plenary

8:10 – 9:20 AM, EGAN CENTER, ROOM 1

- Crystal Leonetti, Indigenous Alaskan
- Doug Austen, Executive Director, American Fisheries Society
- Brian Missildine, President, Western Division American Fisheries Society
- Jeff Falke, President Elect, Alaska Chapter, American Fisheries Society

Plenary



Dr. Steve L. McMullin

Owner, McMullin Training and Consulting, LLC

President, American Fisheries Society

Professor Emeritus, Human Dimensions of Natural Resources, Virginia Tech Department of Fish & Wildlife Conservation

Associate Director, Virginia Tech College of Natural Resources & Environment Leadership Institute

Title: Why a Diverse and Inclusive AFS is Good for Fisheries

Dr. Steve McMullin has been practicing, learning, and teaching leadership in natural resources for his entire 40-year career as a natural resource professional. He began his career as a fisheries biologist for the Montana Department of Fish, Wildlife and Parks and within three years, found himself leading a large research group in the agency. He continued to rise through the ranks in Montana eventually to become Chief of the Fisheries Management Bureau for the state. He left Montana in mid-career to earn the Ph.D. at Virginia Tech and stayed there for 23 years after earning his degree, retiring in 2016. At Virginia Tech, he taught Fisheries Techniques, Human Dimensions of Fisheries and Wildlife, and Leadership and Communication for Natural Resource Professionals, among other courses. He also served as associate Department Head and interim Department Head in Fish and Wildlife Conservation. For the last six years he was at Virginia Tech, Dr. McMullin developed and directed the College of Natural Resources and Environment Leadership Institute, a program designed to introduce outstanding juniors and seniors to principles of leadership.

Student-Mentor Panel Discussion

12:00 – 1:20 PM, EGAN CENTER, ROOM 1

Students (and early career professionals), are you interested in learning more about the fisheries job market? Want to hear how leaders in our field got to where they are today? A panel discussion will be held over lunch and includes professionals from private, state, and federal agencies, as well as academia. The panel discussion will start promptly at 12:10 pm. **LUNCH IS INCLUDED!**

Tuesday, May 22

Tradeshow Social and Poster Session

6 – 8 PM, EGAN CENTER

No.	Poster Title	Author (Student*)
1	Innovative Design Solutions for Steep Fish Passage Structures	Alexandra Jefferies
2	Using BLM's National Aquatic Monitoring Framework to Collect Scalable Data to Address Current and Future Management Challenges	Colin Brady
3	Beyond the Noise: the Challenge of Using "Active" and "Passive" Hydroacoustic Techniques for Fisheries Management	Colleen Sullivan
4	Global Warming of Salmon and Trout Rivers in the Northwestern U.S.: Road to Ruin or Path Through Purgatory?	Dan Isaak
5	Digital Hydrography for Alaska's Rivers	Daniel Miller
6	Using Reach-Scale Electrofish and Snorkel Surveys to Assess Single Pass Capture (Electro) and Observer (Snorkel) Efficiencies and Generate Mark-Recapture Population Estimates in Central Idaho Stream Habitats	David Richardson
7	Sea Lion Predation Impacts on Salmon and Steelhead in the Lower Columbia River, a Growing Problem	Doug Hatch
8	Defining Genetic Population Management Units of Kelps in Alaska	Erica Chenoweth
9	An Inventory and Database for Southeast Idaho Fish Screens	James DeRito
10	Fish Surveys and Culvert Assessments on Adak Island	Jeanette Alas
11	Genetic Data Reveal Broad-Scale Population Structure in the Alaska Inconnu	Jeffrey Olsen
12	Seasonal Variation in the Detection of Northern Pike eDNA in a Southcentral Alaska Lake	Jeffrey Olsen
13	A Software and Hardware System for the Collection, Editing, and Reporting of Salmon Age, Sex, and Length Data: The Fisheries Database Management System (FDMS)	Katie Sechrist
14	Environmental Impacts of Drilling at a Mining Prospect	Kendra Zamzow
15	Control and Eradication of Invasive Northern Pike in Southcentral Alaska	Kristine Dunker
16	Detecting Early Invasions by Lake Trout in Sawtooth Valley Lakes, Idaho, Using Environmental DNA	Kurt Tardy
17	Planning Infrastructure Improvements at Coleman National Fish Hatchery (CNFH) to Aid in Restoration Efforts of Natural Salmonid Runs in Battle Creek	Laurie Earley
18	Status of Stream Temperature Monitoring and Synthesis of a Statewide Database for AK	Leslie Jones
19	A Proposed Set of Metrics to Describe Thermal Regimes of Wyoming Streams	Luke Schultz
20	Prioritizing Land for Ecological Value in Western Cook Inlet Watersheds	Matthew McMillan
21	Assimilation of Old Carbon by Stream Fish in Arctic Alaska	Michael Carey
22	The Center for Salmon and Society	Milo Adkison
23	Creatively Communicating Salmon Fisheries Management in the Alaskan Context	Natascia Tamburello
24	Juvenile Salmon Diets in the Yukon Delta	Rebecca Shaftel
25	Abundance Trends of Wild Chinook Salmon in Bear Valley Creek, Middle Fork Salmon River, Idaho, USA	Ryan Blackadar
26	Determining Reproductive Maturation of Pacific Herring in Sitka Sound, AK Using Scales	Sara Miller
27	Stock-Specific Travel Times Improve Utility of the Port Moller Test Fishery	Tyler Dann

Tuesday, May 22

Tradeshow Social and Poster Session

6 – 8 PM, EGAN CENTER

No.	Poster Title	Author (Student*)
28	Stage Zero Restoration Design at Whychus Creek, Oregon	Cari Press
29	Alluvial Valley Reset: Stage 0 Restoration at Deer Creek, Oregon	Kate Meyer
30	Determining the Stable Isotope Signature Range of Juvenile Hatchery Salmon From Hidden Falls Hatchery in Chatham Strait	Aaron Cook*
31	Estimating Fishing Effects in Three Dimensions as a Tool to Evaluate Fishing Gear Modifications	Aileen Nimick*
32	Viability of Using RADseq to Resolve Polychaete Phylogeny- A Pilot Study	Alyx Hoover*
33	Genetic Variation in the 2016 Arctic Lamprey Yukon River Spawning migration	Andres Lopez
34	Exploring the Use of Mucus to Assess Stress Hormones in Pacific Halibut *Hippoglossus stenolepis*	Anita Kroska*
35	Diet Profiling Alaskan Octopuses: Applying Stable Isotope Analysis to Alaskan Populations of the Giant Pacific Octopus *Enteroctopus dofleini*	Ben Jevons*
36	Spatiotemporal Assessment of Pacific Halibut *Hippoglossus stenolepis* Growth in Southcentral Alaska	Brian Ritchie*
37	Microplastics in Oregon Coast Pacific Oysters and Pacific Razor Clams	Britta Baechler*
38	Examination of Catch Accounting for Trawl-Caught Red King Crab in the Bering Sea	Cory Lescher*
39	Classification of Habitat Suitability for Finescale Dace in the Belle Fourche - Cheyenne and Niobrara Drainages	Evan Booher*
40	A model-based approach to identifying fishing and vulnerable habitat overlaps: An Aleutian Islands case study	John Olson*
41	Merging Scientific and Traditional Ecological Knowledge: Sockeye Salmon *Oncorhynchus nerka* Management in the English Bay Lakes System, Alaska	Karli Tyance Hassell*
42	Biosurfactant Producing Microbes - A Possible Treatment for Organisms Exposed to Crude Oil	Kelly Ireland*
43	Habitat-Based Assessment of Fisheries Dependent and Independent Sampling of Pacific Cod *Gadus macrocephalus* in the Aleutian Islands	Laura A. Junge*
44	Effects of Biotic and Abiotic Factors on the Specific Growth Rates of Rio Grande Cutthroat Trout *Oncorhynchus clarkii virginalis*	Lauren Flynn*
45	Quantifying Food Web Variations and Changes with Sensitive Predator Range Contractions: Implications for Climate Change	Lauren Zatkos*
46	Abiotic Factors Influencing Salmonid Hybridization	Michael Manning*
47	eDNA Mapping of Juvenile Chinook Salmon Overwintering Distributions	Noah S Khalsa*
48	Maintenance of Genetic Variation in a Population of Resident Dolly Varden Located Above a Barrier	Penny Crane*
49	Communicating Complex Climate Science to the Public with an Infographic: Changes Facing Salmon Ecosystems in Alaska	Benjamin Meyer*

Tuesday, May 22

Student and Early Career Professional Mentor Social

8 PM – CLOSE, PORT VIEW BANQUET HALL

Student and Early Career Professional Social (Open to registered mentors, students, and early career professionals) – Western Division AFS Student-Mentor and Early Career Professional Fish Trivia Challenge 2018! Come and test your knowledge of fundamental (and obscure, it IS trivia!) fisheries concepts through a trivia challenge between groups of students and professional mentors! This was a huge success at the Missoula Western Division Meeting in 2017. The event will be held at the Port View Banquet Hall (https://www.alaskaexperiencetheatre.com/) in downtown Anchorage, just blocks from the meeting venue at the Egan Center. Don't miss this opportunity to dazzle the room with your knowledge, meet and network with professionals, and sample some of Alaska's finest beverages and snacks.

Alaska 2018 AFS Fish Film Festival

8 – 11 PM, ALASKA EXPERIENCE THEATRE

Sponsored by Alaska Fish Habitat Partnerships and Western Native Trout Initiative

The 2018 Alaska Fish Film Festival, sponsored by the Alaska Fish Habitat Partnerships and the Western Native Trout Initiative, will feature short films that focus on the connections between people and fish, the unique life cycle and habitat needs of different species, how ordinary people are helping conserve fish and their habitats, and more. The films will be from a variety of perspectives—from fishermen to subsistence users, researchers, volunteers, landowners, and the fish themselves. The festival seeks to inspire fisheries conservation, grow appreciation for and awareness of fisheries and the many ways in which we're connected to fish and all the goods and services they provide, and grow a collection of short films that can be shared.

Films:

1: Yukon Kings (7:15 running time); *Go Project Films*
2: Restoring America's Salmon Forest (6:00); *Sitka Conservation Society – Southeast Sustainable Partnership / US Forest Service*
3: Blueheads & Bonnevilles (6:40); *Sage Lion Media / Western Native Trout Initiative and Desert Fish Habitat Partnership*
4: In Southwest Alaska (4:43); *Jason Ching*
5: Voices of the Chena (12:20); *US Fish and Wildlife Service / Tanana Valley Watershed Association*
6: Alaska Salmon Project-King Maker Chickaloon Village (3:08); *The Salmon Project and Great Land Trust*
7: A Creek Once More (8:50); *US Fish and Wildlife Service / Narrative Lab*
8: Tour the Kwethluk River (3:57); *Lisa Hupp / US Fish and Wildlife Service*
9: Stream Watch Legacy: Growing Strong Roots & Making a Difference for 20 Years! (5:15): *Alaska Teen Media & Kenai Watershed Forum*
10: Unprecedented Fish Passage Improvements in the Mat-Su Borough (3:12); *Mat-Su Borough and US Fish and Wild. Service*

Wednesday, May 23

Welcome, Announcements, Plenary

8:10 – 9:20 AM, EGAN CENTER, ROOM 1

- Jeff Falke, President Elect, Alaska Chapter, American Fisheries Society

Plenary

Dr. Daniel Escher

Social Scientist
D.J. Case & Associates

Title: The Nature of Americans: Disconnection and Opportunities for the Future

Daniel uses data and social theory to help agencies, non-profits, and companies engage diverse people in conservation. He is experienced collecting and analyzing qualitative data from interviews, focus groups, and ethnography. He also uses classic and innovative statistical techniques to examine and visualize cross-sectional and longitudinal quantitative data, including text. Through teaching, lecturing, and facilitating discussions in groups from six to 200 people, he has first-hand understanding of group dynamics and processes. Since joining DJ Case in 2016, he has co-led the Nature of Americans project, a multi-year effort to understand and connect Americans and nature, funded by The Disney Company, U.S. Fish & Wildlife Service, Florida Fish & Wildlife Conservation Commission, Yale University, and many others. In addition, he has helped to facilitate the World Wildlife Fund's Rio Grande / Rio Bravo Binational Forum, working with WWF and Coca-Cola, and has linked on-the-ground observations in the Red River Basin with recommendations for future research for the U.S. Geological Survey.

Dr. Daniel Schindler

Professor, School of Aquatic and Fishery Sciences, University of Washington

Principal Investigator, UW Alaska Salmon Program

Title: The Regional and Global Significance of Alaska's Rivers and Their Fisheries

Dr. Schindler's research takes an ecosystem approach to exploring how aquatic systems are organized and respond to changes in the broader environment. In particular he is interested in how aquatic ecosystems respond to changing climate and land-use, and interact with fisheries. Most of his current research is in southwest Alaska as a principal investigator of the Alaska Salmon Program that has studied Pacific salmon, their ecosystems, and their fisheries in western Alaska since the 1940s. As part of this program, his research group seeks to understand how watersheds function in terms of: 1) capturing, storing and transporting water, 2) processing nutrients and carbon, 3) providing habitat for plankton, insects, fishes, birds and large predators such as bears, 4) supporting ecosystem services to people (e.g., commercial and recreational fisheries) and 5) how geomorphic attributes of watersheds regulate these processes and services. Of particular interest is in understanding how the physical and biological complexity of watersheds affects the resilience of their functions to changes in regional environmental changes such as shifting climate or changes in fisheries. This work seeks to contribute to the scientific foundation upon which responsible and effective management and conservation can be developed.

Wednesday, May 23

Western Division AFS Annual Business Meeting

12:00 – 1:20 PM, EGAN CENTER, ROOM 1

Meeting will start promptly at 12:10pm. Come learn what the Western Division of AFS is doing for you, its financial status, and come see your colleagues get recognized with Division awards for their great work. **LUNCH IS INCLUDED!!!**

Agenda:

1. Welcome and introductions
2. Procedural items
   a. Determination of quorum (minimum 20 WDAFS members in good standing)
   b. Designation of Parliamentarian
3. WDAFS President's address
   a. Officer election results
   b. Bylaw change update
4. AFS President's address
5. Executive Director address
6. WDAFS Secretary-Treasurer's report
   a. Current status and trend of WDAFS finances
   b. 2018 WDAFS annual meeting finances
7. Scholarships, Grants and Awards
   a. Student scholarship awards
   b. Student, Professional, and International Member Travel grants
   c. Riparian Challenge awards
   d. Small project grant awards
   e. Outstanding Chapter and Student Subunit awards
   f. Special Recognition awards
8. WDAFS Committee Reports
   a. Membership and Nominating Committees
   b. Western Native Fishes Committee
   c. Diversity and Inclusion
   d. Early Career Professionals
9. Future AFS and WDAFS annual meetings
   a. 2019 AFS meeting in Reno, NV hosted by the WDAFS and Cal/Neva Chapter AFS
   b. 2020 AFS and WDAFS annual meetings
10. WDAFS Student Representative report
11. New/Ongoing Activities (member input is welcome (as time permits)
12. Next WDAFS Business meeting: October 1, 2019 in Reno, NV
    Hope to see you there!
14. Adjourn

We ask that grant and award recipients come to the stage immediately after the meeting adjourns to pick up their awards and have their photos taken.

Wednesday, May 23

Spawning Run

6 – 7 PM, KINCAID PARK

The 5K Spawning Run associated with the meeting will be held in Kincaid Park. The race starts at 6:00PM in the Stadium, just east of the Chalet parking lot, and finishes at the Kincaid Chalet, where the banquet is being held. The route has over 600 feet of elevation gain over 5K, following a mix of wide Nordic ski trails, single track running trails, and the paved coastal trail. There are public bathrooms at the Kincaid Chalet; however, there are no showers. Participants should bring a duffle bag with their banquet clothes so they can change after the run. There will NOT be time to go back to the hotel prior to the banquet. All participants are **REQUIRED** to sign a waiver prior to participating. Waivers will be at the registration desk throughout the conference. Contact: Kyle Shedd, kyle.shedd@alaska.gov

Banquet (Silent Auction and Raffle)

7 – 10 PM, KINCAID PARK

The meeting banquet will be held at scenic Kincaid Park – situated among 1,400 acres of rolling, forested hills with stunning views of Mt. Susitna, Denali, and Cook Inlet! Come early to enjoy the miles of trails, do a little fishing at Campbell Point Lake, take a hike down to the beach, or check out the Kincaid Sand Dunes. Special art donation by Regina Bos.

REGINA BOS ARTS
ART • NATURE EVOLUTION

Buses to Kincaid Park leave Egan Center starting at 4:30 PM.

Thursday, May 24

Welcome, Announcements, Plenary

8:10 – 9:20 AM, EGAN CENTER, ROOM 1

- **Jeff Falke**, President Elect, Alaska Chapter, American Fisheries Society

Plenary

Dr. Elizabeth Arnold

Joan Shorenstein Fellow
Shorenstein Center on Media, Politics and Public Policy
Harvard Kennedy School

Title: "It's Really Bad; It's Really, Really Bad": An Argument for Solutions in Science Communication

Elizabeth Arnold is a former National Public Radio (NPR) Political Correspondent, Chairman of the Department of Journalism at the University of Alaska, and the producer of arcticprofiles.com. For twenty years she was a familiar voice on Morning Edition and All Things Considered, and a regular presence on PBS Washington Week, covering Congress, the White House, and the American West. Arnold has received numerous awards, including a duPont Columbia Silver Baton and the Dirksen Award for Distinguished Reporting of Congress. Over the last decade, she has reported on the ecological and human impacts of global warming from some of the most remote areas of the Arctic. She is currently a Fellow at Harvard's Shorenstein Center on Media, Politics and Public Policy where she is researching the role of the press in effectively communicating climate change.

Dr. Kris Homel

Chum Salmon Reintroduction Coordinator
Oregon Department of Fish and Game

Title: The History of Chum Salmon in Oregon: collapsed populations on the long road to recovery

Kris has worked with the Oregon Department of Fish and Wildlife since 2012 as the Chum Reintroduction Coordinator. In that role, she is involved in planning and implementing all aspects of reintroducing functionally extirpated chum salmon to the historic range. She also serves as President of Oregon AFS and is working to expand climate initiatives in the chapter. Her current research focuses on Chum Salmon limiting factors, including determining the distribution of a salmon pathogen using environmental DNA, evaluating estuarine occupancy and survival, identifying factors affecting spatiotemporal body size of spawners, and modeling brood year returns as a function of estuary and ocean covariates.

Kris received her Doctorate in Fish and Wildlife Biology from Montana State University in 2013 where she studied the spatial ecology of Snake River Finespotted Cutthroat Trout in the upper Snake River in Grand Teton National Park, WY. She received her Master's in Fisheries from Utah State University, studying the genetic population structure and movement patterns of Bull Trout in Northeast Oregon. Prior to graduate school, Kris began her fisheries career and love of Chum Salmon at Hidden Falls Hatchery in Southeast Alaska.

Thursday, May 24

44th Annual Alaska Chapter AFS Business Meeting

12:00 – 1:20 PM, EGAN CENTER, ROOM 1

Agenda:

1. Call to Order
2. Determination of a Quorum
3. Approval of Agenda
4. Approval of 2017 Annual Business Meeting Minutes
5. AFS Executive Director's Report – Doug Austen
6. AFS Western Division President's Report – Brian Missildine
7. March 2017-May 2018 Chapter Review:
    a. Reports
        - Treasurer's Report – Lee Ann Gardner
        - Secretary's Report – Position Vacant at Time of Meeting
        - Student Representative's Report – Tessa Minicucci
        - Past President's Report – Mary Beth Loewen
            - Bylaws with Hamachan Hamasaki
            - Procedures Manual
            - Committee
        - Vice President's Report – Joel Markis
            - Website Maintenance
            - Membership Update
            - 2019 AFS-Alaska Annual Meeting
        - President-Elect – Jeff Falke
            - 2018 Annual Meeting Program Review
        - Standing Committees
            - Finance Assets Oversight – Ray Hander
            - Molly Ahlgren Scholarship – Ray Hander
            - General Awards – Jon Gerken
                - Wally Noerenberg– Jon Gerken for Ken Gates
                - Cultural Diversity – Lauren Devine
            - Environmental Concerns – Bert Lewis and Nicki Szarzi
            - Continuing Education – Sara Miller
            - Fisheries Communication and Education – Katrina Liebich and Bill Bechtol
        - President's Report – Aaron Martin
            - Student Endowment
            - Surveys
                - Priority Actions
                - Financial Planning
8. Farewell Remarks From Outgoing President – Aaron Martin
9. Remarks From the New President – Jeff Falke
10. New Business:
    a. Appointment of new Executive Committee Officers
11. Open Forum
12. Adjourn

Thursday, May 24

Closing Session – Best Student Paper Awards

5 – 6 PM, Egan Center, Room 1

Stop in and support the next generation of fisheries professionals as they receive awards for their great projects and presentations!

Friday, May 25

Field Trips

Eklutna River Watershed Tour ($30)

Visit sites relevant to the restoration of habitat and streamflow in this Anchorage-area stream including an ongoing dam removal, upstream water diversions for municipal water and electrical generation, and the tailrace and associated hatchery salmon fishery. Participants will have lunch (provided) and a chance to hike along the shore of glacial Eklutna Lake in the Chugach Mountains.

Participants: 8 (min) to 12 (max); Transportation and box lunch provided; Depart Egan Ctr: 9am, Return 5pm

Willow Creek Fishing Shuttle ($40)

Fish for native, wild Rainbow Trout, Dolly Varden, and Arctic Grayling in Willow Creek (and potentially other streams) in the Susitna Valley north of Anchorage. All fishing gear, licenses, and knowledge of pertinent fishing regulations will be the responsibility of participants.

Participants: 8 (min) to 12 (max); Transportation and box lunch provided; Van departure from Egan Ctr: 9am; Van return to Egan Ctr: 5pm

Turnagain Arm Wildlife Tour ($30)

Drive scenic Turnagain Arm with stops to look for Dall sheep, mountain goats, bears, waterfowl, and shorebirds. The Eulachon spawning run will be in full swing and may also bring opportunities to view the fishing behavior of beluga whales, harbor seals, bald eagles, and local humans. Will include a lunch stop in Girdwood (cost not included) and, depending on interest, stops for hiking, a ride up the Alyeska tram, a cruise to the Portage Glacier, or a tour of the Alaska Wildlife Conservation Center.

Participants: 8 (min) to 12 (max); Transportation provided; Bring your own lunch; Van departure from Egan Ctr: 9am; Van return to Egan Ctr: 5pm

Friday, May 25

Field Trips, Continued

William Jack Hernandez Sport Fish Hatchery Tour ($5)

Get a behind-the-scenes look at this high-tech recirculating facility run by the Alaska Department of Fish & Game to produce salmon, trout, and char for southcentral Alaska's sport fisheries. Transportation will not be provided but the hatchery is 3.3 miles from the meeting venue along the Ship Creek bike path (rental bikes are available downtown near the meeting venue; allow at least an hour if walking and 20 minutes if biking). Participants should be aware that they cannot have been sport fishing on the 25th, or wear clothes they wore while sport fishing the day prior. A 5$ donation to the Student Travel Fund covers your attendance for this field trip!

Participants: 8 (min) to 12 (max): No transportation or lunch provided. Tour from 10 am to noon.

Alaska Blackfish Viewing ($5)

Travel to local water bodies with Patrick McCormick from Chugach View Outfitters to view the Alaska Blackfish (*Dallia pectoralis*: Esociformes: Esocidae), a Beringian endemic introduced to the Anchorage Bowl. Cost is $5 donation to Student Travel Fund

Participants: 2 (min) to 4 (max); Transportation provided; Departure from Egan Ctr: 2pm; Return to Egan Ctr: 5pm

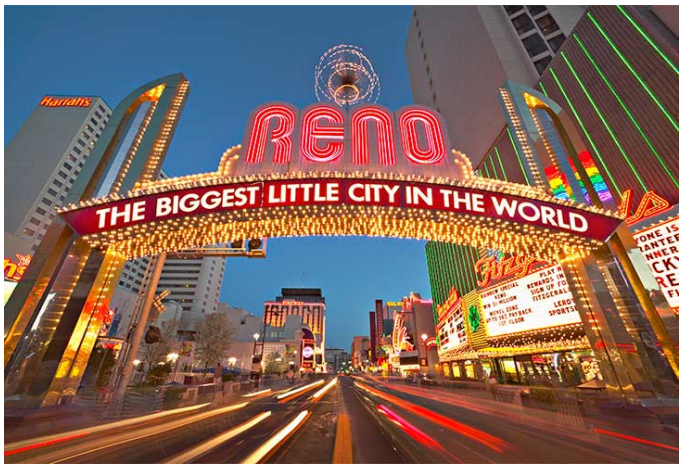
2019 Meeting, Reno, Nevada

Please Join Us Next Year!

The American Fisheries Society's 2019 Annual meeting is being hosted by the Western Division and Cal-Neva Chapter of the American Fisheries Society. This meeting is truly a once in a career opportunity as it is also a joint meeting with The Wildlife Society. Don't miss out on this rare opportunity!

September 29 – October 3, 2019

Reno, Nevada



Technical Session Schedule, TUESDAY 5/22/18, 9:40 AM – 11:00 AM *STUDENT PRESENTATION

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Making Fish Habitat Great Again	Changing Food Webs and Challenges for Freshwater Fisheries Management	Conservation of Western Native Trout: Challenges and Advances	Salmon Enhancement in the Last Frontier	Contributed Papers	Evolving Methods for Specifying Anadromous Waters in Alaska
Room	1	2	3	4	5	6	7
Chair	Spaeder / Schindler	Matt Varner	Ryan Bellmore	Julie Meka Carter	Joel Markis	Lisa Stuby	T. Troll / E. Ammann
9:40 AM	Nushagak R Chinook salmon assessment program, management structure, and stock status Jack Erickson	Identifying a moving target: estimating the rate of change in stream habitats at sites with little land-use pressure W. Carl Saunders	Understanding the indirect effects of climate change on pristine arctic lakes and arctic char Phaedra Budy	Programmatic approach provides genetic specific connectivity for Bull Trout in the Baker River Basin, WA Arnold Aspelund	Evaluating introgressive hybridization between native and propagated non-native steelhead Christopher Caudill	Future of salmon in the face of change: lessons from one of the world's remaining productive salmon regions Erik Schoen	Building digital river networks to improve detection of salmon habitats across Alaska Lee Benda
10:00 AM	Kuskokwim River Chinook Salmon assessment program, management structure, and stock status Zachary Liller	A quick history of National Forest stream restoration in depositional areas of the Pacific Northwest Matt Helstab	Deciphering changes in seasonal predator-prey relationships within a mixed fishery to manage Kokanee production Brian Lanoutte*	Evaluating fish passage and making management decisions: review of fish passage on the lower Clark Fork River L. Brent Mabbott	Steelhead kelt reconditioning and reproductive success studies in the Columbia River Basin Doug Hatch	Younger smolts may explain Kvichak Sockeye Salmon decline Haley Ohms	Production from diverse stock groups within the large and complex Sockeye Salmon run to the Kvichak River Michael Link
10:20 AM	Yukon River Chinook Salmon assessment program, management structure, and stock status Zachary Liller	BLM's National Aquatic Monitoring Framework: collecting scalable data to address management challenges Colin Brady	Riparian defoliation by the invasive green alder sawfly influences terrestrial prey subsidies to salmon streams David Roon*	Optimizing ladder operations - upstream fish passage at Thompson Falls Dam, lower Clark Fork River Kristi Webb	Alaska mariculture initiative – tangible indications of progress as a result of a three-year comprehensive planning process Julie Decker	Monitoring the status of salmon populations and their habitats in British Columbia using the Pacific Salmon Explorer Eric Hertz	Strategies for identifying Alaska's anadromous fish habitat Michael Wiedmer
10:40 AM	Genetic diversity of Chinook Salmon populations inhabiting the Yukon and Kuskokwim rivers Jim Seeb	Stream restoration on Medicine Lodge Creek, Wyoming Laura Burckhardt	Riverine food webs and the contribution and quality of food sources to the threatened Australian lungfish Mark Kennard	Monitoring Bull Trout reintroduction in the Clackamas River, Oregon Marshall Barrows	Using genetics and coded wire tags to understand harvest of Southeast Alaska Chinook Salmon to improve management Kyle Shedd	Reintroducing endangered Sacramento River winter-run Chinook Salmon to historic habitat in Battle Creek, CA Laurie Earley	Documenting habitat for anadromous species: exploring affordable methods for protecting salmon streams Sarah O'Neal*

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Room	1	2	3	4	5	6	7
Chair	Spaeder / Schindler	Matt Varner	Ryan Bellmore	Julie Meka Carter	Joel Markis	Lisa Stuby	T. Troll / E. Ammann
11:00 AM	Assessing the relative contribution of genetic sub-stocks to the lower Kuskokwim River Chinook Salmon subsistence fishery Daniel Prince	Geomorphic analysis for river restoration design of salmon habitat in dredge-mined rivers Tim Hanrahan	Investigating the trophic status of an invasive crayfish in an oligotrophic lake: bottom-up view of a warm and cold-water sport fishery food web John Loffredo*	Hedging bets: dealing with uncertain outcomes by diversifying management approaches Christopher Downs	Harvest of Southeast Alaska wild-origin Chinook Salmon in the Southeast Alaska Troll and Sport Fisheries, 2005–2017 Randy Peterson	Thermal experience modifies energy depletion of Sockeye Salmon migrating at the northern edge of their distribution Michael Carey	Quantifying habitat use of anadromous fish using space-time isotope models Sean Brennan
11:20 AM	Effective population size of Chinook Salmon in Yukon and Kuskokwim river tributaries Wes Larson	The “Resurrection” of Resurrection Creek near Hope, Alaska Brian Bair	Exotic species alter food web structure in Pacific Island streams Richard MacKenzie	The role of aquaculture to support Bull Trout recovery in Glacier National Park Mark Maskill	Stand tall and go wild Ben Van Alen	Is bigger always better? Size-selective early marine survival in an Alaskan Sockeye Salmon population Marta Ree*	Metabarcoding of Alaskan freshwater fish communities using amplicon-based next-generation sequencing of environmental DNA Trey Simmons
11:40 AM	Strontium isoscapes as a tool to quantify production dynamics and life history diversity of Yukon and Kuskokwim Chinook Salmon Sean Brennan	Applying natural channel design techniques to reclaim placer mined streams in Alaska Matthew Varner	Contemporary phenotypic divergence among populations of Northern Pike in its introduced and native ranges of Alaska Katja Berghaus*		Possible roles of hatcheries and dams as bridges to conserve salmon and trout during changing climate Todd Pearsons	Growth rate variation among juvenile Chinook Salmon cohorts and rearing conditions Elianna Rosenthal*	
12:00 PM	LUNCH (12:00 to 1:20 PM)						

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Making Fish Habitat Great Again	Changing Food Webs and Challenges for Freshwater Fisheries Management	Conservation of Western Native Trout: Challenges and Advances	The State of Alaska's Salmon and People	Contributed Papers	Spatial-Stream-Network Models: Recent Advances and Applications
Room	1	2	3	4	5	6	7
Chair	Spaeder/ Schindler	Matt Varner	Ryan Bellmore	Julie Meka Carter	Peter Westley	Sara Gilk-Baumer	Dan Isaak
1:20 PM	Four decades of changing demographic structure in Chinook Salmon across the Northeast Pacific Jan Ohlberger	Stream Restoration: comparing Alaska with the rest of the West: what have we learned and where do we go next? William Rice	Sculpin and trout sensitivity to environmental change in streams: a bioenergetics approach Jason Dunham	Coordinated re-establishment of Lahontan Cutthroat Trout, Truckee River Robert Al-Chokhachy	Alaska salmon and people: setting the stage for the symposium Peter Westley	Emerging genetic baseline for Coho Salmon in Alaska: using on small scale challenges to create large scale solutions Sara Gilk-Baumer	The National Hydrography Infrastructure: water information waves on the NHDPlus framework Becci Anderson
1:40 PM	Demographics of Chinook Salmon spawning runs in the Yukon River using known-sex sample data Randy Brown	Aquatic habitat rehabilitation of placer mined streams in Alaska: past, present and future Matthew Varner	Growth and foraging of juvenile Chinook and Coho Salmon in 3 geomorphically distinct sub-basins, Kenai River Benjamin Meyer*	The salmonid population viability project: modeling trout viability in a desert landscape Daniel Dauwalter	Salmon synthesis: Using open science to integrate and analyze Alaskan salmon data Jeanette Clark	A new Chinook Salmon genetic baseline for Cook Inlet: opening doors to new analyses Andrew Barclay	Spatial stream network models and isoscapes Sean Brennan
2:00 PM	Patterns of Chinook Salmon declines: The story of growth at age Lorna Wilson*	Making Waves: the effects of whitewater parks on fish passage Ashley Brubaker	Incorporating food web dynamics into river restoration planning Emily Whitney	The effect of Tui Chub forage base and declining lake levels on Lahontan cutthroat trout in Pyramid Lake Gary Thiede	PyRiv: new methods for calculating minimum aquatic distance across marine and freshwater habitats Jared Kibele	Partial tetrasomy conserves duplicated genes following whole-genome duplication in Rainbow Trout Matthew Campbell	Controls on the spatial variation of mercury in the Kuskokwim River David French*
2:20 PM	Assessing the limits to production for Upper-Yukon Chinook Salmon Joel Harding	Assessing fish passage in culvert structures with a two-dimensional algorithm Alexandra Jefferies	Juvenile salmon predation by Pacific staghorn sculpins and Dolly Varden in SE Alaska estuaries Douglas Duncan*	Status of Golden Trout on the Kern Plateau during and after prolonged drought David Lentz	Salmon and People: understanding relationships and disconnections through time Courtney Carothers	High throughput genotyping in the world's highest volume fish genetics lab Heather Hoyt	Ecological applications of SSN models in 20 river networks in Europe David Cowley
2:40 PM	Feeding ecology of juvenile Chinook Salmon in the Chena River, Interior Alaska Jason Neuswanger	Variables influencing Cutthroat Trout colonization and abundance in newly accessible habitats Travis Schill	Bioenergetics-based habitat suitability curves for modelling flow effects on juvenile salmonids Sean Naman	Fishery management approach for Rainbow Trout in the diverse Kenai R Brian Marston	Socio-economic dimensions of Alaska's Salmon System: synthesis of available indicators Tobias Schwoerer	DNA mixtures for ecology Suresh Sethi	Predicting the distribution of Yellowstone Cutthroat Trout, upper Snake River Cody Feldman*
3:00 PM	BREAK (3:00 – 3:20 PM)						

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Making Fish Habitat Great Again	Changing Food Webs and Challenges for Freshwater Fisheries Management	Conservation of Western Native Trout: Challenges and Advances	The State of Alaska's Salmon and People	Contributed Papers	Spatial-Stream-Network Models: Recent Advances and Applications
Room	1	2	3	4	5	6	7
Chair	Spaeder/ Schindler	Matt Varner	Ryan Bellmore	Julie Meka Carter	Peter Westley	Sara Gilk-Baumer	Dan Isaak
3:20 PM	Longitudinal patterns of logjams and occupancy by juvenile Chinook Salmon in the Chena River, Alaska Charles Cathcart	Fish passage improvements post replacement of a partial barrier culvert, Buddy Creek, Alaska Gillian O'Doherty	Do anadromous salmon populations recolonizing the Cedar River, WA influence the resident food web? Peter Kiffney	Abundance, productivity, and spatial structure of a mixed O. mykiss population, Central Washington Gabriel Temple	Governance systems for subsistence salmon in Alaska James Fall	Understanding the genetic basis of ecotypic variation in Sockeye Salmon from across Alaska Wes Larson	Thermal and habitat characteristics of a headwater fish species: population success under climate change Mischa Turschwell
3:40 PM	Monitoring Chinook Salmon smolt in Western AK to evaluate freshwater density dependency Ken Harper	Yes we can! Collaborative efforts to improve fish passage in Southcentral Alaska Megan Marie	Foodweb response during and after removal of the Elwha River dams Sarah Morley	Trout Creek Ranch, Wyoming G&F, and East Yellowstone TU conserving Yellowstone Cutthroat Trout Erin Leonetti	Using participatory modeling to empower community engagement in salmon science Michael Jones	Index of relative abundance for combining CPUE across gear types for fish-habitat associations Alice Shelly	Thermal niches of fishes in northern Canada: examining variation of thermal regimes across stream networks Neil Mochnacz*
4:00 PM	Do beavers negatively impact freshwater habitat for juvenile Chinook? Rachel Malison	Fish and floods: a 20 year perspective on fish passage at road-stream crossings in south central Alaska William Rice	Live fish, dead fish, fake fish, no fish: alternative MDN subsidies in central Idaho streams Andre Kohler	Identifying invasive lake trout spawning locations to improve suppression efficacy Jacob Williams*	Conceptualizing and measuring human well-being in Alaska's salmon fisheries Rachel Donkersloot	Integrating fish use of headwaters, backwaters, and big rivers: a Fish Use Habitat Index (FUHI) Kai Steimle	Subsampling ideas for large spatial data sets Jay Ver Hoef
4:20 PM	Assessing heat stress in migrating Yukon River Chinook Salmon Vanessa von Biela	Productivity in the Hanford Reach: flow management benefits for fall Chinook Salmon Peter Graf	Glaciers and salmon, SE Alaska: landscape complexity and mobility influences energy pathways Matthew Dunkle*	Suppressing hybrid and rainbow trout to conserve Westslope Cutthroat in the upper Flathead River Amber Steed	Salmon governance dynamics: the Kuskokwim River Inter-Tribal Fisheries Commission Taylor Brelsford	The Pebble mine and safeguarding Bristol Bay Nelli Williams	Testing for types of spatial dependence on stream networks Dale Zimmerman
4:40 PM	Proximate composition and bioelectrical impedance of Yukon Chinook Salmon Kristin Neuneker		Climate change induced resource synchronization disrupts brown bear and salmon food webs William Deacy	Fluvial population of Bonneville Cutthroat Trout in the highly fragmented Weber River Clint Brunson	Governing salmon and people in Alaska: frameworks, practices and challenges Steve Langdon	Mapping the historical mining footprint related to fish habitat across Alaska and Canada Marcus Geist	Fusing data, spatial stream models, and social networks for conservation, science, and mgmt Dan Isaak

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Hooked: Creative Solutions to Engage the Public in Fish Conservation and Management	Challenge, Change, and Opportunities for Marine Fisheries	Conservation of Western Native Trout: Challenges and Advances	Pink and Chum	Turning the Tide: Enhancing Diversity and Inclusion in the Fisheries Profession
Room	1	2	3	4	5	6
Chair	J. Spaeder / D. Schindler	Katrina Liebich	G. Kruse / V. R. von Biela	Julie Meka Carter	Pete Rand	C. Owens / L. Lee
9:40 AM	Beyond mortality of individuals: population-level indices informing estuarine/marine drivers of Yukon River Chinook Salmon productivity Katie Howard	FISH TALK: Thirty years of talking "fish" Bill Hauser	Reproductive biology informs fishery management of Snow and Tanner Crabs in the eastern Bering Sea Gordon H. Kruse	Structure and spatial distribution of an isolated population of Greenback Cutthroat Trout in a high altitude and high gradient mountain stream Jason J. McFarland	Detecting patterns of covariation between ocean conditions and size at age of Oregon coast Chum Salmon using dynamic linear models Kathleen Neely	A look at diversity and inclusion initiatives within AFS April N. Croxton
10:00 AM	Estuarine ecology of juvenile Chinook Salmon on the Yukon River Delta Katharine Miller	Salmon Blitz: engaging citizen scientists in documenting salmon habitat in the Copper River Watershed Kate Morse	Optical assessment of Weathervane Scallop density and abundance off Kodiak Island, AK Victoria Batter*	Estimating the seasonal migration of Sakhalin Taimen using environmental DNA Hiroki Mizumoto*	Why we need to know why wild Alaska salmon taste better. Eric Jordan	Engaging fishery stakeholders and communities: storytelling with oral history and visual ethnography Jean Lee
10:20 AM	Diet reconstruction of juvenile Chinook Salmon using stable isotope Bayesian modeling Jarred J. Stone*	Diverse efforts to restore a complex fish species – Pacific Lamprey Brian McIlraith	Reduced portfolios in salmon populations in British Columbia Eric Hertz	Effects of instream complexity on habitat suitability for stream-dwelling Cutthroat Trout populations Tyson Hallbert*	Using otolith thermal marks to understand and manage hatchery-wild Pink Salmon interactions in Lower Cook Inlet commercial fisheries Ted Otis	Seeking the mountain top-gaining ground and new perspectives on gender diversity in fisheries Jesse Trushenski
10:40 AM	Do Pink Salmon structure North Pacific ecosystems and contribute to declining Chinook Salmon in the Arctic-Yukon-Kuskokwim region of Alaska? Greg Ruggerone	From creek to plate: a summer of firsts Katrina Liebich	Movement patterns of juvenile Sablefish within a nursery area in Southeast Alaska Rhea Ehresmann*	Tributary reconnection and restoration increases recruitment of wild Cutthroat Trout in Bear Lake (Idaho, Utah) James DeRito	Using thermal marks to identify and enumerate hatchery Pink Salmon strays to streams in Lower Cook Inlet Glenn Hollowell	Native Alaska women in Bristol Bay fisheries Anna Lavoie

TECHNICAL SESSIONS SCHEDULE, WEDNESDAY 5/23/18, 11:00 AM – 12:00 PM *STUDENT PRESENTATION

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Hooked: Creative Solutions to Engage the Public in Fish Conservation and Management	Challenge, Change, and Opportunities for Marine Fisheries	Conservation of Western Native Trout: Challenges and Advances	Pink and Chum	Turning the Tide: Enhancing Diversity and Inclusion in the Fisheries Profession
Room	1	2	3	4	5	6
Chair	J. Spaeder / D. Schindler	Katrina Liebich	G. Kruse / V. von Biela	Julie Meka Carter	Pete Rand	C. Owens / L. Lee
11:00 AM	Life cycle modeling of Yukon River Chinook Salmon reveals signals of large scale climate drivers, hatchery enhancement, and density-dependent juvenile survival Curry J. Cunningham	Cryptic but reel: using social psychology in videos to acquaint the public with lesser known fishes Taylor Ulrich*	Size-based patterns of energy allocation in juvenile Sablefish Matt Callahan*	Temporal variability in the upper extent of fish distributions in southwest Washington Renata Tarosky	Long term productivity trends in natural populations of Pink and Chum Salmon from Puget Sound, Washington, USA Marisa Litz	Bristol Bay Guide Academy: A model for other rural communities? Nelli Williams
11:20 AM	Development and evaluation of a run timing forecast model for Kuskokwim River Chinook Salmon Ben Staton*	Applied fisheries education in a semester package Reid Brewer	Declining condition of a key forage fish in the Gulf of Alaska during the North Pacific marine heatwave Vanessa von Biela	Recovery of fish populations and physical channel characteristics in streams impacted by catastrophic debris flows Jason Walter	Effects of Asian Pink Salmon and Chum Salmon on the growth of western Alaska Chum Salmon Tessa J. Minicucci*	Unity and empowerment of Kuskokwim youth as our future fisheries leaders Janessa Esquible*
11:40 AM	Overview on Chinook salmon bycatch management measures in the Bering Sea Jordan Watson		Assessing the potential for competition between Pacific Halibut and Arrowtooth Flounder throughout the Gulf of Alaska Cheryl L. Barnes*	Using net rate of energy intake foraging model to predict salmonid carrying capacity across multiple reaches Nicolaas Bouwes	Spawning habitat characteristics and phenology of fall Chum Salmon *Oncorhynchus keta* on the Teedriinjik River, Alaska Chelsea Clawson	Using authentic science with fish to increase participation in fisheries E Dale Broder
12:00 PM	LUNCH (12:00 to 1:20 PM)					

TECHNICAL SESSIONS SCHEDULE, WEDNESDAY 5/23/18, 1:20 PM – 3:00 PM *STUDENT PRESENTATION

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Contributed Papers	Challenge, Change, and Opportunities for Marine Fisheries	Marine Mammal-Fishery Interactions: Conflicts, Mgmt , and Solutions	The State of Alaska's Salmon and People	Beyond the Dartboard: Methods for Salmon Forecasts	Keeping the West Wild by Minimizing Impacts of Aquatic Invasive Species
Room	1	2	3	4	5	6	7
Chair	Spaeder / Schindler	Lisa Stuby	Kruse / V. von Biela	Julie Scheurer	Peter Westley	Cunningham / Brenner	A. Martin / T. Davis
1:20 PM	Potential effects of late marine mortality on Chinook Salmon populations Kaitlyn Manishin*	Introgressive hybridization between native and artificially propagated non-native steelhead Christopher C. Caudill	Does fishing disturbance explain distribution of structure-forming benthic features in the Bering Sea? Kelsey Bockelman*	Monitoring, managing, and mitigating marine mammal and fisheries interactions under the MMPA and ESA Julie Scheurer	Characterizing salmon habitats and diversity across the state of Alaska Leslie Jones	Introduction to the Salmon Forecasts symposium Curry Cunningham / Rich Brenner	Aquatic invasive species change ecosystem services derived from Sockeye Salmon: bioeconomic risk analysis Tobias Schwoerer
1:40 PM	Population coherence and environmental impacts on population productivity in AK Chinook Salmon Jan Ohlberger	An evaluation of recycling summer steelhead on the Cowlitz River Scott Gibson	A fishing impacts model to assess tradeoffs between spatial closures and gear modifications T. Scott Smeltz*	Understanding sea otter impacts on subsistence fisheries in Southeast Alaska Sonia Ibarra*	Linkages between salmon diversity and habitat heterogeneity across Alaska Jorge F. Cornejo-Donoso	Salmon forecasting methods used in Alaska: where to go from here? Rich Brenner	Management of the invasive aquatic plant *Elodea* spp. in interior Alaska Aditi Shenoy
2:00 PM	Harvest-population diversity tradeoffs in salmon management: Chinook in the Kuskokwim and Yukon Brendan Connors	Combining runoff modeling and fuzzy classification to identify transitional flow regimes in southeast Alaska C. J. Sergeant*	Should fisheries biologists stop using the PDO and NPGO indices? Mike Litzow	Aquatic farming as an emerging industry in Alaska: Assessing impacts to marine mammals Sue Goodglick	Status of Alaska salmon: a review of escapement and management goals Madeline Jovanovich	Can selective use of historical data improve pre-season forecasts of Fraser River Sockeye Salmon Mike Lapointe	Elodea eradication in south central Alaska Daniel Coleman
2:20 PM	Barriers and bridges to implementing management strategy evaluation in a data limited system Michael L. Jones	Vital rate estimation and reduced handling stress using passive floating PIT tag detectors Ben Stout*	Biodiversity and assemblage structure in demersal fisheries surveys: the role of tow duration Meadhbh Moriarty*	Potential effects of motorized watercraft use on Cook Inlet Beluga Whale activity during seasonal fish spawning periods Suzanne Steinert	Widespread changes in the size and age of Alaska salmon Krista Oke	Was simpler better? 20 years of Sockeye Salmon forecasting in the Columbia Basin Jeffrey K. Fryer	Rapid response for invasive waterweeds in high latitude systems: impacts from herbicide treatment Suresh Andrew Sethi
2:40 PM	Structured decision making to support cooperative in-season management of Kuskokwim River Chinook Salmon Lew Coggins	Mad first impressions: invertebrate communities in three northern California estuaries Kaitlyn Manishin*		Understanding the problem and working toward solutions: Steller sea lions and salmon troll fishing in SE AK Kim Raum-Suryan	Unravelling how climate and competition shape Sockeye Salmon dynamics across the SE Pacific Ocean Brendan Connors	Age-structured state-space models: Can they provide insight into the future? Matt Tyers	Investigating the effects of fluridone on metabolism and host microbiota diversity in Threespine Stickleback Patrick Tomco*
3 PM	BREAK (3:00 – 3:20 PM)						

TECHNICAL SESSIONS SCHEDULE, WEDNESDAY 5/23/18, 3:20 PM – 5:00 PM *STUDENT PRESENTATION

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Contributed Papers	Western Native Fishes	Marine Mammal-Fishery Interactions: Conflicts, Mgmt, and Solutions	The State of Alaska's Salmon and People	Beyond the Dartboard: Methods for Salmon Forecasts	Keeping the West Wild by Minimizing Impacts of Aquatic Invasive Species
Room	1	2	3	4	5	6	7
Chair	Spaeder / Schindler	Lisa Stuby	N. Cathcart / L. Schultz	Julie Scheurer	Peter Westley	Cunningham / Brenner	A. Martin / T. Davis
3:20 PM	Probability and implications of incorrectly detecting over-compensatory recruitment dynamics Timothy Walsworth	Haunted rivers: application of mobile RFID-GPS systems to evaluate the prevalence of ghost PIT tags Eric E. Richer	Gene-by-environment interactions underlie Threespine Stickleback responses to microbiota disturbance Emily Lescak	Beating them at their own game: can fishermen use acoustics to spy on sperm whales? Lauren Wild*	What is causing changes in the size of Alaskan salmon? Curry J. Cunningham	Forecasting Yukon River Chinook Salmon runs three years into the future using juvenile data Katie Howard	Eradication of invasive Northern Pike from Alaska's Kenai Peninsula Kristine Dunker
3:40 PM	Influence of fecundity variation on management reference points for Kuskokwim River Chinook Salmon Matthew Catalano	Return to creel of catchable trout and factors influencing angler satisfaction and catch rates in Arizona streams Zachary Beard	Harnessing eDNA to monitor spatial and temporal dynamics of Eulachon in northern southeast Alaska Meredith Pochardt*	Will pingers reduce entanglement risk of AK humpback whales in commercial fishing gear? Fred Sharpe	Consequences of declining salmon size and age for fisheries management Bert Lewis	Forecast error of Bristol Bay Sockeye Salmon in relation to Sockeye Salmon interactions at sea with Pink Salmon Greg Ruggerone	Invasive Northern Pike suppression in Alexander Creek Parker Bradley
4:00 PM	Does quality matter: relating age, sex and length of spawning Chinook to fecundity and yield potential James Boersma	Quantifying drivers of mercury in resident lake fish from Southwest Alaska network parks Krista Bartz	Spawning migration of Least Cisco in the Chulitna River watershed, southwest Alaska Dan Young	Community science and coop. research: rebounding marine mammals in the Northeast US Andrea Bogomolni	Research in a connected salmon landscape: Understanding and opportunity Coowe Walker	Impact of genetic-based construction of brood tables on Bristol Bay Sockeye Salmon forecasts Greg Buck	Vulnerability of salmonids to invasion by Northern Pike in south central Alaska Chase Jalbert*
4:20 PM	Otolith shape revealing life history traits of Chinook Salmon in Patagonia and Oregon Alex Koeberle*	Warming up the waters in Arctic lakes: implications from individuals to ecosystems Nick Barrett*	Population structures of invasive Alaska Blackfish Patrick McCormick		Decision support for salmon landscapes: Tool development and applications Syverine Bentz	Do smolt data reduce errors in forecasts of Sockeye Salmon returns to the Chignik? Nyssa Baechler*	Invasive Northern Pike suppression begins in Lake Roosevelt, WA Alix Silver
4:40 PM		An overview of FLOW 2018: managing rivers, reservoirs, and lakes in the face of drought Christopher Estes	Wild salmon and shifting baseline syndrome: using redd counts to estimate historical Chinook Salmon production Russ Thurow		SASAP: An approach to our understanding of Alaska's salmon and people systems Ian Dutton	In-season assessment of Fraser River Sockeye Salmon. Mike Lapointe	Assessing effects and probability of suppression of an illegally introduced Walleye population Jason Burckhardt

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Ghosts of Fishes Past, Present, and Future	Western Native Fishes	Turning the Tide: Enhancing Diversity and Inclusion in the Fisheries Profession	Pink and Chum	Water Quality in Fisheries: Keeping an Eye on a Vital Resource
Room	1	2	3	4	5	6
Chair	Spaeder / Schindler	Trent Sutton	Cathcart / Schultz	C. Owens / L. Lee	Pete Rand	P. Kusnierz
9:40 AM	Natural indicators of salmon run timing and abundance Catherine Moncrieff	Ghosts of fishes past, present, and future: confronting data-limited stocks in a changing Arctic Trent M. Sutton	Waste water effluent, estrogenic exposure, and the future of eastern plains native fishes Dana L. Winkelman	Public outreach in secondary schools, lessons from a teacher Patrick McCormick	Alaska Hatchery Research Program: an examination of hatchery-wild interactions Steve Reifenstuhl	Potential impacts of selenium on fish populations in Thompson Creek, Idaho Shai Kamin
10:00 AM	Rampart Rapids Student Data Collection Project 2001-2013 Stan Zuray	Assessing spatial patterns of Arctic Cod (*Boreogadus saida*) abundance and distribution in the Chukchi and Beaufort seas Caitlin Forster*	Food webs, hypoxia, and stable isotopes in a bar-built estuary: Rodeo Lagoon, CA Matthew Young	Indigenous integration of aquatic sciences and traditional-ecological-knowledge Alex Alexiades	Contributions of hatchery- and natural-origin Pink and Chum Salmon returning to Prince William Sound Pete Rand	Mother Nature isn't always kind: impacts of landslides and acidic runoff on biological communities, NM Christopher Craft
10:20 AM	Building a vision for tribal involvement in management of Yukon River Chinook Salmon Stephanie Quinn-Davidson	Arctic Cod, *Boreogadus saida*, and Snow Crab, *Chionoecetes opilio*, in Alaska's Arctic Franz Mueter	A conceptual framework on pathways of stress in large rivers – A case study of age-0 White Sturgeon recruitment Tim Counihan	Hooked on Aquatic Sciences: a fishing program to teach diverse youth about aquatic ecology and conservation Taylor Ulrich*	Performance in migration and reproduction in natural- and hatchery-origin Pink Salmon using stable isotopes Kristen Gorman	Municipal and industrial effluents contributing to fish mortality and harmful algal blooms in Arabian Sea, Pakistan M. Naeem Khan
10:40 AM	Integrating rural residents into co-management and rebuilding of Kuskokwim River Chinook Salmon William R. Bechtol	Environmental and biological influences on the southern distribution of Arctic Cod (*Boreogadus saida*) in the Bering Sea Jennifer M. Marsh*	Stream-specific and generalized habitat suitability criteria for three native desert fishes Zach Nemec*	Introducing the Western Division Diversity and Inclusion Committee Cheyenne Owens	Stress, straying, and performance on spawning grounds by hatchery chum salmon, SE Alaska Peter Westley	Roads to ruin: the threats of urbanization to conservation of a sentinel species Blake Feist

	Understanding the Drivers of Chinook Salmon Decline in Western Alaska	Ghosts of Fishes Past, Present, and Future	Western Native Fishes	Turning the Tide: Enhancing Diversity and Inclusion in the Fisheries Profession	Pink and Chum	Water Quality in Fisheries: Keeping an Eye on a Vital Resource
Room	1	2	3	4	5	6
Chair	Spaeder / Schindler	Trent Sutton	Cathcart / Schultz	C. Owens / L. Lee	Pete Rand	P. Kusnierz / A. Todd
11:00 AM	Linking communities to in-season salmon management: Kuskokwim River community-based salmon monitoring program William R. Bechtol	Upper thermal tolerance of Arctic and Pacific Lamprey larvae and instream thermal dynamics in Japan, Washington, USA Hiroaki Arakawa*	Captive propagation of the Devils Hole Pupfish at the Ash Meadows Fish Conservation Facility Corey Lee	Town Hall	Ecological barriers and bridges to introgression of hatchery produced and natural origin Pink Salmon in Prince William Sound, Alaska Julia McMahon*	Nutrient flux in Sawtooth Valley sockeye salmon nursery lakes, Idaho Kurt Tardy
11:20 AM	Approaches to sustainability for Chinook local populations: exploring a place-based management paradigm Rick Williams	The Chronicles of Charnia: abiotic and biotic factors that structure arctic lake food webs with Arctic Char Stephen Klobucar	June Sucker recovery efforts: response of an endangered species to instream flows and captive rearing Michael Mills	Town Hall	Population structure of even-year Pink Salmon from Prince William Sound, Alaska Wei Cheng*	Addressing water chemistry differences affecting post-release survival of Snake River Sockeye Salmon smolts Jesse Trushenski
11:40 AM	Creatively communicating salmon fisheries management in the Alaskan context N. Tamburello	Migration timing, habitat use, survival, and drainage exchange of Dolly Varden, Arctic Nat'l Wild. Ref Randy J. Brown	Waterfall formation at a dynamic desert river delta isolates endangered fishes Nate Cathcart*	Town Hall	An evaluation of collaborative salmon fishery management in Prince William Sound, Alaska. Tommy Sheridan	Total dissolved gas and gas bubble disease in the lower Clark Fork River: What have we learned in the last 20 years? Paul Kusnierz
12:00 PM	LUNCH (12:00 to 1:20 PM)		WD Native Fish Committee Meeting Luke Schultz	LUNCH (12:00 to 1:20 PM)		

TECHNICAL SESSIONS SCHEDULE, THURSDAY 5/24/18, 1:20 PM – 3:00 PM *STUDENT PRESENTATION

	Marine Derived Nutrients: Myth vs. Reality	Ghosts of Fishes Past, Present, and Future	Western Native Fishes	Salmon Management to Salmon Stewardship	Fishing for Solutions to Important Salmonid Diseases	Beyond the Dartboard: Methods for Salmon Forecasts	Keeping the West Wild by Minimizing Aquatic Invasive Species Impacts
Room	1	2	3	4	5	6	7
Chair	Daniel Schindler	Trent Sutton	Cathcart / Schultz		Winkelman / Fetherman	Cunningham / Brenner	Martin / Davis
1:20 PM	Patterns of food web responses to marine nutrients in stream ecosystems Mark S. Wipfli	Stock assessment of Inconnu in the Kobuk R. Arctic Estuary Complex: where do we begin? James Savereide	Evaluating relationships between fish and flow regime in four Arizona streams Larissa Lee*	Salmon Management to Salmon Stewardship	Introduction to the symposium Dana L. Winkelman	Pink salmon forecasts using data from the SE Alaska Coastal Monitoring program Jordan Watson	What limits invasions in arctic systems? role of temperature on survival and repro., Bering Sea Amanda Droghini
1:40 PM	Effects of Pacific salmon on freshwater and riparian ecosystems John Reynolds	Selawik R. Inconnu age structure and abundance in relation to permafrost thaw Raymond Hander	Translocations lead to a reproducing population of an endangered fish in Grand Canyon, AZ Brian Healy	Salmon Management to Salmon Stewardship	Eradication of whirling disease in a Cutthroat Trout stream through management R. Barry Nehring	Improving Pink Salmon harvest forecasts in southeast Alaska Andrew W. Piston	Capturing an emerging invasion: status of European Green Crab in the Salish Sea, WA Emily Grason
2:00 PM	Consequences of salmon nutrient enrichment on riparian nitrogen cycling Gordon Holtgrieve	Factors influencing harvest rates of Arctic Cisco during the Colville River Delta under-ice subsistence fishery John C. Seigle	The Delta's smelts – demise and discovery among California's estuarine osmerids Levi Lewis	Salmon Management to Salmon Stewardship	Whirling disease resistant Rainbow Trout fry survival: A comparison of two strains Brian Avila*	Applications of oceanographic data to improve inseason forecasts of Sockeye runs into Cook Inlet Mark Willette	Current status of the invasive signal crayfish population of Kodiak Island Kelly Krueger
2:20 PM	Can short-term nutrient additions lead to long-term recovery of Pacific salmon? Joseph Benjamin	Seasonal fish distribution and movements in the National Petroleum Reserve, AK, 2001-17 William Morris	Genomics predict temporal and spatial distribution of life history diversity for a native lamprey Jon E. Hess	Salmon Management to Salmon Stewardship	Whirling disease resistant Rainbow Trout fry stocking in the upper Colorado River Eric Fetherman	Evaluation of Bayesian updating of pre-season indicators of run strength in Pacific salmon fisheries Ben Staton*	Minimizing the impact of introduced Brown Trout on native salmonids in the Trinity River, CA Justin Alvarez
2:40 PM	Movement response of juvenile Chinook Salmon to carcasses of Rainbow Trout and Pacific Lamprey Ryan A. Dunbeck*	Potential implications of climate change for Broad Whitefish (*Coregonus nasus*) in Arctic Alaska Jason Leppi*	An examination of Inconnu life history using radio-telemetry, otolith microchemistry, and sonar Lisa Stuby	Salmon Management to Salmon Stewardship	Improvement of disease resistance through selective breeding: concepts, considerations, and limitations Timothy Leeds	Lessons learned from adaptive management of the Port Moller Sockeye Salmon Test Fishery Scott Raborn	Should we be concerned about Brown Trout invading native trout habitat in the West? Robert Al-Chokhachy
3 PM	BREAK (3:00 – 3:20 PM)						

TECHNICAL SESSIONS SCHEDULE, THURSDAY 5/24/18, 3:20 PM – 5:00 PM *STUDENT PRESENTATION

	Marine Derived Nutrients: Myth vs. Reality	Ghosts of Fishes Past, Present, and Future	Western Native Fishes	Salmon Management to Salmon Stewardship	Fishing for Solutions to Important Salmonid Diseases	Beyond the Dartboard: Methods for Salmon Forecasts	Keeping the West Wild by Minimizing Aquatic Invasive Species Impacts
Room	1	2	3	4	5	6	7
Chair	Daniel Schindler	Trent Sutton	Cathcart / Schultz		Winkelman / Fetherman	Cunningham / Brenner	Martin / Davis
3:20 PM	Landscape heterogeneity mediates flows of salmon subsidies to consumers Jonny Armstrong	Bioenergetics modeling of Broad Whitefish growth in the Alaskan Arctic Duncan G. Green*	Influence of dams and diversions on Burbot movement in the Wind River, Wyoming using genetic, isotopic, and field data Annika Walters	Salmon Management to Salmon Stewardship	Development and optimization of a bacterial coldwater disease vaccine Ken Cain	Use of Port Moller Test Fishery CPUE and genetic composition of catch data to improve in-season Bristol Bay run size forecasts C. J. Cunningham	More cowbell, not invasives: a multi-stakeholder communications plan Katrina Liebich
3:40 PM	Have nitrogen stable isotopes led us astray in our efforts to understand salmon effects in watersheds? Daniel Schindler	Shifts in the baseline: changes to a nearshore Arctic fish community Justin Priest*	Restoring hydrologic connectivity in a desert spring system Corey Lee	Salmon Management to Salmon Stewardship	Quality vs. quantity: manipulating rearing density to increase survival of Rainbow Trout fry pre- and post-stocking Brian Avila*	Stikine Sockeye Salmon Management Model; improving management uncertainty Sara Miller	Harnessing eDNA for early detection and removal of invasive Northern Pike and elodea in Alaska Jeffrey B. Olsen
4:00 PM	The influence of fall-spawning Coho Salmon on juvenile Coho Salmon rearing in beaver ponds, Copper R. Delta, AK Gordon Reeves	An InSAR habitat suitability model to evaluate overwinter conditions for whitefishes in Arctic lagoons Marguerite Tibbles*	PIT tag expulsion in a small-bodied native catfish Timothy D'Amico*	Salmon Management to Salmon Stewardship	Erythromycin injections for controlling bacterial kidney disease in Colorado hatcheries Eric Fetherman	Stikine inseason forecast cross validated Sarah Power	Portable, onsite environmental DNA detection of invasive Northern Pike Adam Sepulveda
4:20 PM			Habitat selection and movement of Stonecat in St. Vrain Creek Timothy D'Amico*	Salmon Management to Salmon Stewardship	Proliferative Kidney Disease in West Patrick Hutchins	Forecasts Group Discussion	Early detection of dreissenid mussels in Tiber Reservoir, MT Adam Sepulveda
4:40 PM						Forecasts Group Discussion	

Symposia Descriptions

Understanding the Drivers of Chinook Salmon Decline in Western Alaska & Exploring New Approaches to Sustainable Salmon Management & Stakeholder Engagement

ORGANIZERS: Daniel Schindler, University of Washington (deschind@uw.edu); Joseph Spaeder, Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (jjspaeder@earthlink.net); Aaron Martin, USFWS; John Linderman, ADF&G, CF Div.

LOCATION: Room 1

TIME: Tuesday, May 22 and Wednesday, May 23, 9:40 am – 5:00 pm; Thursday May 24 9:40 am - noon

DESCRIPTION: Some of the world's largest populations of Chinook salmon spawn in the rivers of western Alaska. Over the past decade, Chinook salmon returning to the Yukon, Kuskokwim and other rivers of this region have shown disastrous declines in abundance. These declines have resulted in years of closed commercial fisheries, unmet escapement targets, and hardship for subsistence dependent communities. Strategic investments in scientific research and stakeholder engagement over the past decade have focused on understanding the causes of these declines, and exploring new ways to evaluate management strategies in these vast and remote rivers. This symposium will feature two types of presentations: 1) The results of research to address key hypotheses explaining the decline in Chinook salmon across this region, and 2) new approaches to management and stakeholder engagement including: participatory modeling, structured decision-making, stakeholder capacity-building, local ecological knowledge, and community-based monitoring. The symposium will showcase the newest science relevant to understanding Chinook salmon dynamics in western Alaska, providing explicit links to management of fishery resources within the region, but also valuable insights relevant to fishery management in complex ecosystems elsewhere.

Making Fish Habitat Great Again: Conservation of Habitats and Connected Stream Networks in the Midst of Resource Development and Urban Growth

ORGANIZERS: Matthew Varner, Bureau of Land Management (mvarner@blm.gov); Gillian O'Doherty, Alaska Department of Fish and Game

LOCATION: Room 2

TIME: Tuesday, May 22, 9:40 am – 5:00 pm

DESCRIPTION: With resource development and population expansion in the West, including Alaska, aquatic habitats are under increased threat. In Alaska, thousands of miles of streams on public lands will likely be opened to new instream mineral development (e.g., placer mining) in the foreseeable future. Oil and gas development continues to grow in Alaska as well as the West. Population growth and increased use of public lands are resulting in expanded infrastructure and localized impacts to high value fisheries as well as low level but landscape scale impacts to watersheds, water quality, and connectivity. Minimizing and mitigating human impacts at various scales and intensities on aquatic habitats is an enormous challenge and has often had limited success, especially in the arid West and the Arctic. This symposium will focus on the planning and implementation of restoration activities with presentations focused on channel scale restoration, fish passage, large scale planning and monitoring initiatives, and the results of effectiveness monitoring. The latest science and coordinated monitoring is helping to address legacy and ongoing impacts to sustainable ecosystems and create new opportunities for the future of fisheries conservation.

Reweaving the Fabric of Nature: Changing Food Webs and Challenges for Freshwater Fisheries Management

ORGANIZERS: Ryan Bellmore, Forest Service Pacific Northwest Research Station (jbellmore@fs.fed.us); Joseph Benjamin and Jason Dunham, USGS Forest and Rangeland Ecosystem Science Center; David Roon, Oregon State University

LOCATION: Room 3

TIME: Tuesday, May 22, 9:40 am – noon

DESCRIPTION: Food webs are self-organizing features of ecosystems that adapt to human manipulation of the environment. These evolving food webs can have unique structures and dynamics that respond differently to management actions relative to un-manipulated webs. The spread of invasive species, for instance, has restructured many freshwater food webs resulting in novel ecological interactions and dramatic declines in native fishes. Although invasive species are a conspicuous agent of change, almost all environmental changes can modify food webs and associated fish populations. In freshwater ecosystems, changes to habitat structure, riparian forests, nutrient regimes, hydrology, water temperature and the timing/magnitude of subsides can all substantially alter food webs. These evolving food webs influence fish by changing the strength of top-down predation, bottom-up prey availability, and competition for shared resources. Reciprocally, changing environmental conditions also affect how fishes interact with the surrounding food web by directly modifying fish phenology, behavior, and bioenergetics. Understanding how freshwater ecosystems will respond to management actions—as well as future environmental changes—will require accounting for this "reweaving" of nature's fabric. This session brings together researchers and managers that are contending with these altered conditions.

Challenges and Advances in the Conservation of Western Native Trout

ORGANIZERS: Julie Meka Carter (jcarter@azgfd.gov); Therese Thompson

LOCATION: Room 4

TIME: Tuesday, May 22, 9:40 am – 5:00 pm and Wednesday, May 23, 9:40 am - noon

DESCRIPTION: The conservation of native trout takes a unified, collaborative effort among multiple state, federal, Tribal, local agencies, private organizations, landowners, and the public to be successful. Conservation for many of the species is advancing, yet challenges remain and there is more work to be done. This symposium will be hosted by the Western Native Trout Initiative (WNTI) and focus on the projects, conservation approaches, and progress made in the areas of habitat degradation and protection, fish passage, fish isolation, nonnative fish removal, genetic assessments, status assessments, climate change, wildfire, and other factors that may impact native trout in the west. There are 21 species of native trout that are the focal species of WNTI, a Fish Habitat Partnership and an organization within the Western of Association of Fish and Wildlife Agencies. We welcome presentations on the following species: Alaska Kokanee, Alaskan Lake Trout, Alaskan Fluvial Rainbow Trout, Apache Trout, Arctic Char, Arctic Grayling, Bonneville Cutthroat Trout, Bull Trout, California Golden Trout, Coastal Cutthroat Trout, Colorado River Cutthroat Trout, Dolly Varden, Gila Trout, Greenback Cutthroat Trout, Lahontan Cutthroat Trout, Little Kern Golden Trout, Paiute Cutthroat Trout, Interior Redband Trout, Rio Grande Cutthroat Trout, Westslope Cutthroat Trout, and Yellowstone Cutthroat Trout.

Salmon Enhancement in the Last Frontier

ORGANIZERS: Joel Markis (jamarkis@alaska.edu)

LOCATION: Room 5

TIME: Tuesday, May 22, 9:40 am – noon

DESCRIPTION: An initial overview of Salmon Enhancement efforts in Alaska with focus on how enhancement operations play into statewide salmon fisheries. General, Biologic, Genetic, and Economic overviews will be followed by directed research projects focused on some of the challenges associated with changing fisheries and the opportunities they may present.

The State of Alaska's Salmon and People: Results from a Large Interdisciplinary Research Initiative

ORGANIZERS: Peter Westley, UAF Fisheries (pwestley@alaska.edu)

LOCATION: Room 5

TIME: Tuesday, May 22, and Wednesday, May 23, 1:20 pm – 5:00 pm

DESCRIPTION: The State of Alaska's Salmon and People program is a large multi-year interdisciplinary initiative supported by the National Center for Ecological Analysis and Synthesis, which aimed to provide an updated understanding of the

complex, coupled social-natural system embodied by Alaska salmon. Drawing from participants across eight working groups, presenters will share emergent results with the broader fisheries community and stakeholders. Presentations center on key themes of *big data, big ideas, equity, access, and*

participation, data enlightened management, and *Alaska salmon in a changing world*. This symposium squarely aligns with the core themes of the 2018 WDAFS annual meeting by highlighting the challenges of a changing natural and social landscape of Alaska salmon, while also revealing opportunities for continued sustainability in the 21st century.

Evolving Methods for Specifying Anadromous Waters in Alaska

ORGANIZERS: Tim Troll, Bristol Bay Heritage Land Trust - Coordinator, SW Alaska Salmon Habitat Partnership (nmwtlandtrust@hotmail.com); Erika Ammann, NOAA Fisheries

LOCATION: Room 7

TIME: Tuesday, May 22, 9:40 am – 11:40 am

DESCRIPTION: Alaskans share a common desire to preserve our state's abundant wild salmon. Alaska statutes Title 16 enshrines this desire by mandating the Commissioner of the Alaska Department of Fish & Game (ADF&G) to "specify the various rivers, lakes, and streams or parts of them that are important for the spawning, rearing, or migration of anadromous fish," and provide for their legal protection.

To carry out this responsibility, ADF&G maintains a dataset, the Anadromous Waters Catalog, that specifies the anadromous waters protected. Waters are included in the catalog after a nomination is submitted that documents a spatially explicit, unambiguous field observation. Documenting waters for the purpose of inclusion in ADF&G's Anadromous Waters Catalog is often expensive and time-consuming due to the remoteness of most rivers, lakes and streams in the state. However Alaska is not alone in the challenge of defining fish distribution and habitat use, many entities maintain similar datasets and would benefit from improved or more easily obtained information on fish distribution.

In this symposium, we will examine the use of new or improved technologies such as environmental DNA analysis, remote photography, LiDAR and satellite imagery, advances in GIS, improved software products for hydrography and evolving modeling techniques for determining fish and habitat distribution, particularly in relation to migratory fish such as salmonids and remote habitats. Questions to be explored are the applicability, accuracy and reliability of different methods, best practices and protocols, relative cost and effort as well as practical use in management, protection, and conservation efforts.

Spatial-Stream-Network (SSN) Models: Recent Technical Advances and a Diversifying Set of Applications

ORGANIZERS: Dan Isaak, US Forest Service (disaak@fs.fed.us); Erin Peterson, Queensland University of Technology; Jay Ver Hoef, NOAA

LOCATION: Room 7

TIME: Tuesday, May 22, 1:20 pm – 5:00 pm

DESCRIPTION: Spatial-stream-network models are a new type of geostatistical model based on covariance structures for network topology. Although the statistical theory and software for SSNs were developed only in the last decade, the adoption and use of the models is growing rapidly because of their predictive accuracy, novel insights, and ability to develop information from many types of stream data (water chemistries, habitat conditions, biological attributes) and large datasets with spatial autocorrelation. Applications include stream temperature modeling for climate change, water quality and nutrient analyses, sampling design optimization, species distribution and fish abundance models, development of network isoscapes, and genetic biodiversity mapping. As existing datasets are compiled into ever larger databases and new data accumulate from growing sensor networks and environmental DNA surveys, SSN model applications and strengths will continue to grow. Key to modeling and organizing those datasets efficiently are computational advances, space-time applications, and the National Hydrography Dataset, which is being revised and updated for Alaska and the conterminous U.S. to higher resolutions. This symposium will highlight new SSN research, technical advances, and applications to describe the current state of knowledge and stimulate discussions about future development.

Hooked: Creative Solutions to Engage the Public in Fish Conservation and Fisheries Management

ORGANIZERS: Katrina Liebich, US Fish & Wildlife Service (katrina_liebich@fws.gov)

LOCATION: Room 2

TIME: Wednesday, May 23, 9:40 am – 11:40 am

DESCRIPTION: Most (if not all) of the changes and challenges facing fisheries today are driven by people. With this comes the opportunity for people to be part of the solution. Our challenge is motivating a broad cross-section of society to care about and act on behalf of fish and their habitats. Fish are virtually invisible to most people, living complex lives beneath the surface of vast expanses of water where their only contact with humans is on the hooks or in nets deployed by a relative few. This symposium brings together a diverse array of fisheries professionals using innovative approaches that can help make fish more visible, "hook" non-traditional audiences on fish, and motivate different segments of society to engage in fisheries conservation and management.

Challenge, Change, and Opportunities for Marine Fisheries

ORGANIZERS: Gordon H. Kruse, UAF (gordon.kruse@alaska.edu); Vanessa R. von Biela, USGS

LOCATION: Room 3

TIME: Wednesday, May 23, 9:40 am – 2:40 pm

DESCRIPTION: Marine fish and invertebrates support economically valuable commercial and recreational fisheries in addition to serving as important subsistence resources that provide food security for residents of coastal communities. Human stressors and climate change and variability, such as the recent 2013-2016 marine heat wave in the Northeast Pacific, cause significant changes in marine ecosystems that include changes in fish distribution, status, and productivity. Such changes are often difficult to predict and pose major challenges to fishery managers who strive to conserve fishery resources while maintaining sustainable yields. This challenge is further complicated by the need to take an ecosystem-based management approach that considers the interactions of fish and fisheries with other ecosystem components, including habitat, bycatch species, interactions with seabirds and marine mammals, and others factors. This symposium seeks contributions that identify challenges, opportunities, and creative solutions for marine fish and invertebrate fisheries that are undergoing change.

Western Native Fishes

ORGANIZERS: Nate Cathcart (cncathca@gmail.com); Luke Schultz, Wyoming Game and Fish Department

LOCATION: Room 3

TIME: Wednesday May 23, 3:20 pm – 5:00 pm; Thursday May 24, 9:40 am – 4:40 pm

DESCRIPTION: Many native fish and aquatic species are investigated within contexts of changing environments and challenging landscapes through more recent opportunities provided by newer technology (i.e., tags, SONAR, eDNA) or expanding perspectives (i.e., nongame species management). In keeping with the theme of the 2018 annual meeting of the Western Division of the American Fisheries Society ("Change, challenge, and opportunities in fisheries") this symposium will highlight relevant studies exploring the ecology and management of species from the desert southwest to Arctic Alaska (and anywhere else within the Western Division). We welcome various presentations from those illustrating case studies highlighting how processes affect decision making of native fishes to experimental designs that innovate our understanding of native fishes in the contemporary world. This fourth annual symposium will consider topics relating to all native fishes.

Marine Mammal-Fishery Interactions: Conflicts, Management, and Innovative Solutions

ORGANIZERS: Julie Scheurer, NOAA Fisheries, Alaska Region (julie.scheurer@noaa.gov); Suzie Teerlink, NOAA Fisheries, Alaska Region; Kim Raum-Suryan, NOAA Fisheries, Alaska Region

LOCATION: Room 4

TIME: Wednesday, May 23, 1:20 pm – 5:00 pm

DESCRIPTION: One of the leading causes of anthropogenic injury and mortality for many marine mammal species is interactions with commercial fishing operations. Fisheries may have direct impacts on marine mammals such as intentional or unintentional injury, harassment, or even death. Fisheries may indirectly impact marine mammals by reducing the availability of their prey or disturbing important habitats. Likewise, marine mammals impact commercial fisheries in a variety of ways including depredation, interference, and by damaging fishing gear. In this symposium, speakers will provide an overview of the regulations governing fishery and marine mammal interactions; explain the types of interactions occurring in the Western Region; identify data gaps, human dimensions, and economic considerations related to mitigating and managing these interactions; and offer innovative approaches to avoid, deter, and minimize marine mammal and fisheries interactions in the future.

Pink and Chum

ORGANIZERS: Pete Rand (psrand@gmail.com)

LOCATION: Room 5

TIME: Wednesday, May 23 and Thursday, May 24, 9:40 – noon

DESCRIPTION: This symposium began in 1962 as The Northeast Pacific Pink and Chum Salmon Workshop held in Juneau, Alaska in 1962. It has been convened on a near biennial basis since that time among three regions: Alaska, British Columbia, and Washington State. The purpose of these Workshops has been to bring resource managers, researchers, and stakeholders together to review the status of pink and chum production in and around the northeast Pacific. The Workshops have provided a forum to share issues and information relevant to pink and chum salmon resource management and help maintain resource sustainably for the mutual benefit of stakeholders, thus helping to promote healthy marine and terrestrial ecosystems. After a brief hiatus, we are pleased to announce the resumption of this historic Workshop series, the 27th in the series!

Over this long span of time we have accumulated a great deal of knowledge about pink and chum salmon. These species continue to exert a strong influence on freshwater and marine food webs, they serve a critical role in food security for many communities, and continue to be of high value in commercial fisheries throughout the North Pacific. We have a growing appreciation for their life histories – in some respects they exhibit some of the simplest life histories among Pacific salmon, and yet we continue to learn that they are more complex than we once thought. As ecosystems become reconfigured with climate change, we believe these two species in particular are poised to expand and colonize new Arctic habitats. As in past Workshops, we intend to highlight some key, recent advances in our state of knowledge. In keeping with the theme of the AFS Conference (Change, Challenge, and Opportunity in Fisheries: Fishing for Solutions), we intend to cover a broad array of topics. We are pleased to announce that Dr. Kristen Homel of Oregon Department of Fish & Wildlife will present a plenary presentation on the long road to recovery of chum salmon in the State of Oregon. We anticipate contributions on a number of important and emerging themes, including climate effects, hatcheries, range expansion, fitness-related studies, conservation efforts, and the on-going challenges of managing pink and chum salmon fisheries.

Turning the Tide: Enhancing Diversity and Inclusion in the Fisheries Profession

ORGANIZERS: Cheyenne Owens, USFWS (cheyenne_owens@fws.gov); Larissa Lee, University of Arizona

LOCATION: Room 6 and Room 4

TIME: Wednesday, May 23 and Thursday, May 24, 9:40 am – noon

DESCRIPTION: The United States has become an increasingly diverse nation, with currently 51 percent of the population being women and more than half of all Americans projected to belong to a minority group by 2044 (US Census Bureau). With these shifting demographics, one of the challenges for the fisheries profession has been reflecting the changing face of America. As part of the strategic plan for 2015-2019, the American Fisheries Society aims to “increase the disciplinary, gender, ethnic, and cultural diversity and engagement of its members as a vital means to maintain relevancy and respond to the challenges facing fisheries science and management”. The goal of this symposium is to be a platform for addressing the challenges toward diversity and inclusion in fisheries and highlighting successful efforts toward promoting diversity and

inclusion in our profession. Topics may include agency initiatives, youth outreach programs, and introducing the new WDAFS Diversity and Inclusion Committee. The symposium will end with a town hall style discussion geared toward "fishing for solutions" we can use at the division, chapter, and member levels to foster a more inclusive environment for members and provide opportunities for the next generation of fisheries professionals.

Beyond the Dartboard: Methods and Recommendations for Salmon Forecasts

ORGANIZERS: Curry Cunningham, NOAA, Alaska Fisheries Science Center Auke Bay Laboratories (curry.cunningham@noaa.gov); Rich Brenner, Alaska Department of Fish and Game

LOCATION: Room 6

TIME: Wednesday, May 23, and Thursday, May 24, 1:20 pm – 5:00 pm

DESCRIPTION: Pre-season and inseason salmon run size and run timing forecasts are a topic of great interest to resource stakeholders and fisheries managers, as they are critical to the efficient and sustainable prosecution of commercial, subsistence, and recreational fisheries in the North Pacific. Salmon forecasts are constructed using data and personnel from multiple state, federal, tribal, university, nonprofit, and industry organizations, using a wide variety of statistical methods. Broadly, salmon forecasting methods can be divided into "naive" and "informed" types; whereby naive forecasts rely solely on historical run size or harvest as predictors, and informed forecasts utilize one or more biological or environmental correlates to inform prediction. Methods for generating forecast estimates and evaluating forecast performance vary by region depending upon available data, resources, and other factors. We will provide a forum for presenting historical and emerging statistical methods for salmon forecasting, as well as retrospective analyses of forecast performance. We will encourage presenters to provide advice and analysis resources to fisheries managers, researchers, students, and biometricians with the objectives of improving salmon forecasting methods and stimulating the exchange of ideas across regions and organizations.

Keeping the West Wild by Minimizing the Impacts of Aquatic Invasive Species

ORGANIZERS: Aaron Martin, U.S. Fish and Wildlife Service (aaron_e_martin@fws.gov); Tammy Davis, Alaska Department of Fish and Game

LOCATION: Room 7

TIME: Wednesday, May 23, and Thursday, May 24, 1:20 pm – 5:00 pm

DESCRIPTION: Aquatic invasive species (AIS) have significant ecological, economic, and socio-cultural impacts in the regions they are introduced. Conserving and restoring ecosystems and the industries and cultures that depend on the native species/ecosystems can be challenging and contentious due to project logistics and scope as well as differing views on what actions should occur and what AIS to prioritize resources towards. However, implementing thorough preventative practices and a comprehensive early detection and rapid response program at local and regional scales can minimize the complexity and cost of AIS management. In this symposium, we will highlight efforts (with emphasis on the partnerships that make them effective) that are underway across the western United States to prevent and or minimize the impacts of AIS in order to keep our native ecosystems sustainable and cultures and industries that rely on these ecosystems functioning. Presentation topics include: emerging technologies in prevention and monitoring; habitat suitability and vector analyses; prevention and early detection efforts; control and eradication efforts; awareness/education campaigns; lessons learned; and emerging issues.

Marine-Derived Nutrients in Coastal Watersheds: What is Myth and What is Reality?

ORGANIZERS: Daniel Schindler, School of Aquatic and Fishery Sciences, University of Washington (deschind@uw.edu)

LOCATION: Room 1

TIME: Thursday, May 24, 1:20 pm – 4:20 pm

DESCRIPTION: A compelling narrative exists about the ecological importance of marine-derived nutrients and energy (MDN) in coastal watersheds. From their roles as prey for terrestrial and aquatic wildlife, to their importance as subsidies of

productivity-limiting nutrients, a complex story is often told about how broadly important salmon are to freshwater and riparian ecosystems. Research quantifying the ecological roles of salmon has proliferated over the last two decades, yet there remains distinct confusion in the literature about how important MDN are to the productivity and dynamics of coastal watersheds and to salmon populations. We need to ask when, where, how, and to whom MDN are important. At present there is little scientific agreement about the answers to these questions, though the story about salmon as universally important to coastal ecosystems persists in the public and conservation communities. The purpose of this symposium is to take stock of what we know and don't know about the importance of MDN in coastal watersheds. Which parts of the MDN narrative are supported by data? What information is most important for management and conservation? What are the remaining uncertainties? Which parts of the salmon-nutrient narrative need rewriting?

Ghosts of Fishes Past, Present, and Future: Confronting Data-Limited Stocks in a Changing Arctic

ORGANIZERS: Trent M. Sutton (tmsutton@alaska.edu)

LOCATION: Room 2

TIME: Thursday, May 24, 10:00 am – 4:40 pm

DESCRIPTION: Climate change, coupled with anthropogenic development, has impacted the structure and function of high-latitude ecosystems, with the status and response largely unknown for many fish species. As a result, improving our knowledge on the distribution, abundance, and life-history dynamics of fishes for which we have a limited understanding and predicting their potential response(s) to change in the Alaskan Arctic is essential for maintaining sustainable fisheries and ecosystem integrity. In this symposium, we will explore past, current, and future opportunities to improve our understanding of data-limited fish stocks through: (1) retrospective analysis of data-sparse fish stocks using conventional data and analytical tools; (2) current and ongoing examinations and assessments of fish population status in data-limited situations; and (3) potential responses and outcomes of fish stocks to varying change scenarios in the Alaskan Arctic. An additional goal of this symposium is to bring together researchers from industry, natural resource agencies, non-governmental organizations, and academic institutions that have been involved in Arctic-based fisheries research in Alaska involving fish species in which there is limited data and/or understanding.

Salmon Management to Salmon Stewardship

ORGANIZERS: Courtney Carothers, University of Alaska – Fairbanks; AlexAnna Salmon (Yup'ik), Igiugig Leader; Danielle Ringer, University of Alaska Fairbanks

LOCATION: Room 4

TIME: Thursday, May 24, 1:20 pm – 4:40 pm

DESCRIPTION: A safe space for facilitated dialogue about indigenizing salmon management – through an equity lens. Within Alaska's salmon management system there is an inverse relationship where the people with intact local knowledge and connections to salmon tend to have the least access to / influence on management decisions. This dialogue will explore how shifting from management to stewardship practices can ensure a sustainable and equitable future for Alaska.

Key considerations:

• What is Indigenous stewardship?

• What are the Indigenous values, knowledge, and governance mechanisms that will improve the long-term sustainability and equity of the Alaska salmon system for the benefit of all?

• What do we learn about the strengths and weaknesses of our current salmon management system when we view it from Indigenous experiences and perspectives?

• How can Indigenous values, knowledge, management and governance mechanisms be better included in current or alternative management systems?

Fishing for Solutions to Economically and Ecologically Important Salmonid Diseases

ORGANIZERS: Dana L. Winkelman, USGS-COCFWRU (Dana.Winkelman@colostate.edu); Eric R. Fetherman, Colorado Parks and Wildlife

LOCATION: Room 5

TIME: Thursday, May 24, 1:20 pm – 4:40 pm

DESCRIPTION: Parasitic and bacterial diseases have caused large economic and ecological losses in wild and hatchery salmonid populations worldwide. Whirling disease (WD) caused major declines in wild rainbow trout fisheries in the intermountain west and proliferative kidney disease (PKD) is responsible for extensive wild fish kills. Bacterial coldwater disease (BCWD) and bacterial kidney disease (BKD) are both economically important diseases in hatchery salmonid populations, causing major losses due to infection and depopulation of hatchery stocks. Management of WD has focused on breaking the parasite life cycle using resistant hosts and the manipulation of host habitats, as well as exploring the molecular immunology of the host pathogen interaction. Current research on PKD is focused on the development of a probe-based assay for fish tissue and eDNA samples to detect the pathogen in the wild. Current solutions to BCWD and BKD include the use of vaccinations, the development of BCWD resistant rainbow trout, and the evaluation of hatchery practices to prevent disease transmission. This symposium will explore the challenges and opportunities associated with controlling and minimizing losses from exposure to these diseases in both hatchery and wild salmonid populations.

Water Quality in Fisheries: Keeping an Eye on a Vital Resource

ORGANIZERS: Paul Kusnierz, Avista (pkusnierz@alumni.nmu.edu); Andrew Todd, American Fisheries Society Water Quality Section President

LOCATION: Room 6

TIME: Thursday, May 24, 9:40 am – noon

DESCRIPTION: Water quality is a key component in the study and management of fish. However, it is not always on the forefront of the fisheries professional's brain. Understanding the water quality dynamics of a waterbody can shape the way we interpret interactions between fish and their physical habitat and help establish limitations on management actions. As such, the Water Quality Section of the American Fisheries Society is sponsoring a symposium that highlights the challenges water quality can pose to fisheries professionals. Through this symposium we seek to demonstrate how understanding water quality can lead to better fisheries management; both for recreational and restoration purposes. For this symposium we sought presentations that specifically address water quality as a challenge to answering fisheries biology and management questions. We hope that having this symposium will aid fisheries professionals in their day to day work and show how considering water quality can create opportunities for success.

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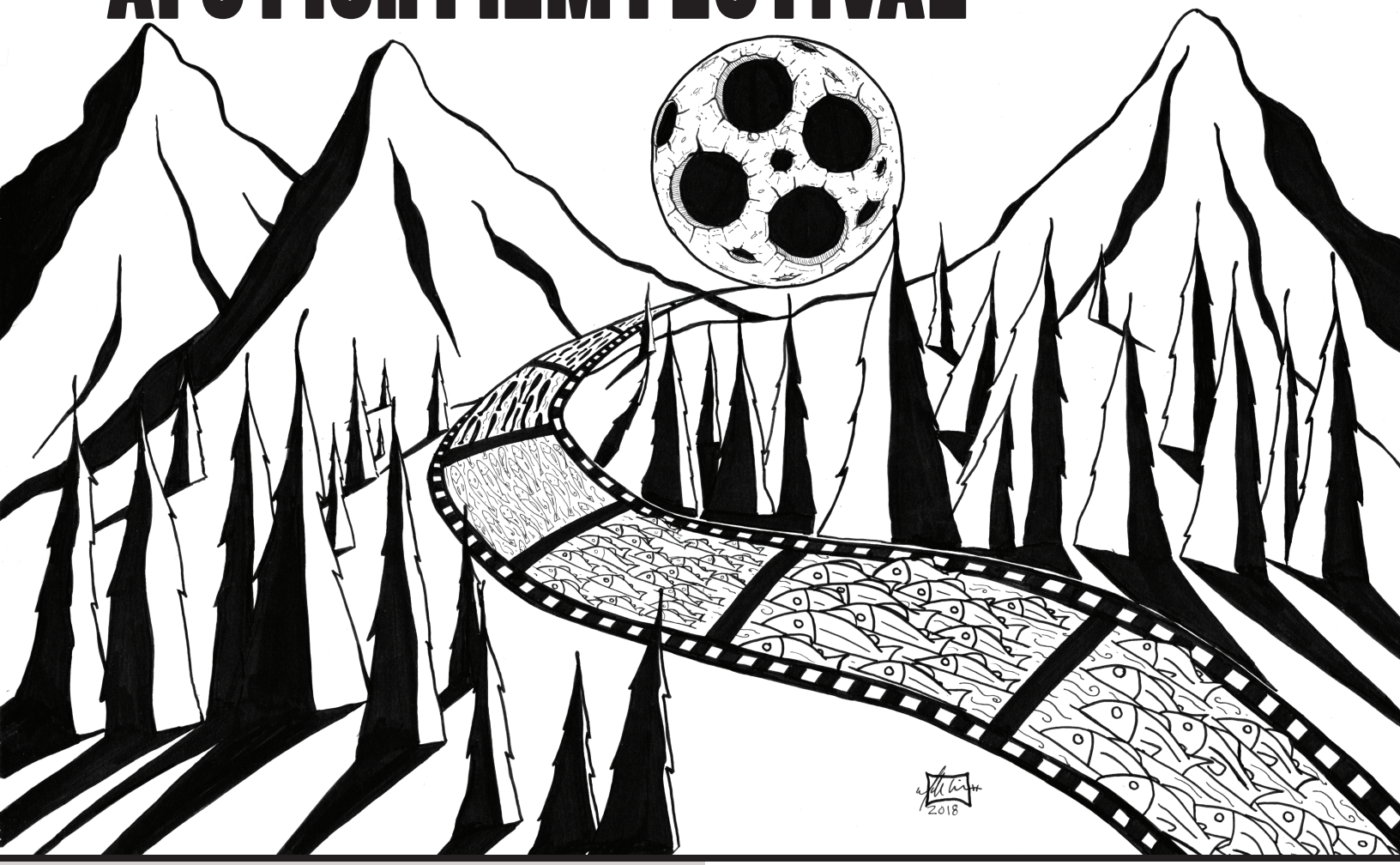

1 Yukon Kings (07:15)

Go Project Films
Emmanuel Vaughan-Lee: Evaughanlee@globalonenessproject.org

Set in the remote Alaskan Yukon Delta, Yukon Kings follows Yup'ik fisherman Ray Waska as he teaches his grandkids how to fish during the summer salmon run. With environmental and cultural forces threatening their subsistence way of life, Ray holds onto the hope that his grandsons will one day pass on the traditional knowledge to their children.

Restoring America's Salmon Forest (06:00) 2

Sitka Conservation Society & Southeast Sustainable Partnership, US Forest Service
Bethany Goodrich: info@sitkawild.org

Nestled deep within our earth's largest temperate rainforest-conservation takes a unique form. Meet a vibrant team of heavy equipment operators working deep in the Tongass National Forest of Southeast Alaska. Learn about the Sitkoh River Restoration Project and the benefits of river and stream restoration.

13 14 15 16 13 14

3 Blucheads & Bonnevilles (06:40)

Sage Lion Media / WNTI and DFHP
Therese Thompson: tthompson@westernnativetrout.org

In 2011, the Western Native Trout Initiative (WNTI) and Desert Fish Habitat Partnership (DFHP) joined the Utah Division of Wildlife Resources, Trout Unlimited, and their many partners in the Weber River Partnership in funding a series of 3 large habitat projects in an 18 mile stretch of the Weber River near Ogden, Utah. This film celebrates the strength of these partnerships to benefit the native bluehead sucker and Bonneville cutthroat trout.

In Southwest Alaska (04:43) 4

Jason Ching
info@jasonching.com / jasonsching.com

This video highlights the scenery of Iliamna Lake and Lake Aleknagik in Southwest Alaska. These two watersheds provide spawning habitat for some of the largest returns of wild sockeye salmon from Bristol Bay, and also serve as important habitat for the development and growth of salmon in their early stages of life. As a keystone species in Bristol Bay, sockeye salmon are of large economic importance to the commercial fishing industry and local lodge outfits, they serve as an important food source for local communities, and also support the diverse and amazing ecosystems within these watersheds.

Western Division / Alaska Chapter - 2018 Fish Film Festival

5 Voices of the Chena (12:20)

US Fish and Wildlife Service / Tanana Valley Watershed Association
jimmy_fox@fws.gov & bryn.tvwa@gmail.com

Deep in the heart of the Great Land lies the Chena River. This river is home to the second-largest run of Yukon River king salmon, yet it flows through one of the most populated cities in the state. This film celebrates the progress the community is making to conserve, restore and protect king salmon and the Chena River for themselves and future generations.

6 Alaska Salmon Project-King Maker Chickaloon Village (03:08)

The Salmon Project and Great Land Trust
eharrington@salmonproject.org & lkugel@greatlandtrust.org

The King Makers of Chickaloon Native Village have brought the salmon back to Moose Creek. The village participated in a habitat restoration project to return Moose Creek to its relic path after being straightened by the railroad nearly 100 years ago. The straightening of the river resulted in bedrock waterfalls that acted as a barrier for spawning salmon. Since the restoration, salmon have returned to the headwaters of Moose Creek. This is their story.

7 A Creek Once More (08:50)

US Fish & Wildlife Service / Narrative Lab
donald_ratcliff@fws.gov/ryan_fogerty@fws.gov & jeff@narrativelab.com

It seemed an almost impossible task: re-create the historic path of a creek in Crater Lake National Park that was wiped off the landscape more than one hundred years ago. Determined conservation partners, tribal organizations, landowners, corporations and individuals banded together to make it happen. More than two dozen key players collaborated to re-connect the historic channel between Sun Creek and Wood River to benefit an isolated population of the now-threatened Bull Trout and Interior Redband Trout. A short film created by U.S. Fish and Wildlife Service tells the remarkable, inspiring story.

8 Tour the Kwethluk Weir (03:57)

Lisa Hupp / US Fish and Wildlife Service
lisa_hupp@fws.gov

Swim with migrating salmon as they move up the Kwethluck River in Alaska and pass through a weir. Tour the weir with our staff and learn more about how weirs help us manage salmon for future generations.

9 Stream Watch Legacy: growing strong roots & making a difference for 20 years! (05:15)

Alaska Teen Media and the Kenai Watershed Forum
alice@kenaiwatershed.org & jack@kenaiwatershed.org

Stream Watch Volunteers are ordinary people making extraordinary efforts to protect Kenai Peninsula fish habitats. The program is jointly administered by KWF and Chugach National Forest. Volunteers complete a myriad of projects ranging from hands-on, river protection projects to sharing on -river, educational stewardship messages. Volunteers come from the local area but also out-of-state and out-of-country. Everyone is invited to make a difference!

10 Unprecedented Fish Passage Improvements in the Mat-Su Borough (03:12)

Mat-Su Borough and US Fish & Wildlife Service
stefan.hinman@matsugov.us

A time lapse videography of the installation of a stream simulation culvert on Cottonwood Creek in the Mat-Su Borough. The funding partners, U.S. Fish and Wildlife Service, Alaska Dept of Fish & Game, and Mat-Su Borough also give commentary on the importance of fish passage projects within the Borough and the Borough's level of commitment.

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Abstracts

Abstracts are ordered alphabetically by last name by symposium. Search using Ctrl+F and presenter last name or title

Beyond the Dartboard: Methods and Recommendations for Salmon Forecast

Do smolt data reduce errors in forecasts of adult Sockeye Salmon returns to the Chignik watershed of western Alaska?

Baechler, Nyssa E. University of Washington*

Schindler, Daniel E. University of Washington; Cunningham, Curry J. NOAA; Finkle, Heather. ADF&G

Preseason forecasts of adult returns for commercially-important Pacific salmon species provide initial guidance for fishery managers on regulations that might be necessary to achieve escapement and harvest goals. The fishing industry also uses these forecasts for planning of their harvesting and processing strategies. However, preseason forecasts often have poor predictive performance and high error around the point estimates, which add considerable uncertainty to the management and harvesting processes. Fishermen and the fishing industry can also suffer economic losses from large forecasting errors and subsequent management decisions affecting harvesting opportunities. The Alaska Department of Fish and Game (ADF&G) forecasts returns of adult salmon using a sibling-return model, a simple linear regression using age class relationships, which is a simple but reliable method for generating preseason forecasts of many Pacific salmon populations in Alaska. The Chignik River system is the largest Sockeye Salmon *Oncorhynchus nerka* producer on the south side of the Alaska Peninsula. The Chignik Management Area (CMA) is relatively unique in that ADF&G ran a smolt enumeration project from 1994-2016 that generated biological juvenile salmon and environmental data that can be useful for testing hypotheses on the effects of incorporating data on smolt abundance, size, and migration timing on preseason forecast model performance. The goal of this analysis is to compare the predictive performance of different stock-by-age models for adult Sockeye Salmon returning to spawn in Black and Chignik Lakes and evaluate the usefulness of incorporating biological and environmental covariates into preseason forecast models.

Salmon forecasting methods used in Alaska: where to go from here?

Brenner, Richard E. Alaska Department of Fish and Game

Cunningham, Curry J. National Oceanic and Atmospheric Administration

In our presentation we will provide a broad overview of preseason and inseason salmon forecast methods used throughout Alaska. With biologists and biometricians in Alaska spread across a vast expanse, a variety of approaches have been employed to forecast salmon run size, quantify associated confidence intervals, and assess the validity of the forecasting methods. The methods used to forecast salmon abundance for a given stock or area are often constrained by the type of available information and life history of the species, but may also depend on other factors including biometric expertise and the methods that have historically been used. Whereas age data of returning Sockeye Salmon and Chinook Salmon enables the use of sibling models to forecast returns for some stocks, for other stocks or areas only harvest data is available. Similarly, indices of juvenile abundance contribute to forecasts for some stocks of salmon, but such estimates are not available elsewhere. Forecasts for larger areas are generally an assemblage of various “naive” and “informed” methods

depending upon available data and level of autocorrelation in abundance time series. Our presentation will include a summary of methods used to forecast salmon runs by species and area and we will provide a series of recommendations for making salmon forecasts more consistent, intuitive, and useful for fisheries managers and resource stakeholders. We hope that our presentation will generate discussion and facilitate the development of a common set of core principles and tools (e.g., code scripts) that can be used by a broad spectrum of fisheries professionals to develop and evaluate salmon forecasts.

Assessing the impact of genetic-based construction of brood tables on Bristol Bay Sockeye Salmon forecasts

Buck, Gregory. ADF&G*

Dann, Tyler. ADF&G; Cunningham, Curry. NOAA

The Alaska Department of Fish and Game maintains brood tables for all major Sockeye Salmon stocks in Bristol Bay. Brood tables are based on biological sampling of the commercial harvest and escapement to Bristol Bay rivers. Periodically, brood tables have been reconstructed to account for the harvest of non-native fish. Starting in 2006, the collection of tissues for genetic analysis has been part of the commercial harvest sampling protocol. Run reconstruction methods are increasingly informed by genetic information using baselines established for each major Sockeye Salmon stock. Here we assess the impact of including genetic data in the run reconstruction process on forecasting. Each year a preseason forecast is made for Bristol Bay that is the summation of individual forecasts for each major age class and river system in Bristol Bay, with these individual forecasts based on sibling survival, overall stock recruitment, or average age class returns. The model selected for each individual forecast is based on the recent historical performance of that model in predicting run size of the age class and stock in question. Here we use brood tables constructed in the fall of 2017 to re-forecast several recent runs and compare the results to the original forecasts. Individual age/river forecasts are compared in terms of the absolute improvement of various river, age, and model combinations as well as how modified model performance alters model selection for individual forecasts.

Use of Port Moller Test Fishery catch per unit effort and genetic composition of catch data to improve inseason Bristol Bay run size forecasts

Cunningham, Curry J. NOAA Alaska Fisheries Science Center*

Boatright, Chris P. University of Washington Alaska Salmon Program; Hilborn, Ray. University of Washington Alaska Salmon Program

Bristol Bay inseason forecasts provide updated information to harvesters and processors about the abundance and destination of returning Sockeye Salmon *Oncorhynchus Nerka*, as the fishing season progresses. Statistical forecast models used by the University of Washington Alaska Salmon Program are informed by both the abundance and age composition of salmon arriving inshore, and the number, age composition, and genetic composition of Sockeye Salmon caught in the Port Moller Test Fishery operated by the Bristol Bay Science and Research Institute in collaboration with the Alaska Department of Fish and Game. We describe how the distribution of test fishery catch per unit effort within the season may be used to generate fishing district-specific estimates of run timing, which can inform run size forecasts based on

inshore arrivals by date. We also present a retrospective comparison of the bias and precision in run size forecasts generated throughout the fishing season, when naïve forecast models and those leveraging estimates of run timing are used.

Was simpler better? 20 years of Sockeye Salmon Forecasting in the Columbia Basin

Fryer, Jeffrey K. Columbia River Inter-Tribal Fish Commission

Forecasting Columbia Basin Sockeye Salmon is seemingly simple as over 99% of Sockeye Salmon returning to the Columbia Basin originate from just two stocks and, typically, over 80% are Age 1.2. Furthermore, significant harvest does not occur until after Sockeye Salmon are counted at Bonneville Dam. Since 1999, I have used sibling models to make forecasts with data generated by age composition data from adult Sockeye Salmon sampling programs conducted at the Bonneville Dam adult fish trap and traps at terminal area dams. McNary Dam smolt abundance indices were used to forecast the initial brood return. Between 1999 and 2013, the median deviation between the forecast and actual escapement was 14.8%. However, recent juvenile Sockeye Salmon PIT tagging programs indicate that my use of McNary Dam smolt indices could not be justified. At the same time acoustic trawl survey (ATS) estimates of smolt abundance became available which could replace smolt index data. Upon examination, in some years this ATS data provided better estimates of Age 1.2 Sockeye Salmon returning two years later than did the jack predictor. In recent years, the importance of ocean conditions became more obvious, and these were also incorporated into the forecast. After incorporating all this new data, how have my forecasts done? In each of the past four years, actual returns have deviated from forecast returns by over 100,000 Sockeye Salmon compared to only twice in the previous 14 years with simpler models. The median difference between the forecast and actual return has increased from 14.8% in 1999-2013 to 53.7% in 2014-2017. Forecasts have become more complex, but seemingly less accurate. However, some of this increased variability in forecast performance is very likely attributable to high variability in environmental factors. It is this variability that makes it unlikely that returning to the old simple methods would result in better forecasts.

Forecasting Yukon River Chinook Salmon Runs Three Years Into the Future Using Juvenile Data

Howard, Kathrine G. Alaska Department of Fish and Game*

Murphy, James. Alaska Fisheries Science Center, NOAA Fisheries

Up to 90% of total statewide subsistence harvest of Chinook Salmon occurs in the Arctic-Yukon-Kuskokwim region, with half of that from the Yukon River in some years. Recent declines in Chinook Salmon returns to the Yukon River have resulted in closures to sport and commercial fisheries and severely restricted subsistence harvests. Pervasive failures to meet escapement objectives in these systems have occurred in recent years, despite harvest reductions. The greatest challenge for managers and stakeholders has been coping with management uncertainty during this period of dramatic productivity changes, while also allowing for sustainable subsistence opportunity. Improved accuracy of preseason and inseason forecasts are the best means of reducing management uncertainty. Marine surveys of juvenile salmon in the northeastern Bering Sea successfully assess juvenile Yukon River Chinook Salmon relative abundance and have facilitated research advancements of Yukon River salmon production dynamics. Research on juvenile ecology is used to assist the interpretation of juvenile assessment models and incorporate ecosystem considerations into juvenile-based forecasts. Data from these surveys provide a leading indicator of adult productivity and have been used to predict Canadian-origin Yukon

Chinook Salmon adult run size since 2013. More recently, total Yukon River Chinook Salmon adult run size forecasts have also been developed. Juvenile-based Yukon Chinook Salmon run forecasts better predict changes in productivity compared to traditional forecasting tools (Ricker and Sibling models), which only consider adult abundance data. Juvenile-based forecasts also provide run expectations up to three years into the future, while traditional models only predict for the upcoming year; thereby providing managers, fishermen, and regulatory bodies with the ability to implement longer-term resource planning.

Can selective use of historical data improve pre-season forecasts of Fraser River sockeye salmon?

Lapointe, Mike. Pacific Salmon Commission

Grant, Sue. Fisheries and Oceans Canada; MacDonald, Bronwyn. Fisheries and Oceans Canada; Michielsens, Catherine. Pacific Salmon Commission

Forecasts of Fraser River sockeye salmon are generated using a standard suite of commonly applied models. The relative performance of each model is evaluated retrospectively to identify the “best” one based on their historical bias and precision. Using all available data when fitting the models and/or when evaluating model performance can be problematic because some past years may be more relevant to the year being forecast than others. Three case studies document outcomes of selective use of historical data. The first example leverages the cyclic pattern in return abundances shown by several Fraser sockeye populations to partition historical data based on patterns in brood year escapements. The second example stems from a Canadian federal inquiry that was triggered in 2009 when Fraser sockeye returned at levels only slightly more than one tenth of the median forecast abundance. The “best” models, given a presumed continuation of low productivity, underestimated the record returns in 2010. The third example emanated from the combined effects of the extremely warm ocean temperatures (SST) in the Gulf of Alaska (known as “the blob”) and the documented negative effects of warm SST on the productivity of sockeye distributed in the southern part of the species range. In developing the 2017 forecast, existing models with a temperature covariate were evaluated and found to be superior based on their performance in past years of extremely warm ocean conditions. Forecasts of 2017 returns based on these models were much closer to actual returns than forecasts based on models which assumed historical average productivity. These examples illustrate some benefits and pitfalls of subsampling long time series in developing pre-season forecasts.

Inseason assessment of Fraser River Sockeye Salmon.

Michielsens, Catherine. Pacific Salmon Commission

Cave, Jim. Retired, former Pacific Salmon Commission; Lapointe, Mike. Pacific Salmon Commission

Though pre-season forecasts are important for informing stakeholder expectations about potential returns, all substantive fisheries decisions regarding Fraser River Sockeye Salmon are based on intra-seasonal assessments of abundance and migration timing. These inseason assessments rely on the combination of CPUE data from marine test fisheries and reconstructed marine abundance estimates based on in-river hydroacoustic data and seaward catches due to the lack of regularly available data from other sources. Stock identification data, provided by real-time genetic analyses of tissue samples obtained from test fisheries, allows for individual assessment of the four different management groups of Fraser Sockeye Salmon. Data are analyzed using a time density model which assumes the daily migration pattern is symmetrical

about a run-timing peak. Conceptually this approach assumes the total abundance can be estimated by doubling the cumulative abundance of the migration prior to the peak of the run. However, prior to observing the migration peak, total abundance and timing are confounded because the fraction of the run represented by the cumulative run-to-date is unknown. A Bayesian framework is used to predict an initial daily abundance pattern based on pre-season forecasts of total abundance and timing. This predicted distribution of daily abundance estimates is then compared to daily abundance estimates derived from the test fishery and acoustics programs to generate inseason estimates of total return and timing. The precision of resulting estimates increases as data accumulate, especially after the peak is observed in the reconstructed daily marine abundance estimates or CPUE data. Model predictions are communicated to stakeholders in terms of median point estimates and 80% probability intervals. These estimates are part of a more general information package that is provided to the Fraser River Panel each summer in their biweekly meetings that are used to determine fishing opportunities.

Stikine Sockeye Salmon Management Model; Improving Management Uncertainty

Miller, Sara E. Alaska Department of Fish and Game*

Bednarski, Julie A. Alaska Department of Fish and Game

Salmon fisheries that harvest Stikine River Sockeye Salmon *Oncorhynchus nerka* in marine waters in Southeast Alaska Districts 106 and 108 and in in-river Canadian fisheries are managed under the Pacific Salmon Treaty. Under this plan, the total allowable catch (TAC) of both natural and enhanced Sockeye Salmon is currently allocated 50/50 between the countries. The Treaty also dictates that inseason estimates of TAC shall be made using an inseason forecast model developed by the Transboundary Technical Committee, and fishing regimes by both countries shall be based on those estimates. The Stikine Management Model (historical-SMM) has been the agreed to inseason forecast model since about the late 1980s/early 1990s and has been used annually through 2017. Using the historical-SMM as the base model, we developed new inseason forecast models to estimate the terminal run size of Sockeye Salmon stocks returning to the Stikine River. Model development occurred in two parts: (1) initial model development of terminal and inriver run size models using historical data, model comparison using Akaike Information Criterion, and managers' preferences, and (2) inseason model testing in years 2014 through 2017. The percent error is the difference between the inseason estimate of terminal run size, using one of the forecast models, and the 'true' postseason (run reconstruction) estimate of terminal run size. Performance of the models was evaluated based on the mean percent error and the mean absolute percent error.

Improving Pink Salmon Harvest Forecasts in Southeast Alaska

Piston, Andrew W. Alaska Department of Fish and Game*

Heinl, Steven C. Alaska Department of Fish and Game

Wild Pink Salmon runs support a large commercial fishing industry in Southeast Alaska. From 2007 to 2016, the Pink Salmon harvest averaged 39 million fish (range: 16–95 million) and the exvessel value was worth an average $48 million. For decades, the Alaska Department of Fish and Game (ADF&G) expended a great deal of effort to conduct research to improve Pink Salmon forecasts, and has provided industry with formal, published forecasts of Pink Salmon production and harvests since the early 1970s. Forecasts generally performed poorly—from 1981 to 2006, the actual harvest was within 20% of the ADF&G forecast only 12 of 26 times and harvests fell outside of forecasted 80% confidence intervals nearly 50%

of the time. Most importantly, forecasts often failed to predict surprise—the most valuable feature of a forecast. Past forecasts relied primarily on measures of Pink Salmon spawning abundance or success, both of which are poorly known and explain little of the variation in annual recruitment, which is largely determined in the early marine environment. In 1997, NOAA began collecting juvenile Pink Salmon catch-per-unit-effort data in standardized surface trawls conducted in northern Southeast Alaska. This index of relative juvenile abundance is highly correlated with harvest of adult Pink Salmon in the following year and it captures information about freshwater and early marine survival that has greatly improved forecast performance in the region. Since 2007, ADF&G Pink Salmon harvest forecasts were produced by first making a naïve forecast based on the trend in harvest, then adjusting this forecast using the NOAA juvenile Pink Salmon abundance data. ADF&G forecasts since 2007 were much improved (mean absolute percent error = 30%) over earlier forecasts (mean absolute percent error = 58%) and performed better than naïve forecasting models.

Stikine inseason forecast cross validated.

Power, Sarah J.H.*

Jaecks, Troy A.; Richards, Philip J.

An inseason forecast of Stikine Chinook Salmon run sizes using catch-per-unit-of-effort will be presented. Prediction performance using cross validation techniques will be assessed.

Lessons Learned from Adaptive Management of the Port Moller Sockeye Salmon *Oncorhynchus nerka* Test Fishery

Raborn, Scott

Link, Michael

The Port Moller, Alaska Sockeye Salmon *Oncorhynchus nerka* test fishery dates as far back as 1967 and is currently used as an input for inseason forecast models. Historical reports and documentation regarding net configuration vary, but our best supposition is that the test fishery was standardized with respect to gear and fishing protocol by 1989. Regardless, measurement error continues to cause the reliability of inseason signals from Port Moller to vary both within and across seasons. In keeping with the strategy of adaptive management, the net design was altered to include an additional mesh size in 2011 to flatten contact selectivity across fish sizes. Additionally, fishing time per station was reduced by two thirds in 2015 to help prevent the possibility of net saturation. Reduced set times allowed for more stations to be added to the daily fishing schedule. The key to substantially reducing inseason forecasting error based on Port Moller lies in teasing apart the estimation of two confounded parameters: (1) TT—travel time between Port Moller and the inshore fishing districts, and (2) RPI—run per index or the number of inshore fish that each test fish index point represents. The knowledge afforded by an adaptive sampling approach has clarified the steps necessary to more accurately estimate these parameters. We present the logic behind our decisions to alter the standardized protocol and the lessons learned from these changes.

Forecast error of Bristol Bay Sockeye Salmon in relation to Sockeye Salmon interactions at sea with Pink Salmon

Ruggerone, Gregory T. Natural Resources Consultants, Inc.*

Pink Salmon and Sockeye Salmon have never been more abundant than now in response to favorable early ocean conditions in northern regions where freshwater habitat is largely intact. However, Pink Salmon abundance has been exceptional, averaging nearly 500 million fish each year during 1990-2015 and up to ~76% of all Pacific salmon in odd-numbered years. Such high abundances may adversely affect other species of salmon such as Sockeye Salmon in offshore marine areas, and offset benefits gained during early marine life. Studies show that Russian Pink Salmon affect the growth and survival of Bristol Bay Sockeye Salmon, and a new study shows that Pink Salmon cause a trophic cascade in the Bering Sea and Aleutian Island region; i.e., zooplankton counts are negatively correlated and phytoplankton counts are positively correlated with Pink Salmon abundance, 2000-2014. Do Pink Salmon introduce error in pre-season forecasts of Bristol Bay Sockeye Salmon? Forecast error of Sockeye Salmon stocks from southeastern Bristol Bay (Kvichak, Naknek, Egegik, and Ugashik) exhibited a biennial pattern consistent with competition by Pink Salmon, which are highly abundant in odd-years. After standardizing ADF&G forecast error relative to adjacent years, forecasts in even-years were too high and forecasts in odd-years were too low, reflecting competition with Pink Salmon during the year prior to the return year. Sockeye Salmon from northwestern Bristol Bay (Wood River) exhibited weaker forecast error relationships with Russian Pink Salmon abundance, which is consistent with their more easterly distribution at sea. Forecast error was most apparent among age-1.2 and age-2.2 Sockeye Salmon because these fish interact with either abundant odd-year or much less abundant even-year Pink Salmon but not both. This study provides new evidence that Pink Salmon affect the survival of Sockeye Salmon, and that consideration of Pink Salmon abundance patterns might improve forecasting of Bristol Bay Sockeye Salmon.

Evaluation of Several Approaches to Bayesian Updating of Pre-season Indicators of Run Strength in Pacific Salmon Fisheries

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Catalano, Matt. Auburn University

Pre-season forecasts of Pacific salmon run strength are notoriously uncertain (and often wrong) due to a lack of understanding of drivers of population change which would provide empirical predictive relationships. Thus, it may be desirable to use information collected inseason (e.g., various indices of abundance, fishery catch rates, etc.) to update the pre-season forecast for inseason decision-making regarding harvest targets. These inseason data are often uninformative unless auxiliary information regarding the timing of the incoming run is also available. For example, average index counts early in the season can be equally plausible under small/early and large/late run scenarios, yet the harvestable surplus is vastly different between these two cases. Bayes' Theorem offers a powerful and intuitive framework to perform information-updating: the pre-season run size forecast can be viewed as prior knowledge to be updated with new information regarding run size as it is collected inseason. We assessed the relative performance of three Bayesian information-updating procedures: pre-season forecast only (inseason data carries no weight), updating with inseason test-fishery abundance indices and the historical distribution of run timing, and updating with the test fishery information and a pre-season run timing forecast. Preliminary results indicate that inseason Bayesian updating provides more accurate run size estimates during the time when harvest decisions need to be made, but that the incorporation of run timing forecasts has relatively little utility in terms of increased accuracy or precision. The Bayesian approach provides a probabilistic expression of run size beliefs which results from a weighted synthesis of all previous and current knowledge, which could be useful in a transparent risk-assessment framework for setting and altering harvest targets inseason.

Age-Structured State-Space Models: Can They Provide Insight into the Future?

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Obtaining reliable estimates of escapement and subsequent recruitment is arguably the most challenging problem a salmon stock assessment biologist endures because management of many Alaska salmon stocks is based on a fixed escapement goal that, when appropriate, attempts to maximize sustainable yields. In contrast, deriving predictions or forecasts about how abundant next year's salmon run will be is likely the most challenging problem a fisheries manager endures because the escapement goal policy dictates the harvests from these fisheries are sustainable and the forecast is used to predict the allowable harvest that will ensure sustainable escapement. We used an age-structured state-space spawner–recruit model to fit estimates of relative and absolute abundance, harvest, and age composition for Copper River Chinook Salmon *Oncorhynchus tshawytscha* from 1980 to 2016. Bayesian statistical methods were employed to assess uncertainty in the presence of measurement error, serial correlation, and missing data. Ricker stock-recruit parameters and management reference points were estimated, including the escapement that provides for maximum sustained yield (SMSY). The model also provides a prediction of total run and escapement for the subsequent year. A retrospective analysis is currently being completed to assess this state-space model's ability to forecast future Chinook Salmon runs and the results will be presented during this symposium.

ForecastR Project: Automating procedures for forecasting of terminal run and escapement of Chinook, Coho, and Chum Salmon stocks using open-source statistical software

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I will talk about the ForecastR project funded by the Pacific Salmon Commission to assist the generation of salmon return forecasts by providing a unified and flexible approach. ForecastR is an R program that enables the users to perform the following interactive tasks with the help of a Graphical user Interface. These tasks include: (a) the selection of forecasting approaches from a wide set of statistical and/or mechanistic models for forecasting terminal run, escapement or pre-fishery abundance (production); (b) the selection of several measures of retrospective forecast performance (e.g., MRE, MAE, MAPE, MASE, RMSE); (c) the comparison of best forecasting models and model ranking based on the selected performance metrics; and, (d) the reporting of forecasting results (point forecasts and interval forecasts) and numerous model and forecast diagnostics by producing either a detailed report or an executive summary in MS Word. Currently, ForecastR involves the generation of age-specific or total-abundance forecasts using a variety of generic models, including: (i) simple and complex sibling regressions with the ability to include environmental covariates; (ii) time series models such as ARIMA, exponential smoothing, and naïve models (based on preceding 1 year, 3 years or 5 years in abundance time series); and (iii) mechanistic models such as average return rate models that depend on auxiliary data such as the number of outmigrant juveniles, the number of hatchery fish released or the number spawners. For both age-structured and non-age-structured data, AIC-based model selection takes place within model types prior to model ranking across model types based on the abovementioned metrics of retrospective evaluation. Future ForecastR development involves the development

of Kalman Filter sibling regressions to incorporate potential trends in survival or maturity as well as the development of alternative retrospective forecast evaluation for sibling regressions using “dynamic selection” of best models.

Can naïve forecasts be improved beyond random walk models?

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Scheuerell, Mark D.; Holmes, Elizabeth E.; Thorson, James T.

Short-term forecasts based on time series of counts or survey data are widely used in population biology to provide advice concerning the management, harvest, and conservation of natural populations. Many of these forecasts are naïve in that they ignore age structure, sex structure, or environmental variation. More commonly, forecasts are produced using time-series models, of different types, fit to time series of counts (abundances, redd surveys, etc). Similar time-series models are used in many other disciplines, however relative to the data available in these other disciplines, population data are often unusually short and noisy and models that perform well for data from other disciplines may not be appropriate for population data. In order to study the performance of time-series forecasting models, we conducted a meta-analysis of highly variable highly variable (marine fish productivity) and strongly cyclic (adult salmon counts) time series. We tested the predictive performance of 49 different forecasting models grouped into three broad classes: autoregressive time-series models, non-linear regression-type models and non-parametric time-series models. Low-dimensional parametric autoregressive models gave the most accurate forecasts across a wide range of taxa; the most accurate model was one that simply treated the most recent observation as the forecast. More complex parametric and non-parametric models performed worse, except when applied to highly cyclic species. Finally, we present potential multivariate extensions of these methods as options to improve forecasts.

Pink Salmon forecasts in Southeast Alaska using data from the Southeast Alaska Coastal Monitoring program

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Pink Salmon *Oncorhynchus gorbuscha* harvests in southeast Alaska have varied from 3-95 million fish annually since 1960. These returns are difficult to forecast because their two-year life history includes only one ocean winter and precludes the use of younger returning age classes to predict cohort abundance. The NOAA Auke Bay Laboratories has conducted the Southeast Alaska Coastal Monitoring program (SECM) since 1997. SECM sampling of juvenile salmon and environmental data, which occurs in seaward migration corridors, facilitates predictions of Pink Salmon returns in southeast Alaska during the following year. Average juvenile Pink Salmon catch per unit effort in Icy and Upper Chatham Straits is the leading indicator of returns, with local climatic and oceanographic information helping to further refine forecast models. Despite a simple linear modeling framework, SECM forecasts have been remarkably accurate. During a 14 year period, Pink Salmon harvests were within the forecasted harvest range in 11 years, with harvest exceeding the forecast in one year (2013) and failing to meet expectations in two other years (2006 and 2015). Recent changes in environmental conditions have been associated with larger forecast error ranges than were historically seen, and 2018 is among the lowest expect run sizes of the time series. Pink Salmon forecasts provide a tool for regional pre-season planning and model development.

Applications of Oceanographic Data to Improve Inseason Forecasts of Sockeye Salmon Runs into Upper Cook Inlet

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Historic oceanographic and salmon test fishery data were analyzed to identify effects of changing oceanographic conditions on salmon migratory behavior and develop applications to improve inseason forecasts of Sockeye Salmon runs into upper Cook Inlet. Tides were the dominant force affecting physical parameter distributions along the test fishery transect running across Cook Inlet west of Anchor Point. On the ebb tide, a warm low salinity surface layer spread eastward. On the flood tide, cold high salinity water at depth forced the low salinity layer to the west creating a southward flowing baroclinic jet in the center of the inlet. Retrospective analyses of salmon catch data indicated that Sockeye Salmon used tidal currents to facilitate their northward migration into Cook Inlet, but they also aggregated along frontal boundaries and avoided low salinity (<29 o/oo) surface layers. Sockeye Salmon residence times in the inlet ranged from 1-8 days with longer (shorter) residence times associated with cooler (warmer) ocean temperatures and weaker (stronger) salinity gradients. Since 1996, mean July surface salinities along the transect declined 0.075 o/oo year-1. Sockeye Salmon run timing appeared to be determined in part by density-dependent growth in the year prior to inshore migration. Warmer ocean temperatures in the northeast Pacific region likely reduced Sockeye Salmon growth and delayed inshore migration the following year. Sockeye Salmon run timing was further delayed by strong north winds over Cook Inlet in late July. Application of a Sockeye Salmon run-timing model using ancillary data reduced early (July 15-20) inseason salmon run forecast errors from 59.1% to 14.0%. More accurate early season salmon run forecasts will improve management for escapement goals needed to achieve high sustained yields from future runs.

Challenges and Advances in the Conservation of Western Native Trout

Return of a Giant: Coordinated Conservation Leads to the Re-establishment of Lahontan Cutthroat Trout in the Truckee River for the first time in over 80 Years

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The loss of freshwater biodiversity across the globe is alarming. In the United States, contemporary patterns of distribution and abundance of many freshwater fishes have been greatly reduced, with particular loss of migratory fishes. The recovery and expansion of depleted populations can be challenging as threats are often plentiful and complex, especially in arid environments where demands for water resources are high. Here, we describe how a collaborative and multifaceted approach has spurred the recovery of Lahontan Cutthroat Trout (LCT) in Pyramid Lake and the Truckee River, Nevada, once home to one of largest freshwater salmonids in North America. The factors limiting LCT were immense, including habitat fragmentation, degradation, and non-native species-attributes common in the declines of native salmonids across North America. Yet for the first time (2014-present) since being listed under the Endangered Species Act and over 80 years since the last documented natural spawning, adfluvial Lahontan Cutthroat Trout have spawned in the Truckee River,

resulting in tens of thousands of young-of-year recruiting each year to Pyramid Lake. We present the results of field studies demonstrating the early success and potential limitations for LCT within the Truckee River-Pyramid Lake ecosystem. In addition, we describe the results and progress towards recovery within the context of the collaborative conservation and management efforts. While additional challenges remain, the LCT recovery program in the Truckee River basin provides a template for the conservation of imperiled fishes.

Montana DNRC Habitat Conservation Plan for Bull Trout, Westslope Cutthroat Trout, and Interior Redband Trout; 5-year status review and future actions

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Montana Department of Natural Resources and Conservation implemented a Habitat Conservation Plan (HCP) for forest management activities in 2012. The plan was developed to mitigate effects of forest management practices on Bull Trout, Westslope Cutthroat Trout, and interior Redband Trout populations on state trust lands in western Montana. Aquatic conservation strategies focused on; 1) riparian management, 2) sediment delivery, 3) fish connectivity, 4) grazing, and 5) cumulative watershed effects. Riparian timber harvest commitments established stream buffer zones and associated riparian monitoring. Fish connectivity commitments included evaluating existing road-stream crossings and develop a prioritization framework for crossing structure improvement. Riparian timber harvest monitoring has indicated that riparian buffers are largely effective at protecting stream metrics paramount to fish habitat. Target levels of large woody debris (LWD) established in the HCP have been exceeded in all sites during post-harvest monitoring. Long-term recruitment of LWD to the stream in post-harvest stands has also been assessed, and model results will be verified with continued monitoring to document future LWD recruitment. Significant decreases in stream shading was observed at several sites, however, coincidental increases in stream temperature were observed at only one site. Assessment of shade and temperature provides a more complete view of mechanistic effects of riparian stand structure on aquatic resources, as well as variation among riparian forest types. Road-stream crossing inventories identified 140 sites limiting connectivity in streams occupied by HCP-covered species. During the first 5-years of implementation, 18 sites were improved, and 43 sites were removed from consideration based on hydrology and fisheries surveys. Connectivity improvements on Bull Trout streams will be completed by no later than 2027, with all remaining sites completed by 2042. These data and future monitoring efforts will be used to inform and improve forested land management practices and conservation of native trout populations on state trust lands in Montana.

Programmatic Approach that Provides Genetic Specific Connectivity for Bull Trout in the Baker River Basin, Washington

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A new 50-year license for two hydroelectric developments on the Baker River in Washington State address the capture and upstream transport of Bull Trout *Salvelinus confluentus* from the lower Baker River, the capture and downstream transport of Bull Trout from the upper Baker River reservoir (Baker Lake) and lower Baker reservoir (Lake Shannon), and potential capture and transport of Bull Trout from Lake Shannon to Baker Lake. Historically all native char entering the lower Baker River fish trap were moved to Baker Lake, including Bull Trout that originated outside of the Baker Basin. Bull Trout

upstream passage segregation by origin began in 2009. Current Bull Trout management objectives support the development of transport protocols that preserve the reproductive potential of each basin's various natal populations and aim to return Bull Trout to their specific basins, while providing all Bull Trout the opportunity to migrate to downstream habitats. This has resulted in a unique programmatic approach to a fish way for Bull Trout where current management objectives support a program that includes active collection of Bull Trout (angling), DNA sampling to determine geographic origins, and transport of Lake Shannon, Baker Lake and out-of-basin Bull Trout to their appropriate sub-basins. Metrics to monitor success of the program are reviewed annually.

Monitoring Bull Trout Reintroduction in the Clackamas River, Oregon

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Historically, Bull Trout *Salvelinus confluentus* were widely distributed in the Willamette Basin, but in the Clackamas River Subbasin, no sightings had been documented since 1963. Beginning in 2011 and continuing through 2015, the U.S. Fish and Wildlife Service, in cooperation with the State of Oregon, and other partners, translocated adult and subadult Bull Trout from the Metolius River Basin to the Clackamas River. In addition, juvenile Bull Trout were translocated to multiple Clackamas River tributaries. Genetic samples from each individual were collected and all transferred fish were PIT-tagged to allow for subsequent detection and identification. Since the project's inception, the effectiveness of the reintroduction effort has been monitored by PIT tag interrogation systems, spawning surveys, electrofishing, and other methods. Monitoring efforts have documented that translocated individuals survive, mature, migrate, and spawn within the study area, but direct evidence of natural recruitment into the population has yet to be confirmed. During 2017, a video/PIT detection weir with an upstream adult trap were deployed in Pinhead Creek, the primary spawning tributary within the study area, to further evaluate the spawning population. The majority (83%) of adult fish captured in the trap were PIT-tagged, indicating they were translocated individuals. A relatively large portion of the trapped males (90%) were previously tagged, while a lower percentage of trapped females (71%) were previously tagged. Similarly, video and PIT detection data from the weir indicated 89% of males and 43% of females were previously PIT-tagged. The information gathered suggests that a portion of the spawning population may include naturally recruited individuals, but the disparity between the percentage of tagged male and female fish may indicate notably lower tag retention among females. Continued monitoring and genetic analysis will help to evaluate the long-term success of this reintroduced population and help inform future Bull Trout reintroduction efforts range-wide.

Using Net Rate of Energy Intake foraging model to predict salmonid carrying capacity across multiple reaches

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Net Rate of Energy Intake (NREI) foraging models synthesize hydraulics, food availability, and temperature to predict energetic profitability of stream habitats. These models have been shown to be accurate in predicting position preference, carrying capacity, and energetic benefits of stream restoration. Data availability and computational costs often limit foraging model application, especially at large spatial scales. We have updated an existing NREI model to evaluate carrying capacity of salmonids from reach scale topographic surveys. This model now takes advantage of automating hydraulic model solutions at ongoing monitoring sites and developing a raster-based methodology for describing flow patterns near modeled focal points that are computationally very efficient. We have updated territory sizes and shapes to account for both interference and resource competition (drift depletion) to estimate carrying capacity for salmonids at a site. We estimated and validated carrying capacity of Bonneville Cutthroat Trout in the Logan River, Utah, which is thought to be a healthy population near natural carrying capacity. While we found a strong correlation between observed and predicted carrying capacities, model estimates were nearly 3 times higher than observed densities. While we believe these models provide valuable insight into fish habitat requirements in respect to foraging, other factors will also need to be incorporated in order to more accurately predict carrying capacity.

Hedging bets: Dealing with uncertain outcomes by diversifying management approaches

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Physical habitat stressors such as habitat degradation, population fragmentation, and climate change act synergistically with biological stressors such as invasive fish to put unprecedented pressure on some native fish species, such as Bull Trout. Case in point, the expansion of invasive Lake Trout within the Flathead Basin has dramatically reduced the ability of protected areas with largely pristine physical habitat, such as Glacier National Park, to serve as refuges for native species like Bull Trout. We are applying a holistic, multi-pronged strategy of restoration, isolation, monitoring, and population replication to maximize the ability of Glacier's landscape to provide secure habitat for Bull Trout and other native fish species into the future. This program is relatively unique due to its comprehensive nature and its implementation in a backcountry Wilderness setting. The program requires a close linkage of research and management, while navigating competing/complex policy mandates and public opinion, as well as challenges in implementing field tasks that would be considered straight-forward in a front-country, non-Wilderness setting. We present a variety of approaches we have utilized that may aid others working to address similar resource challenges.

Effects of Instream Complexity on Habitat Suitability for Stream-Dwelling Cutthroat Trout Populations

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The availability of suitable habitat is a primary factor limiting the abundance of stream-dwelling salmonid fishes. For drift-feeding fishes that must swim against the stream current in order to forage, suitable habitat can be defined areas where individuals can maintain a positive energy balance and capture enough food for growth and reproduction. In this study, we examined whether the addition of instream habitat complexity increases the availability of suitable habitat for Cutthroat Trout *Oncorhynchus clarkii* populations. We manipulated the availability of pool habitat by adding instream structures to four headwater streams in southeast Idaho and compared the change of habitat quality to un-manipulated control sections within

the same streams. We measured habitat quality at monthly intervals between July and October 2016 and estimated the energetic profitability of the available habitat with a bioenergetic model. The model estimates habitat quality by subtracting the energetic costs accrued from the total energy gained by trout while foraging. The aim of this study is to determine how space limitation may restrict the growth of salmonid populations, and to determine the mechanism by which habitat complexity creates suitable habitat for drift feeding fishes.

Estimating the seasonal migration of Sakhalin Taimen using environmental DNA

Mizumoto, Hiroki

Araki, Hitoshi

Sakhalin Taimen *Parahucho perryi* is one of the largest freshwater fish in the world and considered critically endangered by the IUCN. Historically distributed in the Russian Far East and Northern Japan, this species has declined drastically due to human activities such as river modification and deforestation. The rarity and migratory nature of Sakhalin Taimen make direct detection and observation difficult, which has been a major limitation of field survey of the endangered species. As the breakthrough for those issues, environmental DNA (eDNA) technique has drawn attentions recently. This technique was first reported in 2008 for detecting aquatic vertebrate species in the wild from environmental water samples. The strong advantages of this technique are that there is no need to observe target species directly and that it is easy to collect samples for monitoring across large spatial and temporal scales. In our presentation, we will show the results of station sampling for estimating the seasonal migration of Sakhalin Taimen using eDNA technique in Japan, Hokkaido. We collected water samples from upper to lower in two river systems that are known to hold stable population of Sakhalin Taimen. As the results of these sampling, patterns of their seasonal migration were different between these two river systems. This result suggests that there are population-specific migration patterns, and eDNA technique has a possibility for investigating the behavior of anadromous fish.

The Salmonid Population Viability Project: Modeling Trout Viability in a Desert Landscape

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Many species of conservation interest exist solely or largely in isolated populations, where management priorities ideally would be guided by quantitative estimates of extinction risk. However, conventional methods of demographic population viability analysis (PVA) generally model each population separately and require temporally extensive datasets that are rarely available. We developed a new multiple population viability analysis (MPVA) that combines fish sampling data with remotely-sensed and other environmental data to deliver estimates of carrying capacity, inter-annual variability, and viability for all populations simultaneously. Remotely-sensed spatial covariates describe habitat size and quality, while temporal variability is a function of temperature and flow. A hierarchical approach includes an observation model which calculates site- and pass-specific probabilities of detection and informs a sampling model, which feeds into a process (population dynamics) model. MPVA can leverage information from well-sampled populations to extrapolate to poorly sampled or even un-sampled areas; it also allows for evaluation of different management scenarios (e.g., barrier or non-native trout removal). We applied MPVA to Lahontan Cutthroat Trout *Oncorhynchus clarkii henshawii*, a federally threatened trout native to the

Great Basin Desert, to generate simultaneous estimates of extinction probability and evaluate management action effectiveness across the sub-species' range.

Trout Creek Ranch, Wyoming Game & Fish, and East Yellowstone Trout Unlimited Chapter collaboratively working together to conserve Yellowstone Cutthroat Trout habitat and populations

Leonetti, Erin E.*

Scribner, Nick; Stahl, Lew

Yellowstone Cutthroat Trout (YSC) *Oncorhynchus clarkii bouvieri* are a species of greatest conservation need (NSS3(Bb)) in Wyoming and are found in Trout Creek, a tributary to the North Fork of the Shoshone River in northwest WY. Resident and fluvial YSC are found using Trout Creek and its tributaries for refuge and spawning. Trout Creek meanders through Trout Creek Ranch for 4 miles supporting a blue ribbon fishery for Rainbow Trout and YSC before flowing into the North Fork Shoshone River. Since 2000, Trout Creek Ranch, Wyoming Game and Fish (WGFD), and East Yellowstone Trout Unlimited Chapter have worked collaboratively on multiple fish passage projects to help conserve the wild YSC trout population. Projects completed include sampling irrigation ditches for entrained fish, building fish friendly diversions, and installment of fish screens on 3 of their 4 irrigation diversions. The ranch agreed to be testing grounds for various fish screen types, so 3 different screens were installed including a drum, a farmer, and a Hydrolox, and have allowed educational and informational tours to an assortment of groups about this work. These tours allow WGFD to educate, inform, and discuss fish passage concepts and different fish screens and how they function. Recently, the ranch asked WGFD to assist with flow monitoring to improve water management on the property to balance the needs of their land with habitat in the stream to ensure fish have adequate resources. This partnership has led to great improvements of habitat within Trout Creek and allowed WGFD to learn the long term maintenance requirements of various fish screening technology to apply statewide.

Evaluating Fish Passage Success and Making Management Decisions: A Review of 7-years of Upstream Fish Passage for Inland Fisheries, on the Lower Clark Fork River, in Northwestern Montana

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Is it necessary to have "statistical significance" to make management decision for the better good of a natural resource? After 7 years of operating an upstream fish passage facility (fish ladder) at Thompson Falls Dam, located on the lower Clark Fork River in northwestern Montana, these are some of the questions and discussions NorthWestern Energy, the owner and operator of the dam, and agency collaborators grapple with as the first 10-year evaluation period draws near. Since 2011, the ladder has operated annually between March and October and successfully passed over 30,500 fish representing 14 species plus three hybrids. Between 1 and 5 Bull Trout ascend the ladder annually, which is representative of their low occurrence in the system. Because the fish ladder was the first of its kind designed for an inland riverine fishery, inland fishery metrics to evaluate effective fish passage were not yet established and the default criteria (delay, fallback, ladder efficiency) were derived from anadromous fish passage facilities on the Columbia River. Evaluating success has been challenging when the metrics are based on anadromous fish and the movement patterns, behaviors, and life histories of Bull

Trout and other inland fish documented at the ladder are not the same. Inland fish movement and behavior is motivated by more than spawning and may be caused by environmental conditions/stressors, food availability, species interactions/competition, etc. After 7 years, we found these fish “wander” up and downstream, show a variety of movement patterns, and do not behave like salmon. After a range of river conditions over the years (above average, average, and below average streamflows and water temperatures) and testing of various operating metrics (weir modes, attractant flow, spill schedule, etc.), NorthWestern reviews the success stories, the knowledge gained, and the future challenges of upstream fish passage for inland fisheries.

Fishery management approach for Rainbow Trout in the large and diverse salmonid fisheries of the Kenai River.

Marston, Brian

Fishery management focused on sustaining wild fish populations is the cornerstone of ADF&G fishery management. However, the fishery management objective of maximum yield is difficult to address for fish species that anglers prefer not to harvest. Additionally, total removals of a fish species can be heavily influenced by fisheries for other species that occur in sympatric habitats. If fisheries for other species are particularly large, or occur during vulnerable life stages, incidental mortality could impact angler preferences for catch and release angling. The Kenai River area supports close to 1/4 of the total statewide angler effort in Alaska with more than 500,000 angler days. This effort on the Kenai River alone exceeds 375,000 angler days and is focused at Chinook Salmon, Sockeye Salmon, and Coho Salmon, as well as resident Rainbow Trout. Angler preference for catch and release fisheries of Rainbow Trout have evolved into complex regulation for the Kenai River. Regulations include low trout harvest limits, limited size of harvested fish, closures to all angling during trout spawning, and bait restriction, as well as hook size. However, because of recent public requests, attempts have also been made to simplify and create consistency in regulations for all species in this very complex regulatory environment. The diversity and biology of the many species available on the Kenai River, high angler effort, and varied angler preferences, all influence management specifics for trout in the Kenai River. This presentation will summarize the current fishery and management of Rainbow Trout in the Kenai River, explore the evolution of the regulatory complexity, and present a path forward for this fishery which sustains the fish population while allowing for diverse angler preferences in all Kenai River fisheries.

The Role of Aquaculture to Support Bull Trout Recovery in Glacier National Park

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This presentation will describe the role aquaculture plays in recovering Bull Trout in Glacier National Park Montana. This effort is in response to Bull Trout recovery actions taken in Glacier NP and conducted collaboratively with the USFWS Creston NFH, USGS Northern Rockies Science Center and Glacier National Park. The project involves removal of non native fish, collection of wild gametes, rearing of progeny in an isolation facility at Creston and translocation of juvenile fish back into Glacier. This collaborative effort aims to re-establish self sustaining Bull Trout populations in Glacier NP.

Structure and spatial distribution of an isolated population of threatened Greenback Cutthroat Trout in a high altitude and high gradient mountain stream

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Greenback Cutthroat Trout (GBCT) were once abundant across the western slope of Colorado. Victims of habitat degradation and fragmentation, competition from non-native trout, and hybridization with Rainbow Trout, GBCT were thought extinct by the late 1930s. However, a few small and secluded populations persisted and by 1978 the species status was upgraded from endangered to threatened. Today, GBCT have been extirpated from nearly 99% of their former range and are limited to isolated headwater streams and lakes. One of the top five most genetically pure populations of GBCT inhabits a headwater portion of the Fraser River drainage, called Little Vasquez Creek. The population is isolated to the headwaters of the drainage by a permanent passage barrier that allows fish to emigrate downstream, but blocks fish passage upstream. Consequentially, the population's existence depends entirely on habitats within Little Vasquez Creek. Until now, life history and population characteristics data were lacking for this small population of fish. In 2017 a study was conducted to better describe GBCT spatial distribution, habitat use, and population dynamics in Little Vasquez Creek. Results from this study expanded the previously known extent of habitat use by almost 60% and nearly tripled the previously estimated population size. Findings provide the most comprehensive evaluation of GBCT distribution, habitat use, size class structure, and population size for the Little Vasquez Creek drainage to date. This data serves as a basis to monitor future changes in the population and a methodology to evaluate similar populations. The study underscores the importance of collecting comprehensive baseline information to better manage and reliably monitor sensitive, bottlenecked fish populations.

Selecting for a legacy: Suppressing hybrid and Rainbow Trout as a conservation strategy for migratory Westslope Cutthroat in the upper Flathead River drainage

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Boyer, Matt. Montana Fish, Wildlife and Parks; Hunt, Rick. Montana Fish, Wildlife and Parks; Belcer, Durae. Montana Fish, Wildlife and Parks

Opportunities to conserve native Cutthroat Trout within entire river drainages are generally limited; yet, at this spatial scale the presence of migratory life history forms provide additional population resiliency to environmental change. The North and Middle forks of the Flathead River drainage (2,801 sq. mi.) comprise a substantial portion of remaining interconnected habitat for migratory, non-hybridized Westslope Cutthroat Trout (WCT) in Montana. However, genetic and radio telemetry data document the spread of Rainbow Trout (RBT) introgression within the drainage, predominantly from downstream tributaries. Beginning in 2000, migrant traps and electrofishing were used to capture and remove hybrid trout from source populations with a high proportion of RBT admixture. Drainage-wide surveys conducted in 2015-2016 provided an updated assessment, revealing that RBT introgression continues to spread to sites where it was previously not detected, yet many sites categorized as "conservation" populations (< 10% admixture) still persist. Radio telemetry demonstrated that about 50% more hybrids and RBT spawned in the Mainstem Flathead River during 2016 and 2017 than during 2000-2005 when most spawning occurred in tributaries containing WCT – suggesting that their spatial overlap with WCT spawning habitat

may have changed. Further, the suppression effort has resulted in a decline in the rate at which RBT admixture has increased among sites in the drainage, a reduction in the number of highly admixed hybrids within mid-range sites, and a decrease in CPUE of up to one order of magnitude across sites. Although non-hybridized WCT continue to be threatened by spreading RBT introgression, these results suggest that focused suppression of hybridization sources can be an effective strategy for maintaining conservation populations of WCT in a large, interconnected river drainage.

Abundance, Productivity, Spatial Structure, and Diversity of a Mixed Resident and Anadromous *O. mykiss* Population in Central Washington State

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The Steelhead Trout *Oncorhynchus mykiss* exhibit some of the most diverse life histories of any Pacific salmonid. Included in the diversity of this species is the variable expression of anadromous and resident life histories. The anadromous form may smolt and migrate to the ocean after one, two, three, or more years of residency in freshwater and the return to its natal stream after spending one or more years in the ocean. In contrast, the resident life history form, also known as Rainbow Trout, spends its entire life in freshwater. Our understanding of this species is further complicated by the fact that both forms can interbreed and produce offspring of the opposite type. While Steelhead Trout in the Yakima Basin (mid-Columbia Distinct Population Segment) are currently listed as threatened under the Endangered Species Act (ESA), the resident form, Rainbow Trout, currently provide one of the best wild trout fisheries in Washington State. The flexibility in life history expression is thought to provide significant resiliency in unstable environments, although it substantially complicates our ability to manage them and further complicates the recovery of the anadromous form which is mandated under the ESA in the Yakima Basin. In this paper, we present the preliminary results from a large scale PIT tagging study we initiated to improve our understanding of the abundance, productivity, spatial structure, and diversity metrics associated with an *O. mykiss* population comprised of both resident and anadromous life histories.

The importance of the Tui Chub forage base and declining lake levels on the growth and carrying capacity of Lahontan Cutthroat Trout in Pyramid Lake, Nevada

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Pyramid Lake, Nevada is one of the last remaining strongholds for lacustrine Lahontan Cutthroat Trout (LCT) *Oncorhynchus clarkii henshawi*; almost all other large lake populations have undergone population declines or extirpation due to invasive species interactions and habitat degradation. Despite the potential for predator-prey decoupling due to stocking, LCT remain apex predators attaining record sizes and exhibiting extremely high rates of piscivory, primarily on Tui Chub Gila bicolor. Based on bioenergetics modeling simulations bolstered by a retrospective cohort analysis, we estimated LCT consumed between 60 – 76% of Tui Chub production annually, suggesting LCT are currently not limited by food in Pyramid Lake and

have not met or exceeded carrying capacity. However, although Tui Chub abundance has been highly variable over time, the catch per unit effort of Tui Chub appears to be demonstrating a steep and significant decreasing trend since the mid-1980s. Further, lake elevation has also been steadily declining over the past 15 years, with likely effects on abiotic and biotic factors (including area of littoral habitat) that may control Tui Chub abundance. Concentrations of total dissolved solids (TDS) directly linked to lake elevation may play a role in regulating zooplankton and Tui Chub abundance and could become an important predictor of Tui Chub abundance if lake levels continue to decline. These results have important implications for the continued success of this valuable and prospering native sport fishery and the recovery of an important population of LCT; declining lake levels may have significant indirect effects on LCT in the future, manifested through a declining forage base.

Discovery of a Fluvial Population of Bonneville Cutthroat Trout in the Highly Fragmented Weber River

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The presence of large Bonneville Cutthroat Trout *Oncorhynchus clarkii utah* in the lower Weber River prompted the Utah Division of Wildlife Resources (UDWR), Utah State University, and Trout Unlimited to complete a study to characterize the life-history of this population. Between 2011 and 2016, over 2,200 Bonneville Cutthroat Trout were marked with Passive Integrated Transponder (PIT) tags and 5-9 Passive Instream Arrays (PIA) were placed into 4-8 tributary streams each year. Bonneville Cutthroat Trout have moved into each of the tributary streams and have traveled up to 27 km to spawn in a given year. These data verify that a fluvial population remains in the lower Weber River. Six mainstem and 10 tributary barriers to fish movement have been identified; however, PIT-tag recapture and PIA data indicate that some of these barriers are more permeable than originally believed during some flow regimes or depending on how some in-stream structures are operated. For example, 29 fluvial Bonneville Cutthroat Trout have been documented to move upstream past a major Weber River mainstem structure during times of the year when operation favored fish passage. To date, one mainstem and three tributary structures have been modified to allow fish passage and other barriers targeted for fish passage are being prioritized using data from this study.

Tributary reconnection and restoration increases recruitment of wild Cutthroat Trout in Bear Lake (Idaho, Utah)

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Bear Lake is an oligotrophic lake located in Southeast Idaho and Northeastern Utah in the Bear River Watershed. Up to seven tributary streams provided spawning habitat for native, adfluvial Bonneville Cutthroat Trout (BVCT). Irrigation diversions and other fish passage barriers, along with irrigation water withdrawal greatly limited BVCT access to these tributaries. In 1973, the Utah Division of Wildlife Resource began a hatchery propagation program to increase BVCT numbers and enhance the lake's sport fishery. Hatchery production was successful and nearly 90 percent of BVCT caught in annual gill-netting surveys in the lake were hatchery origin during the late 1990's. Beginning in the early 2000s, numerous efforts were begun to improve survival of Cutthroat Trout produced in Bear Lake's tributary streams. The most significant

habitat work included removing a fish migration barrier on Fish Haven Creek and the installation of fish screens on 15 irrigation diversions. As a result, there has been a steady increase in the wild-produced BVCT, with nearly two-thirds of all gill-netted fish in the lake being wild in 2014-2017. Also during the last seven years annual hatchery stocking of yearling BVCT was decreased from 270,000 to 170,000. Despite the reduction in hatchery stocking, the overall gill-net catch rate has remained the same or increased. Since 2015, over 80% of the adult BVCT returning to the Swan Creek fish trap were of natural origin. Anglers are also reporting catching primarily wild BVCT (i.e., no fin clip) in the lake fishery. We conclude that the tributary projects are responsible for the recent population increases in BVCT. Additional research will be required to determine the magnitude of recruitment for individual tributaries and what steps could be taken to effectively optimize limited tributary stream flows to produce the greatest BVCT recruitment to Bear Lake.

Recovery of Fish Populations and Physical Channel Characteristics in Streams Impacted by Catastrophic Debris Flows

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Frasen, Brian. Shagpoke Consulting; Tarosky, Renata. Weyerhaeuser; Schill, Travis. Weyerhaeuser

In 2007, an extreme magnitude storm event impacted southwest Washington. The heaviest recorded rainfall associated with the storm fell within the upper Chehalis River basin, resulting in an estimated 500-year flood event. As a result of the storm many streams in the area experienced record high flows, as well as channelized landslides that developed into catastrophic debris flows. Coincidently, the area of the most intense storm impact occurred where comprehensive data on stream habitat and fish populations had been collected by Weyerhaeuser Company since the mid-1970s. This forty years of previous aquatic research and survey work provided the opportunity to assess the impact of the storm on fish distribution and habitat conditions, and to monitor post-storm recovery. The re-colonization of fish populations and recovery of habitat conditions in streams impacted by catastrophic debris flows is currently being monitored in over 29 kilometers of stream channel within 19 individual sub-basins using spatially continuous, single-pass electrofishing, and physical stream habitat surveys. As of 2017, fish have recolonized habitats up to or beyond the upper extent of their pre-storm distribution in 12 of the 19 sub-basins. This study is ongoing, but preliminary results indicate fine-scale physical habitat characteristics including stream gradient, size, and the presence of natural blockages significantly influence the rate and extent of fish re-colonization in these systems.

Temporal Variability in the Upper Extent of Fish Distributions in Southwest Washington

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Tarosky, Renata. Weyerhaeuser*; Fransen, Brian. Shagpoke Consulting; Schill, Travis. Weyerhaeuser

Washington forest practice rules require different protective measures on fish (Type-F) streams than non-fish (Type-N) streams during the application of forest management activities. Weyerhaeuser utilizes Protocol Electrofishing Surveys as a tool to assess the upstream extent of fish distribution and to identify water type breaks separating fish and non-fish streams. To address the potential for temporal variability in fish distribution, these surveys incorporate the extent of “habitat likely to be used by fish”, when delineating the water type break. This determination of ‘potential fish habitat’ can be done more accurately with a better understanding of the temporal variability that exists in the location of the uppermost fish. From sites

where Weyerhaeuser conducted Protocol Electrofishing Surveys in 2015 (n=490), 69 streams were resurveyed in 2016 and 2017 to assess temporal variability in the upstream extent of fish distribution. Where the location of the uppermost detected fish changed relative to the original survey, we measured the distance to the previous last fish point and recorded stream habitat characteristics associated with the new uppermost fish point. This study is ongoing, but preliminary results indicate minimal temporal variability in the upstream extent of fish distribution. For instance, results from the 69 streams resurveyed in 2016 show no change in the location of the uppermost fish in 33 of the 35 streams with a 'lateral' F/N break, and in 12 of the 34 streams with a 'terminal' F/N break. While temporal variability in the location of the uppermost fish was more common in 'terminal' than 'lateral' sites, changes in the location of the uppermost fish were within 100 feet of the original point in 70% of cases. Where variability did exist, movement was almost always incorporated into the extent of habitat likely to be used by fish identified in the original protocol survey.

Optimizing Ladder Operations for Bull Trout and other Fishes - An Upstream Fish Passage Facility at Thompson Falls Dam located on the Lower Clark Fork River in Northwestern Montana

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Nearly a century after the construction of Thompson Falls Dam on the lower Clark Fork River in northwestern Montana, an upstream fish passage facility (fish ladder) designed for Bull Trout was constructed in 2010. NorthWestern Energy operates the ladder annually between March and October. Since 2011, over 30,500 fish were passed upstream representing 14 species and 3 hybrids. Over 79% percent of the fish released upstream represent native species and about 20% represent non-native game fish. Fish are recorded at the ladder throughout the operational season, however most fish recorded at the ladder ascend during the declining limb of the hydrograph (June or July) as stream temperatures are warming (but less than 23 ºC). Although fish have been recorded at the ladder at 79,700 cfs, fish presence at the ladder declines substantially when flows exceed 43,000 cfs. The fish ladder was built to allow for two alternative modes of passage between ladder pools, weir mode or orifice mode. NorthWestern evaluated the effectiveness of ladder operations through the manipulation of weir mode (notch versus orifice) to optimize passage for Bull Trout, other native fish, native and non-native game-fish species. When comparing weir modes, the data show: 1) Bull Trout can ascend the ladder in orifice (n=15) and notch (n=1), but the optimal mode is unknown due to the low sample size (16 fish); 2) significantly more native fish and significantly more non-salmonids ascend the ladder in orifice than notch; and 3) salmonids ascend the ladder faster in notch (median=1.3 hours) compared to orifice (median=2.0 hours) but a lower percentage entering the ladder reach the top in notch (51%) compared to orifice (68%). Overall, more fish appear to prefer and successfully ascend the ladder in orifice versus notch mode.

Identifying Invasive Lake Trout Spawning Locations in Yellowstone Lake to Improve Suppression Efficacy.

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Suppression of Lake Trout in Yellowstone Lake is a high priority for Yellowstone National Park. Suppression efforts have removed approximately 2.7 million Lake Trout since 1995, primarily by gillnetting. Targeting known spawning locations increases the efficiency of adult Lake Trout suppression during the spawning season. Historically, it was assumed that Lake Trout spawned at three locations, but recently nine additional spawning sites have been confirmed. The discovery of additional spawning areas demonstrated the lack of our understanding regarding Lake Trout spawning locations. Insight into the spawning habits of Lake Trout will be useful for suppression efforts. The objectives of the study were: 1) identify Lake Trout spawning locations, 2) describe differences in seasonal aggregations of Lake Trout, and 3) evaluate the efficacy of targeting tagged Lake Trout to increase catch rates. Lake Trout (N = 469) were surgically implanted with acoustic transmitters from 2015 through 2017. Tracking resulted in 1,995 detections of 254 individual Lake Trout in 2016 and 2,685 detections of 379 individuals in 2017. Kernel density estimation was used to analyze Lake Trout Locations. Analysis identified an additional twelve putative Lake Trout spawning areas throughout Yellowstone Lake with the highest concentrations of Lake Trout in the West Thumb.

Evolving Methods for Specifying Anadromous Waters in Alaska

Building Digital River Networks to Improve Detection of Salmon Habitats across Alaska

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Recent availability of high resolution digital elevation models across Alaska (IfSAR 5m and LiDAR 1m), in conjunction with numerical algorithms to extract digital river networks from them, is heralding a new era for mapping the distribution and quality of salmon habitats across Alaska, including for Coho Salmon, Chinook Salmon, Pink Salmon, Chum Salmon, and Sockeye Salmon. The NetMap system merges disparate elevation data sources into contiguous digital elevation models (DEMs) with minimal artifacts, calibrates channel initiation criteria to local conditions, obtains optimal flow paths that preserve all topographic information when creating hydrologically conditioned DEMs, breaches road crossings, delineates floodplains and channel confinement, utilizes open-water break-lines derived from IfSAR and LiDAR orthorectified intensity imagery to guide flow paths through areas where topographic relief can't resolve channel courses, and smooths DEM-derived channel courses to improve estimates of channel length and gradient. Target geographic areas in the last five years include Copper River basin, Southeast Alaska, Matanuska-Susitna basin, Chena River, all U.S. Yukon tributaries, Kuskokwim River, eastern Kenai Peninsula and several Arctic watersheds. Partners include Ecotrust, U.S. Forest Service (Tongass and Chugach National Forests), The Nature Conservancy, University of Alaska, U.S. Geological Survey and NRCS. In the Mat-Su basin our synthetic network increased the NHD stream length by 32,000 miles (125% increase); potential salmon habitats increased by 350% to 1,000% over the Anadromous Waters Catalog. In the Copper River watershed, mapped Chinook Salmon habitat increased 400% over the AWC. The new synthetic river networks in the Mat-Su watershed and southeast Alaska are being used to update the NHD. The attributed synthetic river networks are linked to terrestrial landscapes creating NetMap's virtual watersheds to support other applications related to fishery management, including new fish models, climate change impacts, forestry and wildfire management, and restoration. Numerical methods are implemented in a set of Fortran programs licensed under the GNU Open-Source General Public License v3.

Quantifying habitat use of anadromous fish using space-time isotope models

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Migratory animals, such as anadromous fishes, pose difficult challenges to conservation and management because it is rarely possible to identify critical habitats over the course of their lives. Endogenous tracers, e.g., isotope ratios, stored in the otoliths of fish, however, represent a powerful tool to reconstruct habitat use patterns through time. A general probabilistic framework has emerged that compares predictive models of isotopic variation across landscapes (isoscapes) to the isotopic composition recorded in a biogenic tissue of an animal to generate probability density functions of habitat use across a spatial domain. To date, this approach has been applied to analyses that reflect habitat use during a 'snapshot' in time of an animal's life. Because the otolith grows over the course of a fish's life, however, the otolith represents a serial record of isotope information which can be used to quantify habitat use through time. Here, we develop and demonstrate how 'space-time isotope models', which use multiple types of information in addition to isotopic variation, including habitat geomorphology and directional movement patterns of juvenile salmon, can quantify habitat use of juvenile salmon during freshwater residence. We applied these models to a published dataset of 87Sr/86Sr otolith profiles of adult Chinook Salmon harvested in Nushagak Bay during a coastal fishery in Bristol Bay, Alaska. We show how individual and populations of juvenile Chinook Salmon and Sockeye Salmon (i) utilize an array of habitat types to achieve the total growth needed before ocean migration, and (ii) that 'hotspots' in habitat use change over the course of freshwater residence. By synthesizing diverse types of information, space-time isotope models quantified the habitat use of Chinook Salmon and Sockeye Salmon at spatial and temporal scales typically not accessible using traditional ecological methods - yielding unique insights for their effective conservation.

Production from diverse stock groups within the large and complex Sockeye Salmon run to the Kvichak River

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The Kvichak River supports the largest run of Sockeye Salmon *Oncorhynchus nerka* on Earth. Kvichak Sockeye Salmon are most widely known for their large contribution to the Bristol Bay commercial salmon fishery but are also vitally important to the region’s ecosystem and subsistence fisheries. Interestingly, the Kvichak is the only run in Bristol Bay to have exhibited strong cyclic production among year classes for most of the 125-year history of the commercial fishery, producing peak annual returns of up to 48 million fish. After a decade of very low productivity that began in the mid-1990s, the Kvichak again supports a viable fishery but the cycle has disappeared – perplexing scientists, fishery managers, and industry. We used DNA as a natural tag to quantify smolt production of four groups of populations of Sockeye Salmon from the Kvichak River in 2012-2016. Analyses relied on a baseline of 22 populations and 96 genetic markers. Smolt were sampled in proportion to daily and annual abundance estimates obtained from sonar arrays in the Kvichak River near the outlet of Lake Iliamna. Relative production among the four stock groups varied in the five years, but Northeast Iliamna consistently produced the majority of smolts (48%; 32-57%). The Iliamna Island beaches group, believed to have played an important role in the historic cyclic production, contributed the least across the five smolt runs (8%; 4-14%). A sister project will estimate adult returns of the same groups of populations to evaluate survival and productivity of brood years 2012–2015 at smolt and returning adult life stages. Combined, these results will guide management policies for this important and complex salmon run.

Documenting habitat for anadromous species: Exploring affordable methods for protecting Alaska's salmon streams

O'Neal, Sarah L.

Young, Daniel B.; Ostberg, Carl O.; Hoy, Marshall S.; Simmons, Leonard (Trey); Menning, Damian M.; Hughes, Robert M.

In Alaska, anadromous fish must be explicitly documented and nominated to the Alaska Department of Fish & Game's (ADF&G) Anadromous Waters Catalog (AWC) for fish conservation statutes and regulations to apply. However, ADF&G estimates that less than half of the state's streams have been surveyed. Because most streams are remote, AWC surveys are time consuming and costly. Consequently, we are evaluating alternative methods of documenting fish distribution in remote Bristol Bay watersheds. We are conducting presence/absence surveys in and near Bristol Bay mining claims in the Chulitna, Newhalen, and Koktuli River basins using electrofishing and two methods of environmental DNA (eDNA) collection (barcoding for all teleost taxa, and quantitative polymerase chain reaction targeted for salmonids). Preliminary results indicate agreement between all three methods occurred in 31-71% of sites (n=24), depending on the species. Agreement was most common when species were absent using all methods. The two eDNA methods agreed in 58-79% of sites, depending on the species, and suggested that eDNA is capable of detecting more species than traditional electrofishing methods. We will present preliminary results describing the potential application of eDNA methodology for documenting fish distribution and expanding overall coverage of the AWC.

Metabarcoding of Alaskan freshwater fish communities using amplicon-based next-generation sequencing of environmental DNA: conducting fisheries surveys using water samples

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Menning, Damian. U.S. Geological Survey; Talbot, Sandra. U.S. Geological Survey

The cost of conducting traditional gear-based surveys for fish and other aquatic organisms can be prohibitive in large, remote Alaskan landscapes. This can severely limit our ability to obtain landscape-scale data on the composition of aquatic communities, including the distribution of anadromous fish species. To address this challenge, we have developed methods for the simultaneous detection of multiple fish species, using environmental DNA (eDNA) collected through on-site filtration of water samples. We use a two-step analysis procedure, consisting of an initial multiplex PCR amplification step conducted with multiple primer pairs, each targeting a specific region of the mitochondrial 12S, 16S or COX1 genes. Potential primer sequences were identified using a set of Python/Biopython scripts that optimize primer selection based on sequence data for all species of interest obtained from the Genbank sequence repository. The second step consists of next-generation sequencing of the pooled amplification products using an Illumina MiSeq system. The resulting DNA sequence data are analyzed with Python/Biopython scripts and customized reference sequence libraries to identify the species present in the original sample. We have tested this approach with eDNA samples obtained from a number of lakes and streams where traditional fish surveys have been conducted, providing field confirmation of the eDNA detections. In general, this method returns accurate detections of fish species compositions from these water bodies. The exceptions reflect inadequate sequence variation available in Genbank for some Alaskan fish species.

Strategies for identifying Alaska's anadromous fish habitat

Wiedmer, Michael

For 56 years, the Alaska Legislature has directed the Department of Fish and Game (ADF&G) to specify the fresh waters important to state's anadromous fishes. In response, ADF&G has produced The Atlas and Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes (Anadromous Waters Catalog; AWC). These twin documents are the key foundational references for fish habitat conservation in the state. They are specifically referenced by many local, state, and federal statutes, regulations, codes, and policies designed to conserve aquatic and riparian habitats important to anadromous fish. However, after more than a half century of effort, ADF&G reports that the AWC specifies <50% of Alaska's streams, rivers and lakes actually used by anadromous species. ADF&G estimates that ≥20,000 or more fresh water bodies remain to be added. By convention, ADF&G requires field observations of specific species and life stages before adding water bodies to the AWC. Given the vastness and remoteness of Alaska, these field observations require individually and collectively large expenditures of time and money. Strategies to update and manage the AWC, or alternative efforts, must explicitly recognize the spatial and biological scope of the task and the distribution patterns of the state's anadromous fish species and life stages.

Making Fish Habitat Great Again: Conservation of Habitats and Connected Stream Networks in the Midst of Resource Development and Urban Growth

The "Resurrection" of Resurrection Creek near Hope, Alaska

Bair, Brian

Marzullo, Corinne; Blanchet, Dave; MacFarlane, Bill; Lang, John

In 2005 and 2006 the U.S. Forest Service initiated a large-scale watershed restoration project on Resurrection Creek, near Hope, Alaska. Beginning at the turn of the past century, placer mining operations had adversely affected stream function and fish habitat. Prior to restoration, the channel was deeply entrenched creating poor fish habitat, had little sinuosity or large woody debris, few pools and side channels, and was artificially straightened and confined limiting its interaction with the riparian and flood plain areas. To design the new channel, a previously undisturbed reach upstream of the recovery area was surveyed and used as a template. Using heavy construction equipment, the U. S. Forest Service constructed a new stream channel corridor that approximated the reference reach morphology. The results were an increase in the overall channel length from 1097 m to 1392 m, channel sinuosity from 1.1 to 1.3, average slope from 1.7% to 1.4%, the amount of pool habitat from 1% to 17%, run type habitat from 0% to 26%, and riffle area from 99% to 57%. The results in fish use were seen immediately with large increases in adult Chinook Salmon *Oncorhynchus tshawytscha*, adult Pink Salmon *O. gorbuscha*, Chum Salmon *O. keta*, and Coho Salmon *O. kisutch*. From 2005 to 2018, fish use and spawner abundance has continued on increasing trends.

Using BLM's National Aquatic Monitoring Framework to collect scalable data to address current and future management challenges

Brady, Colin

Varner, Matthew; Post, Jason; Miller, Scott; Cappuccio, Nicole

The Bureau of Land Management (BLM) manages over 118,000 miles of perennial stream and lotic riparian habitat, as well as almost 3 million acres of lakes throughout the State of Alaska. Overall, Alaska aquatic systems make-up more than 87% of the Bureau's riverine resources. The large majority of BLM Alaska's aquatic resources are believed to exist in a relatively unaltered state; however, little monitoring data is available to objectively characterize current conditions or to detect change in response to development or shifting climatic and meteorological conditions. Section 201 of the Federal Land Policy and Management Act of 1976 (FLPMA) requires the BLM to prepare and maintain a current inventory of public land resources. The need for knowing the condition and trend of aquatic systems is underscored by increased resource uses (e.g., mining, energy development, and recreation) and landscape level change. In order to quantitatively monitor and assess the condition of aquatic systems on BLM-administered public lands, the AIM NAMF was developed. The AIM-NAMF strategy seeks to integrate both local- and regional-scale monitoring activities to inform condition assessments by establishing core indicators, standardizing field methodologies, using statistically valid sample designs, and developing electronic data capture and storage technologies. This information serves as the foundation for decision-making and is critical to achieving the Bureau's multiple use mission of "sustaining the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations."

Making Waves: the effects of whitewater parks on fish passage

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With more whitewater parks (WWPs) than any other state, Colorado has become the epicenter for WWP development in the United States. While WWPs have recreational and economic benefits for boaters and local communities, their impact on fisheries and aquatic ecology remains poorly understood. Previous research has shown that the increased water velocity and decreased depth necessary to create a recreational play wave can impair upstream passage. This study evaluates impacts of WWP construction on fish passage for Brown Trout *Salmo trutta*, Mottled Sculpin *Cottus bairdii*, and White Sucker *Catostomus commersonii* at the Gore Canyon WWP on the upper Colorado River and the Montrose WWP on the Uncompahgre River. Baseline channel morphology at each WWP site was surveyed in 2014 prior to construction. Post-construction surveys were conducted in 2015, with additional surveys in 2016 and 2017 to increase the density of survey points at WWP structures. Topographic data were collected using survey grade GPS and an Acoustic Doppler Current Profiler. Survey data were used to develop two-dimensional hydraulic models with River2D to evaluate changes in depth and velocity at the WWP structures between pre- and post-project conditions. Results from hydraulic modeling were compared to species-specific criteria for minimum depth and burst swimming velocity to evaluate fish passage across a range of flows. Results from this study can be used to develop design guidelines for WWPs that optimize both recreational and ecological benefits.

Stream restoration on Medicine Lodge Creek, Wyoming

Burckhardt, Laura. Wyoming Game and Fish Department

Medicine Lodge Creek, located in northcentral Wyoming, has high fisheries, wildlife and cultural resource significance in Wyoming. A section of Medicine Lodge Creek, located on Wyoming Game and Fish Commission owned property and within

the Medicine Lodge State Park, has experienced significant anthropogenic channel instabilities for at least 40 years. This section the stream channel and floodplain are laterally and horizontally confined by one bridge, by road and trail development, and development and maintenance of two irrigation diversion dams. In the 1970s, the Wyoming Game and Fish Department documented that the majority of the stream habitat damage had been caused by instream bulldozer work at the two irrigation diversions. The WGFD repaired the channel degradation across 0.8 miles of stream using natural channel design. This stream restoration project reduced bank erosion by approximately 2,300 tons of sediment per year, eliminating non-point source sediment pollution from entering Medicine Lodge Creek. In addition, year-round fish passage was restored, and a stable stream channel was constructed which allows for sediment transport, floodplain connectivity and fisheries habitat. During this presentation, the impairments of the stream, the goals, and the restoration approach will be discussed. The necessary planning, stakeholder coordination, and permitting required to construct a restoration project while protecting a culturally sensitive archeological site, State Park aesthetics, sage-grouse core area, and instream flow and irrigation water rights, will be discussed.

Mapping and Measuring the Historical Mining Footprint as it relates to Fish Habitat across Alaska and Northwest Canada

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The Alaska Center for Conservation Science at the University of Alaska Anchorage, in partnership with the Northwest Boreal Landscape Conservation Cooperative, embarked on a project to map the historic mining footprint across interior Alaska and northwestern Canada. The goal was to build a seamless dataset that spanned international boundaries by stitching information from state, provincial and territorial entities in order to represent landscape intactness in the boreal ecosystem. Commonly, mines have been depicted by point locations which do not convey their relative sizes; or mining activity is represented by claims polygons which overestimate their actual footprints and have a recency bias. Using 2.5 meter ortho-imagery and 5 meter digital elevation data, ACCS digitized visible surface disturbance related to historic and current mining. Nearly 2000 source point locations were evaluated from the US Geologic Survey, British Columbia Ministry of Energy and Mines, and the Yukon Department of Energy, Mines, and Resources. The mining footprint dataset includes over 650 digitized polygons totaling 1200 square kilometers with a mean size of 1.8 sq. kms. The footprints have been summarized at the watershed (USGS HUC10 – mean area 688 sq. kms) scale across Alaska and at a more coarse scale, sub-sub drainage unit (mean area 16,000 sq. kms) within Canada. Overlaying these data with the Anadromous Waters Catalog (AWC) and the National Hydrographic Dataset (NHD) has yielded some initial results of cumulative, historic impacts at a watershed scale and applicable to known and potential fish habitat. This dataset could help: inform decisions regarding natural resource monitoring, identifying potential mitigation/restoration sites, and for conservation planning at watershed scales.

Hydropower and High Productivity in the Hanford Reach: A synthesis of how flow management may benefit fall Chinook Salmon in the Columbia River

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The fall Chinook Salmon population that spawns in the Hanford Reach of the Columbia River (WA) is paradoxical because it is located above four and below ten mainstem Columbia River dams and yet is one of the largest and most productive Chinook Salmon populations in the Pacific Northwest. A synthesis of hydrological and biological data suggests that the current hydrology in the Hanford Reach, which is shaped by both power generation and an environmental flow program, has contributed to a highly productive Chinook Salmon population. The Hanford Reach flow protection program, which began in 1984, is adaptable to environmental cues and fish behavior and relies on annual field monitoring. Each year the flow regime is tailored to observed spawning behavior and redd site selection and flow protection targets adapt throughout the year based on embryo development. Productivity analysis suggest that the flow program has increased egg-to-presmolt survival from 33.1% to 56.8%. Using the Hanford Reach as a case study, we examine how environmental flows designed to mitigate the impacts of hydropower at each life-stage have benefited the Chinook Salmon in this reach. Plausible mechanisms for contributing to high productivity include: (1) more wetted area available during the spawning period, (2) reduced desiccation and scour of redds, and (3) improved flow exchange within redds. The current hydrograph in the Hanford Reach is the result of balancing trade-offs between power generation and fish production. The Hanford Reach flow program provide a positive example of adaptive management and directed flow management for the purposes of avoiding harm to valued biota and the real-time adaptive approach could be applied more broadly to improve societal benefits.

Geomorphic analysis for river restoration design of salmon habitat in dredge-mined rivers

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The John Day River Watershed is the second longest free-flowing river in the continental United States and its spring Chinook Salmon and summer Steelhead population are two of the last remaining intact wild populations of anadromous fish in the Columbia River Basin. The Granite Creek, Oregon, project area has been impacted by land management activities since the mid- to late-1800s when prospectors arrived in the region to mine for gold and silver, trap for furs, and harvest timber. Commercial mining activities began in the late-1800s, and placer mining was extensive throughout the watershed through the 1940s. Placer mining consisted of dredging most of the floodplain and channel by digging and sorting the alluvial material. Developing restoration concepts based on analog or historical information is problematic because of the long history of development, mining, logging and agricultural land use practices in the watersheds and valleys of the region. We applied an analysis of geomorphic characteristics and sediment transport processes to river restoration designs for approximately 1.6 km of Granite Creek. The expected planform pattern that should exist for the project reach was estimated using several methods based on discharge, slope, width, depth, Froude number, bed material size, and unit stream power. The channel geometry and longitudinal profiles in the restored channel were subsequently designed based on estimates of sediment transport capacity in the existing channel, with the intent to encourage bed material storage, channel complexity, and secondary channel formation within the restored channel. The restored channel has a reduced slope, significant increase in secondary channel length, and increased spatial density of large wood material. These restoration designs will lead to a 10-fold increase in juvenile rearing habitat and a 5-fold increase in spawning habitat. The geomorphic approach to sustainable river restoration design is particularly effective in dredge-mined rivers.

Assessing Fish Passage Success in Culvert Structures with a Two-dimensional Algorithm Considering Physical Capabilities of Juvenile Salmonids

Jefferies, Alexandra E. W.*

Fish passage through culvert structures requires suitable physical conditions for fish. Current practice consists of “stream simulation” design where the stream is replicated throughout the crossing structure; however, space and/or budget constraints do not always allow this practice and require the designer to model hydraulics against fish swimming abilities to assess for barriers. Current models (such as FishXing) are one-dimensional and can be overly conservative. Field data (including hydrology and fish passage PIT tagging data) was collected by the Alaska Department of Fish & Game (ADF&G) over several years on Buddy Creek near Talkeetna, Alaska, and used to develop and test a two-dimensional model. This model was compared with actual passage data from the ADF&G PIT tagging study and with a one-dimensional FishXing model. Both 1D and 2D models resulted in approximately 55% congruency with the actual passage results. Based on similar results, FishXing appears to fairly accurately take into account occupied velocity of the juvenile fish when using proper velocity reduction factors; although, velocity reduction factor selection appeared fairly ambiguous. The results of the study suggests that both FishXing and the 2D algorithm are fairly conservative and appear to be limited by the studied fish swimming abilities, especially for juvenile Chinook Salmon and Coho Salmon.

Yes We Can! Collaborative Efforts to Improve Fish Passage in Southcentral Alaska

Marie, Megan E. Alaska Department of Fish & Game*

Alaska’s fish habitat protection statutes have existed since statehood and reflect the longstanding ideal that fishery resources and habitats are important for our quality of life. Current practices for implementation and enforcement of fish passage laws ensures that new culverts installed in fish-bearing waterways provide for unimpeded access to upstream habitat for all species and life stages of fish. However, there are many areas of the state where we are playing catchup from older development practices and hastily built military infrastructure. This talk will highlight collaborative efforts in the Copper River Watershed, Kodiak Island, and other areas of Southcentral Alaska where we have successfully leveraged resources from state, federal, and local agencies, NGOs, and members of the public to seek out funding and implement fish passage improvement projects. Current and future projects highlighted will result in restored and expanded access to over 30 miles of upstream habitat for anadromous and resident fish species. Lessons learned during project development, design, and construction will be addressed in addition to considerations for monitoring the effectiveness of fish passage projects.

Fish Passage Improvements post replacement of a partial barrier culvert, Buddy Creek, Alaska.

O'Doherty, Gillian M. Alaska Department of Fish and Game.

Historically culverts were placed in streams with little or no consideration for effects on the stream channel or for aquatic organisms. Perched culvert outlets, excessive water velocities, constricted stream channels, debris plugged culverts or culverts with inadequate water depth often impact fish passage by delaying or impeding fish movements. Over the past 20 years the assessment, prioritization and replacement of culverts has taken place all over the Western US. The benefit of replacing culverts that are total barriers to fish passage is clear but the benefits of replacing partial barriers or barriers to some life stages or species is less well understood. This study examined the effect of the replacement of a partial barrier culvert on the movements of juvenile Coho Salmon and Chinook Salmon in Montana Creek, Alaska over a four year period. The existing structure was a battery of three culverts that was hydraulically undersized, damaged, prone to plugging with debris and fairly typical of the culverts found during ADF&G assessment work in Alaska. PIT tagging was used to directly

monitor juvenile fish movement through the structure during the open water period before and after replacement with a stream simulation type structure. This talk presents the results of that work and discusses the improvements in fish passage observed at the site.

Fish, Floods, and More Fish, a 20 Year Perspective on Fish Passage at Road-Stream Crossings in South Central Alaska

Rice, William J. U.S. Fish & Wildlife Service

Over the past 20 years, fish passage at road crossings has moved from being an obscure side note for consideration by the engineer to one of the primary considerations when replacing or installing a culvert or bridge, not only in South Central Alaska but across the State. This talk discusses the “fish passage renaissance” and its impact on removal of fish barriers across the landscape from a policy, funding and construction aspect. The rise and effectiveness of local policies is discussed and why they were implemented, how various funding mechanisms moved to maximize removal of barriers and what technologies and natural events came about that enabled such success. Available monitoring of various projects over the years is also summarized to highlight the effectiveness of these barrier removals. Lastly, perspectives of various designs that have been installed are discussed, both ones that worked and others that did not, showcasing tips and traps practitioners have found working in the Alaskan landscape over the years. Overall, barrier removal for fish passage has been one of the largest public success stories in the State.

Stream Restoration: Comparing Alaska with the Rest of the West…What Have we Learned and Where Do We Go from Here?

Rice, William J. U.S. Fish & Wildlife Service

Over the last 20 years, restoration efforts across the country have resulted in a toolbox of methods for stream restoration and improving fish passage at road-stream crossings. In Alaska, some of these techniques were developed here while others came from areas of the West. Through a series of project-based experiences over the past 15 years, this talk highlights key restoration solutions across Alaska’s diverse landscape and comparisons to similar projects in Western environments. Successful and not-so-successful design approaches and revegetation techniques in diverse environments are highlighted. Remaining challenges in Alaska are discussed, particularly as they relate to availability of data and restoration in wetland and arctic conditions.

Identifying a moving target: estimating the rate of change in stream habitats at sites with little land-use pressure

Saunders, W. Carl

Archer, Eric; Ojala, Jeff; Van Wagenen, Andrew; Al-Chokhachy, Robert; Roper, Brett; Kershner, Jeff

A major goal of long-term monitoring programs of streams and riparian areas on public lands is to evaluate the current condition of streams subject to land use practices and to evaluate whether habitat conditions are being maintained or

improving through time. However, riparian ecosystems, and the streams that traverse them, are constantly in flux. Data on sites subject to minimal levels of land-use impacts provide needed data to interpret current habitat conditions as well as to describe natural rates of change expected owing to large-scale drivers such as climate variability and natural disturbances such as wildfire. We used PACFISH/INFISH Biological Opinion (PIBO) Effectiveness Monitoring Data to estimate the rate at which change occurred at the 254 minimally managed sites during 2001-2017 for 7 key metrics of steam condition using generalized linear mixed effects models. On average, at minimally managed sites, large wood was accumulated at a rate of 4.2 pieces per kilometer per year and pool frequency per kilometer increased at a rate of 0.25 pools per year. Additionally, the percentage of banks that were both stable and covered with vegetation increased by 0.65 percent per year. In contrast, fine sediments accumulated in pool tails, median particle size, residual pool depth, and bank angle did not show any significant change through time. Overall, these results suggest that natural process can drive changes in stream channels in the absence of anthropogenic disturbance. Given an understanding of stream channel characteristics that have naturally changed over the last two decades, managers can identify streams reaches that are failing to keep track with natural rates of change or fall below expected conditions.

Applying Natural Channel Design Techniques to Reclaim Placer Mined Streams in Alaska

Varner, Matthew S. Bureau of Land Management

Many approaches have been used to reclaim placer mined streams in Alaska. The most common approach involves basic recontouring and the construction of a “pilot” channel at the lowest elevation in the valley. Other techniques have involved recreating the pattern, profile, and dimensions of the stream based on reference reach surveys. These approaches have produced inconsistent results often leaving streams in an unstable state for decades after reclamation. Using Bureau of Land Management’s (BLM) Aquatic Assessment, Inventory, and Monitoring program, the BLM has been able to compare the recovery of reclaimed streams to regional reference conditions. These data indicate that reclaimed streams exhibit a moderate-major departure from reference condition across a variety of indicators and often for decades. To help improve stream reclamation success, the BLM has developed tools for stream design, such as regional hydraulic geometry curves, and applied Natural Channel Design techniques to several demonstration projects. Three stream reclamation projects were constructed in the Fortymile Wild and Scenic River watershed beginning in 2015. Unlike previous demonstration projects, the design and construction of these projects utilized Natural Channel Design (NCD) techniques with a focus on four key attributes of stream stability: floodplain connectivity, bedform diversity, lateral stability, and riparian vegetation. While these projects are continuing to be monitored, the results to date indicate rapid improvement in habitat conditions and a positive trend. The NCD approach to stream reclamation planning and construction shows a great deal of promise at rehabilitating fisheries habitat compared to traditional techniques in Alaska.

Aquatic Habitat Rehabilitation of Placer Mined Streams in Alaska: Past, Present and Future

Varner, Matthew S. Bureau of Land Management

Placer mining has been part of Alaska’s history for more than 100 years; however, efforts to rehabilitate aquatic and riparian habitats has only recently become an area of emphasis during the last 30 years. Heavily reliant upon natural recovery, contemporary reclamation approaches focus on re-establishing streams at the lowest elevation of recontoured valleys. Streams that are reclaimed using this type of approach can take several decades to stabilize and even longer periods to recover instream habitat heterogeneity to within the range of reference conditions. On federal lands in Alaska, mining has

been limited to less than 500 stream miles; however, the revocation of mineral withdrawals is increasingly likely and could expand mining to tens of thousands of stream miles. This potential increase in placer mining, as well as increasing oil and gas development onto federal lands, underscores the importance of successful stream reclamation. Over the last ten years, the BLM has been working to understand the causes of stream reclamation failures and what techniques can be used to increase the probability of success in the shortest possible timeframes. The BLM has developed datasets to enhance stream reclamation planning and established several demonstration projects using Natural Channel Design techniques. These projects have shown that severely degraded sites can be stabilized and rehabilitated to within the range of reference conditions using a deliberate design process and regional datasets. Future stream reclamation success will depend on agency and industry collaboration, the integration of science in reclamation planning, a commitment to effectiveness monitoring, and the acknowledgement that stream reclamation is not cheap.

An Evaluation of Variables Influencing the Rate of Cutthroat Trout Colonization and Abundance in Newly Accessible Habitats Upstream from Previously Blocking Road Crossings

Walter, Jason. Weyerhaeuser

Schill, Travis. Weyerhaeuser; Tarosky, Renata. Weyerhaeuser; Fransen, Brian. Shagpoke Consulting; Jongenberger, Frank

Weyerhaeuser ownership in Washington incorporates a significant amount of forested lands containing extensive road network systems. In accordance with Washington Forest Practices Road Maintenance and Abandonment Plan (RMAP), road crossings transecting fish bearing streams must meet certain criteria to allow fish passage. Coastal Cutthroat Trout are often the sole salmonid species utilizing headwater stream habitats which can be inaccessible due to anthropogenic blockages such as non-fish passable road crossings. The purpose of this study is to monitor and assess variables influencing Cutthroat Trout colonization and abundance upstream from previously blocking road crossings. 30 study sites were selected in streams with non-fish passable road crossings where (1) Cutthroat Trout presence was identified in the stream segment downstream from the blockage and (2) suitable fish habitat existed upstream from the blockage. Upon repairing or decommissioning road crossings at the selected sites, we monitored upstream fish colonization and abundance using spatially continuous, single pass electrofishing and physical stream habitat surveys. Preliminary results indicate fine-scale physical habitat characteristics including temporary blockages to fish passage, stream gradient, and stream size effect coastal Cutthroat Trout colonization both spatially and temporally.

Fishing for Solutions to Economically and Ecologically Important Salmonid Diseases

Quality vs. quantity: manipulating rearing density as a strategy for increasing survival of Rainbow Trout fry pre- and post-stocking

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Winkelman, Dana L. U.S. Geological Survey, Colorado Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife and Conservation Biology, Colorado State University; Fetherman, Eric R. Colorado Parks and Wildlife

Bacterial Coldwater Disease (BCWD), caused by the bacterium *Flavobacterium psychrophilum*, is one of the most significant salmonid pathogens in the world, causing substantial hatchery mortality. Antibiotics are commonly used for

treatment in hatcheries; however, the development of antibiotic resistance could reduce their effectiveness. Additionally, antibiotic treatment requires isolating and identifying BCWD prior to treatment, a costly and time-consuming process. Preventing infection would be desirable to post-hoc treatment and, although *F. psychrophilum* is ubiquitous in aquatic environments, wild populations are rarely affected, indicating that BCWD can be prevented. Potential management of BCWD in hatcheries would mimic natural environments thereby reducing stress. One management strategy is to raise fish at lower density, thereby reducing stress, increasing water quality, and making high quality diets a realistic option. The tradeoff to raising fish at lower density is reduced hatchery production; however, if lower rearing density increases post-stocking survival, then lower production may be offset by increased recruitment. We conducted a study to determine if hatchery rearing density and feed type affected Rainbow Trout post-stocking survival in a lake ecosystem. Rainbow Trout were raised for three months at two densities (1,400 fish/ft3 - 350 fish/ft3 and 350 fish/ft3 - 87.5 fish/ft3) and fed two commercially available feeds. Prior to stocking, we tagged fish with passive integrated transponder (PIT) tags. We stocked PIT tagged fish into Parvin Lake, Colorado and sampled the lake for tagged fish every two weeks for two months. Recapture data indicated that apparent survival of stocked fish was higher for fish raised at low density in the hatchery but was not affected by feed type. Higher post-stocking apparent survival of fish raised at low density in the hatchery could compensate for reduced hatchery production and rearing fish at lower densities could be a management alternative for mitigating stress and reducing losses occurring from BCWD.

Whirling disease resistant Rainbow Trout fry survival: A comparison of two strains

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Introduced pathogens can affect fish populations and three main factors affect disease occurrence: the environment, host, and pathogen. Manipulating at least one of these factors is necessary for controlling disease. *Myxobolus cerebralis*, the parasite responsible for salmonid whirling disease, became established in Colorado and caused significant declines in Rainbow Trout *Oncorhynchus mykiss* fisheries. Attempts to reintroduce Rainbow Trout have focused on manipulating host resistance. A resistant Rainbow Trout known as the GRxCRR was developed by crossing a whirling disease resistant Rainbow Trout known as the German Rainbow (GR) with the susceptible Colorado River Rainbow (CRR). The GRxCRR exhibits resistance similar to the GR and survival and reproduction was expected to be similar to the CRR. One disadvantage of stocking GRxCRR is that outcrossing and backcrossing could decrease resistance, and laboratory studies indicate that this may occur. A potential disadvantage of stocking pure GR is decreased survival due to domestication; however, this has not been extensively evaluated in wild streams. To compare fry survival between the strains, a field experiment was conducted in 1.6 km reaches of nine streams in Colorado. Each stream was stocked in August 2014 with 5,000 GRxCRR and 5,000 GR. Apparent survival was assessed in October 2014, April 2015 and August 2015. Two laboratory predation experiments were also conducted. The field experiment revealed that two-month apparent survival and growth rate was influenced by strain and average temperature. However, after 12 months there was no significant difference in apparent survival or growth rate between the GR and GRxCRR. Laboratory experiments revealed that Brown Trout Salmo trutta predation did not affect survival between the strains. Our results indicate that the GR may be a viable option for stocking in streams where *M. cerebralis* is enzootic.

Development and Optimization of a Bacterial Coldwater Disease Vaccine

Cain, Kenneth D. University of Idaho

Over that past decade, our group has developed and patented a live attenuated immersion vaccine that protects fish from bacterial Coldwater disease (CWD), caused by the gram negative pathogen *Flavobacterium psychrophilum*. This vaccine has been proven efficacious in fish as small as 0.5 g and it is currently being optimized for regulatory approval and commercialization. The vaccine consists of a live attenuated strain of *F. psychrophilum* (259-93-B.17) grown in iron limited media (referred to as B.17-ILM vaccine). This vaccine, when delivered by the immersion route has been shown to significantly protect Rainbow Trout for up to 24 weeks when challenged with the virulent wild-type strain of *F. psychrophilum*. A series of experiments have confirmed safety and efficacy of this vaccine. Studies have included dose determination, size at vaccination, booster vs no booster, and cross-protective efficacy of the B.17-ILM vaccine against multiple *F. psychrophilum* isolates from various genetic lineages and geographic regions. Such studies are especially important for resource based and commercial hatchery programs where substantial heterogeneity of *F. psychrophilum* has been documented. A recent trial involved nine diverse strains isolated from several fish species across the globe. All strains were found to be virulent and cause mortality in Rainbow Trout *Oncorhynchus mykiss*. To assess protection following vaccination, groups of trout fry were immersion vaccinated with the B.17 vaccine and then challenged at eight weeks post-immunization with each strain of *F. psychrophilum*. The B.17-ILM vaccine provided significant protection against all strains, with relative percent survival (RPS) values ranging from 51-72%. Results from these and many additional trials support the practical application of this live-attenuated vaccine under standard hatchery conditions, and suggest that it will be efficacious in multiple fish species that may be affected by widely diverse strains of F. *psychrophilum.*

Erythromycin injections for controlling bacterial kidney disease in Colorado hatcheries

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Neuschwanger, Brad. Colorado Parks and Wildlife; Davis, Tracy. Colorado Parks and Wildlife; Wells, Colby. Colorado Parks and Wildlife; Kraft, April. Colorado Parks and Wildlife

Bacterial Kidney Disease (BKD), caused by the bacterium *Renibacterium salmoninarum*, is a potentially serious disease of salmonids. *R. salmoninarum* is unique in that it is a gram positive intracellular parasite that can be both horizontally and vertically transmitted. As such, it can be difficult to prevent vertical transmission within hatchery broodstocks using traditional egg disinfection techniques. A regulated pathogen in Colorado, detection of *R. salmoninarum* restricts movement of infected fish and production from wild and hatchery broodstocks. In 2015, detection of *R. salmoninarum* at the CPW Glenwood Springs Hatchery resulted in depopulation, and losses of thousands of pounds of production fish and important Cutthroat Trout and whirling disease resistant Rainbow Trout broodstocks. Detections at additional CPW broodstock facilities in 2016 resulted in a necessary change in spawning operations, specifically lethal spawns coupled with maintaining individual groups of progeny until they could be confirmed negative for BKD, at the infected facilities to prevent further losses of important broodstocks. In 2017, Erythromycin injections were tested as a potential form of treatment in a broodstock of whirling disease resistant Rainbow Trout. Intramuscular injection with Erythromycin occurred three times in 150 trout, with a minimum of 21 days between injections. The remainder of the broodstock maintained as non-injected controls. Lethal spawn allowed detection of R. salmoninarum in spawned adults, and offspring were maintained separately until infection status could be tested after swim-up. No injected adults tested positive, whereas 14 control adults tested

positive for *R. salmoninarum*. However, progeny from two families of injected fish and three families of control fish tested positive for the bacterium. Results suggest that Erythromycin injections did not prevent vertical transmission of *R. salmoninarum*, and potentially masked the presence of *R. salmoninarum* in spawned adults.

Whirling disease resistant Rainbow Trout fry stocking in the upper Colorado River

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Whirling disease *Myxobolus cerebralis* was introduced to Colorado in the late-1980s. By the early 1990s, population level effects of the disease were evident, and statewide Rainbow Trout population declines occurred in rivers to which the disease had been introduced. In some cases, up to 98% of the population was lost to the disease. Recruitment from the fry to adult life stages was low to non-existent, causing further declines. A strain of *M. cerebralis* resistant Rainbow Trout from Germany, known as the Hofer, was crossed with the wild Colorado River Rainbow Trout, creating a cross known as the H×C which was expected to exhibit both resistance to M. cerebralis and the wild characteristics needed for survival in Colorado's rivers. The H×C was stocked as subcatchable-sized fish in the upper Colorado River between 2006 and 2010. Larger fish were expected to exhibit increased post-stocking survival because they were larger than the gape limitations of Brown Trout predators and because they were less susceptible to infection by M. cerebralis. However, survival of these fish was low (0.007 over seven years), and the adult Rainbow Trout population continued to decline. Changing tactics, H×C began being introduced as fry in 2013 to reduce the amount of time fish spent in the hatchery prior to stocking and potentially negative effects of a history of domestication from the Hofer strain. Since fry introductions began, the adult Rainbow Trout population has increased exponentially, from 3 fish per mile in 2013 to 165 fish per mile in 2017. Myxospore counts have also decreased in the Colorado River over time, presumably a result of the increased number of resistant Rainbow Trout throughout the system. Stocking fish as fry appears to be a viable management option when stocking fish with a history of domestication.

Proliferative Kidney Disease in West

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An outbreak of proliferative kidney disease (PKD) in the Yellowstone River, Montana in 2016 resulted in a large kill of Mountain Whitefish *Prosopium williamsoni*, a multi-week closure of 180 river miles to all recreation, and lost business revenue. While the causative agent of PKD – the myxozoan parasite *Tetracapsuloides bryosalmonae* – had been reported in remote areas of Montana previously, little is known about this parasite in the West. Though temperature is clearly an important variable of PKD outbreaks, temperature alone does not sufficiently explain PKD disease dynamics in wild fish populations. To improve knowledge about *T. bryosalmonae* distribution in wild fish and waters in Montana, we developed novel molecular detection assays to detect this parasite in fish tissue and in environmental water samples. We then used these assays to determine the presence and prevalence of *T. bryosalmonae* in wild fish and water sampled from rivers in central and western Montana in 2016 and 2017. We are currently using population genetics approaches to determine if

distinct genetic variants of *T. bryosalmonae* exist and, if so, examine the relationship of this genetic variation with biogeographical patterns, fish infections, and disease outbreaks.

Genetic Improvement of Disease Resistance Through Selective Breeding: Overview of Concepts, Considerations, and Limitations

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Bacterial cold water disease (BCWD) is a frequent cause of mortality in farmed Rainbow Trout, and producers have historically had limited options to manage the disease. With mounting evidence that BCWD resistance is heritable, scientists at the National Center for Cool and Cold Water Aquaculture established a closed, specific-pathogen-free resource population and began a family-based selective breeding program to improve innate resistance to Flavobacterium psychrophilum, the etiological agent of BCWD. Critical to the success of the program were: 1) development of a high-throughput, standardized disease challenge model; 2) maintenance of a large, fully-pedigreed population; and 3) development and maintenance of contemporary susceptible and randomly-mated control lines for reference. After five generations of selective breeding (10 years), survival of the selected line (ARS-Fp-R) in the standard challenge model increased by 60 percentage points (~12 percentage points per generation) compared to the contemporary reference lines. In farm trials to date with confirmed exposure to F. psychrophilum, the ARS-Fp-R line has demonstrated increased survival and decreased pathogen load compared to the contemporary reference lines and resident populations. The improved resistance in the ARS-Fp-R line was also maintained following triploidization. ARS-Fp-R germplasm has been released to U.S. stakeholders for commercial propagation. The divergently-selected lines developed as part of the breeding program have served as important resources for scientists to elucidate mechanisms of host resistance, pathogen virulence, and host × pathogen interactions. Recent efforts using genomic and bioinformatic technologies to predict the genetic merit of disease resistance in naïve fish suggest that rates of genetic improvement can be increased considerably compared to family-based selection. Selective breeding is an effective tool that can be used in combination with vaccination strategies and best management/biosecurity practices to control disease in aquaculture.

Eradication of Whirling Disease in a Cutthroat Trout Stream through Management Interventions

Nehring, Barry.* Colorado Parks & Wildlife (retired)

Alves, John. Colorado Parks & Wildlife; Nehring, Joshua. Colorado Parks & Wildlife; Felt, Benjamin. Colorado Parks & Wildlife

The myxozoan parasite *Myxobolus cerebralis* (Mc), the causative agent of Whirling Disease (WD) among susceptible trout and salmon, was first detected in Germany in the 1890s. Two susceptible obligate hosts, a salmonid fish and the aquatic oligochaete *Tubifex*, are required for completion of the life cycle. Beginning in the 1990s, WD was devastating wild rainbow, brook and cutthroat trout populations in several states across the Intermountain West. Throughout the 20th century, the fish-infective myxospores were considered highly resistant to natural degradation and thought to remain viable for years or even decades in the sediment of aquatic ecosystems. However, laboratory research in California and Colorado during the first decade of this century demonstrated that Mc myxospores degraded rapidly, becoming completely nonviable in one year or

less. Based on these findings, management interventions were initiated to break the life cycle of the Mc parasite in Placer Creek, a Rio Grande Cutthroat (RGC) Trout stream in Colorado. Management objectives were to keep the stream fishless for approximately 3 years until myxospores in the stream sediment became nonviable and infected oligochaetes died of old age. Chemical eradication of all fish began in 2007 and was completed by 2009. Twenty-two thousand RGC trout fry were first reintroduced in September 2010. Among more than 280 RGC trout collected and tested in 2012, 2013, 2014 and 2016 throughout Placer Creek upstream of barriers where chemical reclamation was conducted, no evidence of infection was detected indicating the life cycle of the Mc parasite has been broken. In the stream reaches below the downstream barrier where no chemical reclamation was conducted, disease screening in 2005, 2006, 2011, 2012, 2013, 2014 and 2016 revealed the Mc parasite has remained enzootic.

Introduction to the symposium on “Fishing for solutions to economically and ecologically important salmonid diseases”

Winkelman, Dana L. U.S. Geological Survey, Colorado Cooperative Fish and Wildlife Research Unit*

Fetherman, Eric R. Colorado Parks and Wildlife

Infectious pathogens are a serious threat to fisheries and aquaculture production worldwide. The threats that pathogens pose to fisheries has stimulated research into control and management. Three main factors affect disease transmission and ultimately options for control. These factors consist of the environment, host, and pathogen and manipulating one of more these factors is necessary to reduce the prevalence and severity of a pathogen. Typically, disease management in fisheries consists of efforts to control or eradicate the pathogen. The use of antibiotics is a common treatment for pathogens, particularly bacteria, in many hatchery production settings. Antibiotics have been used to control Bacterial Kidney Disease (BKD) and Bacterial Coldwater Disease (BCWD) in salmonid hatcheries and remain the primary treatment for these pathogens. We present several studies addressing the use and development of vaccines and antibiotics. Manipulating host resistance is also an option for pathogen control. Parasite resistance has been developed and used extensively in Colorado for reestablishing Rainbow Trout *Oncorhynchus mykiss* populations in the presence of the whirling disease parasite *Myxobolus cerebralis*. More recently, research has focused on developing Rainbow Trout resistance to BCWD. Several talks are focused on the use and development of resistant strains of Rainbow Trout and management options for reducing the effects of pathogens. Environmental factors have also been manipulated to reduce the prevalence and severity of pathogens, particularly in hatchery environments. Environmental manipulation usually consists of efforts to increase water quality, reduce stress to fish, or both. Density is one critical factor that may exacerbate disease transmission by reducing water quality, increasing transmission, and increasing stress, and may provide options for pathogen management. Environmental factors may also be crucial in controlling pathogens in the wild, and the importance of the environment is addressed in this symposium.

Ghosts of Fishes Past, Present, and Future: Confronting Data-Limited Stocks in a Changing Arctic

Upper thermal tolerance of Arctic Lamprey and Pacific Lamprey larvae and instream thermal dynamics within larval lamprey habitat in Ishikawa, Japan (southern limit of Arctic Lamprey distribution) and Yakima Subbasin, Washington State, USA (Upper Columbia River tributary)

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Water temperature greatly influences the metabolic activity of fishes and is therefore a critical element of fish habitat. High water temperatures in the summer can severely limit the distribution of cold water anadromous fishes, including Arctic Lamprey *Lethenteron japonicum* and Pacific Lamprey *Entosphenus tridentatus.* These two species are distributed in the streams and rivers in the northern Pacific Ocean (Arctic Lamprey generally positioned in higher latitude than Pacific Lamprey). Both species are considered to be important ecologically as well as culturally (as food and medicine), yet recent population declines observed for both species have severely limited their distribution and abundance. Although many threats exist for these two lamprey species, high water temperature can be a limiting factor in many streams. Our study objectives were to 1) estimate thermal tolerance of larval Arctic and Pacific Lampreys from rearing experiments in lab, and 2) measure and compare instream water temperatures within fine sediment habitat (preferred larval lamprey habitat) and overall water column within the southern limits for Arctic Lamprey (Ishikawa, Japan) and within the interior Upper Columbia region for Pacific Lamprey (Yakima Subbasin). The results for these two species suggest that larval lamprey are remarkably tolerant of high water temperatures (28.5-31.0 C), although negative growth regularly occurs at these high temperatures and considerable reduced growth can be observed at even lower temperatures (21-24˚C). These two species of lampreys also have the ability to overcome even higher water temperature conditions in streams due to the unique cold water refuge microhabitat they occupy, which are typically 1-5 degrees cooler compared to the surface water during the summer. However, it is evident that these two species inhabit habitat that are close to their upper threshold temperature limits and water temperature rise due to future climate change could certainly cause extinction of the local populations.

A radio telemetry investigation of migration timing, habitat use, survival, and straying of mature Dolly Varden *Salvelinus malma* in the Canning River, Arctic National Wildlife Refuge

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During summer, Dolly Varden in northeast Alaska encounter sufficient water to migrate along rivers and to sea, but during winter rivers stop flowing, the sea under ice becomes too cold, and all fish congregate in small volumes of water associated with perennial springs. The Canning River is one of the larger rivers in the area with numerous perennial springs that support Dolly Varden during winter. The Canning River also marks the western boundary of the Arctic NWR as it flows across the coastal plain to the Beaufort Sea. Because of potential industrial activity in the area, we sought a more detailed understanding of migration timing, habitat use, survival, and straying of Dolly Varden from the Canning River. To achieve these objectives, we deployed 210 radio tags in mature Dolly Varden during 2014 and 2015, and then tracked their migrations and seasonal locations with aerial surveys of the Canning and other eastern North Slope rivers and with a fixed radio receiver located in the lower Canning River. Migration to sea occurred during a brief period in early to mid-June, while fish returned to the river in small numbers over the next three months. Dolly Varden spawned and overwintered in several areas of the central main stem and perennial spring habitats in the upper reaches of the drainage. Non-spawning fish occupied similar main-stem habitats during winter but did not migrate into upstream reaches. The estimated annual survival

of non-spawners (0.62) was significantly greater than for post-spawners (0.34). Survival in freshwater (winter) was significantly greater than for marine environments (summer) for both demographic groups. The straying rate was estimated to be 0.37 (95%CI = 0.31-0.52). These data enhance our understanding of annual cycles of Dolly Varden migration and habitat use, which should improve managers' ability to minimize disturbance from industrial activity.

Assessing spatial patterns of Arctic Cod *Boreogadus saida* abundance and distribution in the Chukchi and Beaufort seas

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As a result of the challenges inherent in sampling the remote Arctic environment, most knowledge of Arctic species' life history is constrained to information collected from opportunistic research efforts. Arctic Cod *Boreogadus saida* warrants additional study because it is a key forage fish species and provides a critical energetic link between lower and upper trophic levels in this marine ecosystem. Spatially explicit studies synthesizing Arctic Cod distribution across a multitude of research efforts have not been conducted in the western portion of its range. The need for an initial characterization of the spatial distribution of Arctic Cod is particularly relevant given the 2009 actions of the North Pacific Fisheries Management Council (NPFMC), which closed the U.S. Arctic to commercial fishing until sufficient information is available to sustainably manage a fishery. We used spatial generalized additive models (GAM) to map the distribution of Arctic Cod by size class and relative to environmental variables. By compiling demersal trawl data from 22 research cruises conducted from 2004 – 2017 on the Chukchi and Beaufort seas shelves and investigating size-specific patterns in distribution, we hope to infer the movement ecology of Arctic Cod as they develop from juvenile to adult life stages. Preliminary results suggest modest population structure in the U.S. Beaufort Sea as well as some degree of spatial separation between juvenile and adult life stages. Characterization of this species' distribution not only contributes to general understanding of Arctic Cod life history in the Pacific Arctic, but is also an essential input for any future quantitative ecosystem modeling efforts in this region. An increasing human presence in the Arctic renders this analysis both timely and necessary for responsible decision making regarding this key Arctic fish species.

Bioenergetics modeling of Broad Whitefish growth in the Alaskan Arctic

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Rapid warming in the Arctic is already impacting high-latitude ecosystems, although organismal response is largely unknown for many species. Rural communities in Arctic Alaska rely heavily on the species in these ecosystems for a food source; for example, subsistence fisheries on the Alaskan Beaufort Sea coast primarily target whitefish species like Broad Whitefish *Coregonus nasus.* This study examined potential responses of juvenile Broad Whitefish to varying climate change scenarios in the Alaskan Arctic. To achieve this goal, bioenergetics modeling was used in conjunction with field-collected data from nearshore waters in the Prudhoe Bay region of the Beaufort Sea. Temperature input for the model was obtained by pairing projected daily air temperatures for the region with 35 years of daily summer water temperature measurements. Ongoing laboratory research is being conducted on wild-collected juvenile Broad Whitefish to obtain metabolic rates and

energy density values for the species, the first to be quantified for this fish to our knowledge. Upon completion of this study, these species-specific parameters will be used to further refine modeling efforts. Bioenergetics modeling of poorly studied fishes has historically relied on physiological parameters borrowed from other species, casting doubt on the accuracy of results. By using species-specific parameters as bioenergetics model inputs, this continuing research will increase our understanding of Broad Whitefish and its potential responses to a warming Arctic environment within the context of future subsistence availability.

Evaluating Selawik River Inconnu Age Structure and Spawning Population Abundance in Relation to Permafrost Thaw Activity

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Thawing permafrost is increasing in arctic and sub-arctic Alaska and altering aquatic habitat qualities. In 2004, a large retrogressive permafrost thaw slump (slump) occurred upstream of the Selawik River Inconnu *Stenodus leucichthys* spawning ground and emitted large quantities of fine sediment and organic debris into the river for over seven years. These Inconnu spawn in a 30 km reach consisting of gravel and cobble substrate. Inconnu is a major subsistence food resource in northwest Alaska and there is concern that spawning habitat quality may have declined because of the deposition of fine sediment into gravel substrates where eggs need to settle and incubate. We assessed the potential impact of sediment deposition on egg survival through spawner recruitment age distribution profiles of mature pre-spawning Selawik and Kobuk River Inconnu from 2011–2016 and established pre- and post-slump age comparisons. This paired sample of affected and unaffected Inconnu populations allowed us to evaluate the impact of the slump on recruitment of the Selawik population. We detected similarities in Selawik and Kobuk Inconnu age and length structures that indicate recruitment is occurring in both populations, although weaker in post-slump (2014–2016) years in the Selawik population. In addition, we counted downstream migrant post-spawning Inconnu on the Selawik River using sonar technology to estimate abundance and spawn timing. Spawner abundance estimates ranged from 18,700–24,900 and the peak migration date was 3 October. We expect Selawik River Inconnu spawner abundance to plateau and then decrease as the poorer post-slump recruitment is coupled with harvest and natural mortality. In contrast we expect Kobuk River recruitment to increase and then be dominated by younger age cohorts. Landscape-scale thermokarst activity that negatively affects spawning habitats for some gravel spawning fish may eventually reduce their population sizes, particularly for species that cannot adapt to these changes.

The Chronicles of Charnia: evaluating the abiotic and biotic factors that structure arctic lake food webs with consideration of Arctic Char *Salvelinus alpinus* populations

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Complex interactions between abiotic and biotic factors control lake food web dynamics. In arctic Alaska, despite low species diversity, there is a surprising amount of variation in trophic structure across the thousands of lakes that dominate this landscape. However, beyond basic geomorphic constraints, we have a limited understanding of the specific factors that drive this trophic variation, and further, Arctic Char, found in many North Slope lakes, often exhibit polymorphism in other areas of their native range. We studied a suite of physically and trophically diverse lakes across a range of Arctic Char populations (e.g., abundance, size structure) to better understand the capacity of arctic Alaskan char populations to respond in a changing climate. We quantified Arctic Char morphological traits, growth rates, diets, and niche space as well as diets and niche space of potential competitors. Despite obvious phenotypic differences (e.g., coloration, maximum size), we did not observe strong morphological differences across Arctic Char sizes based on statistical clustering. However, we did detect shifting diet preferences (e.g., zooplankton to snails) across sizes and trophic divergence across populations. Arctic Char niche spaces were larger and overlapped up to 87 – 90 % less among conspecifics in lakes with lower population densities. While overall community composition and ecosystem size did not directly affect Arctic Char size structure (PERMANOVA; $p = 0.29$), biotic factors such as potential for intraspecific competition (e.g., arctic char density; $p < 0.01$) and primary production (e.g., Secchi depth; $p < 0.01$) were significant contributors to char growth rate and size structure. Overall, our findings add to our knowledge of char population in arctic Alaska. These findings will be important to consider for subsistence and conservation decisions, especially as our other work suggests lake-specific carrying capacity, but also population cycles and stochastic vulnerability, will likely increase in a warmer climate.

Potential Implications of Climate Change for Broad Whitefish *Coregonus nasus* in Arctic Alaska

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Arctic hydrology is controlled by periglacial processes and landforms that are highly vulnerable to changes in climate which, in turn, can influence fish habitat and populations. Projections of how Arctic freshwater ecosystems and fish species will be affected by a warming climate are lacking. Here we present a synthesis that describes global climate change drivers to regional responses in climate, periglacial processes, hydrology, and instream habitat to anticipate effects on Broad Whitefish *Coregonus nasus*, an important subsistence resource for residents of Arctic Alaska. Degraded permafrost features from climate change are expected to deepen stream networks, enhance groundwater exchange, and create new flow pathways, which will alter historical flow regimes and present habitat connectivity. Warming and lengthening of the growing season may increase the potential for fish growth, but exceedance of threshold temperatures in some habitats will likely create migration barriers and increase stress, disease, and therefore potentially mortality. Elevated streamflow could expand overwintering habitat but, conversely, may impact embryo and larvae life stages. Biological effects are uncertain and therefore identifying important habitats and filling knowledge gaps will be key to understanding impacts to these fish populations and the subsistence fishery.

Environmental and biological influences on the southern distribution of Arctic Cod *Boreogadus saida* in the Bering Sea

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Mueter, Franz J. Department of Fisheries, College of Fisheries and Ocean Sciences, University of Alaska Fairbanks

Arctic Cod *Boreogadus saida* is the most abundant and ubiquitous fish species throughout the Arctic Ocean. As such, they serve an important ecosystem role linking upper and lower trophic levels and transferring energy between the benthic and pelagic realms. Our objective is to explore what limits the southern distribution of Arctic Cod in the Bering Sea by examining time series of survey, oceanographic and sea ice data. We quantify the variability in the southern extent of the Arctic Cod distribution in the Bering Sea to determine potential mechanisms (lagged sea ice extent, bottom temperature and potential predators and competitors) driving the variability. We hope to gain insight into how the distribution of Arctic Cod may shift as climate warming continues to increase sea temperatures and reduce ice cover in the Arctic.

Seasonal Fish Distribution and Movements in an Arctic Drainage in the National Petroleum Reserve - Alaska – 2001 through 2017.

Morris, William. Owl Ridge Natural Resource Consultants, Inc.*

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Arctic fish populations are dependent on a short summer growing season to regain condition after an overwintering period lasting as long as 8 months. Broad Whitefish *Coregonus nasus* spawn in fall at freeze-up, expending substantial energy just prior to entering the winter season, while Arctic Grayling *Thymallus arcticus* spawn in spring and must survive winter with adequate energy to negotiate peak annual flows, reach spawning grounds, then spawn. In both strategies, maximizing summer feeding and growth opportunities is critical to success and survival. Providing yet an additional challenge for Arctic fish species is the general lack of viable wintering habitat, as ice thickness exceeds water depth in the vast majority of Arctic streams in Alaska. Peak migrations coincide with the two major hydrologic periods in the Arctic and occur during the shoulder seasons in spring during and just after snow-melt and then in fall as freeze-up begins. Seasonal migration and habitat use studies have been conducted in the Fish Creek Drainage beginning in 2001 with key movement periods sampled through 2017. Fish population size structure for multiple species, including Broad Whitefish and Arctic Grayling, has been recorded and tracked throughout. While no major shifts in seasonal distributions, population length class structure, or species composition have been observed to date, the long term study is structured to detect such shifts as both climate and anthropogenic conditions continue to change in Arctic Alaska.

Arctic Cod *Boreogadus saida* and Snow Crab *Chionoecetes opilio* in Alaska's Arctic

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Vestfals, Cathleen D. University of Alaska Fairbanks; Marsh, Jennifer M. University of Alaska Fairbanks; Divine, Lauren M. University of Alaska Fairbanks; Weems, Jared. University of Alaska Fairbanks; Iken, Katrin. University of Alaska Fairbanks; Bluhm, Bodil A. University of Alaska Fairbanks

Arctic Cod and Snow Crab, along with Saffron Cod *Eleginus gracilis*, were identified as species of potential commercial interest in NOAA's 2009 Arctic Fishery Management Plan. The Plan prohibits commercial fishing in Alaska's Arctic waters based on what little was known about these species at the time. A number of opportunistic surveys, and several broad-scale ecosystem surveys have been completed since then, providing new information on the distribution, abundance and biology of pelagic and benthic fishes in the Chukchi and Beaufort seas. Here we combine multiple sources of information to provide an updated assessment of the status of Arctic Cod and Snow Crab in the region. Low to modest abundances of adult Arctic Cod in the Northern Bering Sea and Chukchi Sea contrast with very high densities of young-of-year (YOY) Arctic Cod on the northeast Chukchi shelf observed during three separate hydro-acoustic surveys. The prevailing currents and a biophysical modeling study suggest that these YOY cod originate from potential spawning areas in the Bering Strait region. However, the sources of the large spawning biomass that is required to account for the observed number of offspring are currently unknown. Small Snow Crab dominate invertebrate biomass over much of the Chukchi Sea shelf and a hotspot of mostly very small crab to the north of Bering Strait suggest a Bering Sea origin. Mature Snow Crab on the northern shelf and the presence of early zoea over Hanna Shoal and in the Barrow Canyon area suggest successful spawning in the area, with offspring potentially contributing to a downstream population of larger Snow Crab along the outer shelf and slope of the western Beaufort Sea. Neither Arctic Cod nor Snow Crab appear to be candidates for a viable fishery in the Alaskan Arctic at present.

Shifts in the Baseline: Changes to a Nearshore Arctic Fish Community

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Nearshore fish communities make up a fundamental part of the Arctic marine ecosystem as well as serving as an important subsistence resource, but exist in a region undergoing substantial environmental change. As climate change affects Arctic waters, nearshore fish communities may also shift; however, how these communities will respond to climate change is not currently well understood. This project summarizes recent trends from a long-term (2001–2017) nearshore sampling program in Prudhoe Bay, Alaska, along the coastal Beaufort Sea. Abundance data from daily sampling (July–August) at four stationary sampling locations show distinct shifts in fish communities. Since 2001, the annual species richness has significantly increased, with several new species present. For many common species, abundance patterns show considerable increases or decreases in abundance, while the variability of abundance has increased substantially compared to early years of the project. The overall species assemblage structure appears to be in the process of shifting as well: non-metric dimensional scaling (nMDS) and Bray-Curtis dissimilarity matrices show changes in community indices (e.g., relative abundance) in recent years. Such departures from expected values are likely caused by shifts in abiotic forces such as temperature, salinity, and wind velocity. This pattern of altered baselines provides important context from which to evaluate potential ecosystem shifts resulting from climate change in the Arctic.

Stock Assessment of Inconnu in the Kobuk River Arctic Estuary Complex: Where Do We Begin?

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Huang, Jiaqi. Alaska Department of Fish and Game

Inconnu *Stenodus leucichthys* are an extremely important fish resource in Northwest Alaska for subsistence and sport fishing. Considerable information has been gathered on the two known spawning populations that support Inconnu fisheries, including annual spawning abundance and seasonal movement patterns. The exploitation of these stocks, however, is poorly understood because in addition to incomplete harvest estimates, the relationship between spawning abundance and total abundance is not known. An understanding of this relationship is needed to recommend sustainable harvest levels. A common theory among scientists that study iteroparous fish in high latitudes is that the energetic requirements of spawning in sequential years are too high and most fish, especially females, will skip a year or more between spawning events, therefore affecting the relationship between spawning abundance and total abundance. To improve our understanding of how spawning behavior may affect estimates of total abundance a radiotelemetry study was designed to estimate spawning frequency and survival, and document any additional spawning locations in the Kobuk River, Alaska. From 2008 through 2014, spawning migrations and locations of 253 radiotagged Inconnu were documented using aerial and stationary tracking data. Numerous models were explored to estimate annual proportions of Inconnu that returned to spawn from each of two tagging years. This study documented both skip spawning and sequential year spawning for both males and females in all years of the study. Few studies have documented sequential year spawning for females before this study. The energy requirements for sequential year spawning may be satisfied for this stock because these fish spend the majority of their life history rearing and feeding in a highly productive river delta and estuary.

Factors influencing harvest rates of Arctic Cisco during the annual Colville River Delta under-ice subsistence fishery

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The annual under-ice gillnet fishery for Arctic Cisco *Coregonus autumnalis* in the Nigliq Channel of the Colville River delta, Alaska is important to the food security of residents of Nuiqsut. In a typical fall fishing season, fishers harvest tens of thousands of this anadromous whitefish species which is prized for its high fat content and quality of meat. Summertime westerly winds transport age-0 fish from spawning grounds in the Mackenzie River system to the Colville River Delta where they spend 7–9 years before returning to Canadian waters where they will spawn and continue to live for up to an additional 10 years or more. We analyzed more than 30 years of long-term monitoring data collected at three sites on the Nigliq Channel and in nearshore waters near Prudhoe Bay, Alaska to determine the importance of young-of-the-year recruitment to Alaskan Beaufort Sea waters on subsequent harvests in the Colville River as adults. We also investigated the importance of intra-annual factors, including seasonal wind speed and direction, water salinity, timing and location of fishing effort, and individual fisher skill on harvest success. Our results confirm that annual young-of-the-year recruitment to nearshore Alaska waters explains much of the variability in annual harvest success 5–7 years later in the Colville River. Timing and location of fishing also contributed to the prediction of harvest rates, which were highest at locations closest to the river mouth. Harvests increased at all sites with increasing salinity up to 25 ppt, above which harvests decline. Wind speed was related to harvest rates only at the middle locations in the Nigliq Channel, as a result of westerly winds pushing saline waters upstream throughout the harvest season, increasing salinity from below preferred levels for Arctic Cisco (<15 ppt) in the early fall to an optimal salinity range (15–25 ppt) by late fall. Individual fisher skill appears to have little impact on harvest success. Understanding the factors influencing Arctic Cisco harvests in the Colville River Delta will help stakeholders manage the fishery sustainably, particularly in the face of a rapidly changing climate and ongoing infrastructure development in the region.

Ghosts of Fishes Past, Present, and Future: Confronting Data-Limited Stocks in a Changing Arctic

Sutton, Trent M. University of Alaska Fairbanks*

Climate change and anthropogenic development have impacted the structure and function of high-latitude ecosystems and, as a result, the status and response for many fish species that inhabit these regions remains unknown. As a result, improving our knowledge on the distribution, abundance, and life-history dynamics of fishes for which we have a limited understanding and predicting their potential response(s) to a changing Alaskan Arctic is essential for maintaining sustainable fisheries and ecosystem integrity. For this presentation, I will provide an overview and highlight current and future data needs relative to previous and ongoing studies to better understand fish stocks in Arctic waters of Alaska. In addition, I will also discuss the opportunities to collect the necessary data needed to better understand and predict how fish stocks will respond to changes in their environment through the examination of: (1) retrospective analysis of data-sparse fish stocks using conventional data and analytical tools; (2) current and ongoing examinations and assessments of fish population status in data-limited situations; and (3) potential responses and outcomes of fish stocks to varying change scenarios in the Alaskan Arctic. Because an additional goal of this symposium is to bring together researchers from industry, natural resource agencies, non-governmental organizations, and academic institutions that have been involved in Arctic-based fisheries research in Alaska, I will conclude my presentation by providing examples of ongoing efforts to improve data and information sharing across this region as well as the development of a platform for collaborative research involving fish species in which there is limited data and/or understanding.

An InSAR habitat suitability model to evaluate overwinter conditions for whitefishes in Arctic lagoons

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Lagoons provide critical habitats for many fishes, including whitefishes, which are a mainstay in many subsistence fisheries of Arctic Alaska rural communities. Despite their importance, little is known about the overwintering habits of whitefishes in Arctic Alaska due to the challenges associated with sampling during winter. We developed a habitat suitability (HS) model to understand the potential range of physical conditions that whitefishes experience during the Arctic winter, using three indicator lagoons that represent a range of environmental characteristics. The HS model was built using a three-step approach. First, interferometric synthetic aperture radar (InSAR) remote sensing identified areas of floating and bottomfast ice. Second, through in-field groundtruthing, we confirmed the a) presence, and b) quality of liquid water (water depth, salinity, and dissolved oxygen) beneath the ice cover. Third, we assessed the suitability of that liquid water as habitat for whitefishes, based on published literature and expert interpretation of water quality parameters. To groundtruth the HS model, we sampled the lagoons for fishes in March. InSAR determined that 0, 65.4, and 88.2 % of the three lagoons were composed of floating ice, corresponding with areas of liquid water beneath a layer of ice. The HS model indicated that all three lagoons had reduced suitability as whitefish habitat in winter as compared to summer due to loss of habitat from the presence of bottomfast ice and a reduction of liquid water quality due to cold temperatures, high salinities and low dissolved oxygen levels. However, only the shallowest lagoon had lethal conditions and zero suitability as whitefish habitat. The methods outlined here provide a simple, cost-effective method to allow stakeholders to identify lagoons that consistently

provide critical winter whitefish habitat that are widely used for subsistence as the Arctic faces an uncertain future with climate change and increased oil and gas exploration.

Hooked: Creative Solutions to Engage the Public in Fish Conservation and Fisheries Management

Applied fisheries education in a semester package

Brewer, Reid S. University of Alaska Southeast

Markis, Joel A. University of Alaska Southeast

Most traditional university programs are designed around a 4 year, 120 credit sequence of courses that have a tremendous amount of General Education Requirements as well as a suite of courses that can be transferred to most other universities in the country. The University of Alaska Southeast Fisheries Technology program has begun offering short, semester-intensive programs that are meant to put students to work. Through the Alaska Salmon Culture Semester, the Alaska Dive Semester, and the Alaska Fisheries Management Semester, students complete a 12 credit, four-course sequence that gives them a skill set that will serve them in seasonal and entry level jobs in various fisheries fields. The intensives are based around hands-on learning and internships with industry partners so that students can either go directly into the workforce with a knowledge base and skill-set, or develop platform that can be used as a stepping stone for a higher level degree. As many people know, Alaska is experiencing a "Greying of the Fleet" which spans every aspect the fisheries industry, the UAS Fish Tech program is hoping that these hands-on, experiential micro-credentials can plant the seeds for Alaska's fisheries future.

FISH TALK: Thirty years of talking “fish”.

Hauser, Bill. ADF&G, retired. *

I worked on an Alaska Department of Fish and Game (ADF&G) stream fish habitat rehabilitation project in the late-1980s and I needed volunteer manpower for a day to deliver and install steambank rocks and Christmas trees (as ”soft armor”) on an Anchorage urban stream. When the Alaska Flyfishers (AFF) sportsman club agreed to help, I felt an obligation to do more than say ‘thank you’ and walk away. I took some time to write a couple articles for their monthly newsletter and, after several months, I was invited to continue with contributions. Before long, the regular column, FISH TALK was born and is still continuing in the AFF monthly newsletter some 30 years later. FISH TALK is just that. It is about fish. Life histories, biology, ecology, behavior, anything. Sometimes I get questions. Often, I ask questions to create a dialogue. Scientific terms are avoided or carefully explained. Presentations are in ‘plain talk’. Short and sweet. Use a bit of public information and explain it differently or use it to step off into a new topic. I have been pleased, on many occasions, when a casual conversation with some person commented... “Oh, Fish Talk!” “Yeah, I enjoy that; I always read it.” And, my greatest reward came as an accident one day some years ago. I fished from my float tube near another flyfisher and our conversation wandered toward AFF and FISH TALK. I said, “I write that.” His excited reply was, “Oh! You are Bill Hauser?!” That was my sweetest reward.

From Creek to Plate: A Summer of Firsts

Liebich, Katrina. U.S. Fish & Wildlife Service

Ulrich, Taylor. University of Arizona

The significance of fish in Alaska is absolutely real. But for all the people who live to fish, there are many more who do not. Youth in particular face many barriers to building connections with the fish and wildlife right in their own backyards and Alaska's urban youth are no exception. In Anchorage, many have not ever fished or stepped foot in creeks that literally run right by their schools and homes. Creek to Plate is a U.S. Fish & Wildlife Service program entering its sixth year that introduces Anchorage youth to safe fishing opportunities near home. Youth go from not knowing how to hold a fishing rod to developing the skills and confidence necessary to become proficient, life-long anglers. In 2017, 100 kids spent over 1,000 hours participating in this program. We track four of these youth through their full circle experience, from learning fishing fundamentals to catching and eating the fish they caught.

Diverse efforts to restore a complex fish species – Pacific Lamprey

McIlraith, Brian J. Columbia River Inter-Tribal Fish Commission*

Rose, Bob. Yakama Nation; Wang, Christina. U.S. Fish & Wildlife Service; Lampman, Ralph. Yakama Nation; Jackson, Aaron. Umatilla Tribe; Statler, Dave. Nez Perce Tribe; Baker, Cyndi. Warm Springs Tribe

Pacific Lamprey *Entosphenus tridentatus* are a culturally and ecologically important fish species to the Columbia River basin and the West Coast of North America. Adult returns have declined dramatically over the last 100 years due to a variety of known and unknown threats which have limited the geographic distribution of Pacific Lamprey as well as harvest opportunities for Columbia River basin tribal members. The tribes have successfully harvested and managed Pacific Lamprey for thousands of years and have been leaders in lamprey research, recovery, and restoration since the late 1990's. Since 2000, there have been increasing efforts by the tribes and other groups to (1) highlight the decline of lamprey and their importance to the Columbia River basin and the West Coast of North America, (2) obtain a better understanding of Pacific Lamprey life history, and (3) develop and implement solutions, using the best available knowledge, that address known threats and critical uncertainties associated with lamprey declines. This talk will highlight the diverse array of collaborative research, outreach, and management efforts being implemented to restore Pacific Lamprey. Due to the extensive range and diverse life history of Pacific Lamprey, restoration and recovery of these fish requires equally extensive and diverse partnerships.

Salmon Blitz: Engaging Citizen Scientists in Documenting Salmon Habitat in the Copper River Watershed

Morse, Kate. Copper River Watershed Project*

Jurica, Kirsti. Copper River Watershed Project; Brenner, Rich. Alaska Department of Fish & Game

An understanding of Pacific salmon habitat use at all life stages is necessary to sustain Alaska's wild salmon populations into the future. Alaska Department of Fish & Game's (ADF&G) Anadromous Waters Catalog (AWC) is used to document all known rearing and spawning habitat of anadromous fish. However, due to the vast number of streams in Alaska and limited resources, not all salmon streams are currently listed or have detailed information about their use (e.g. rearing and/or spawning). The Copper River Watershed Project has worked with ADF&G and other partners to develop Salmon Blitz, a

citizen science program that engages community volunteers in field surveys to collect data needed to nominate additional habitats to the AWC, and provide more detail for habitats currently listed in the catalog. This project provides important data to inform management of salmon as well as hands-on learning opportunities for participants. By connecting people with their surroundings and deepening their understanding of the resources on which they depend, we hope to instill a greater sense of engagement and responsibility for the long-term health of the region's salmon. Over the course of four field seasons, 483 volunteers completed 114 surveys at 81 sites, resulting in 56 nominations. Nominations included 55.93 new stream kilometers, 67.89 ha of new lakes and wetland complexes, and new data for 60.1 km of already cataloged streams. With 100% of nominations accepted by ADF&G, Salmon Blitz demonstrates the effectiveness of citizen science for collecting accurate data to inform salmon management efforts in Alaska.

Cryptic but Reel: Using social psychology in videos to acquaint the public with lesser known fishes

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Bonar, Scott A. USGS Arizona Cooperative Fish and Wildlife Research Unit; Sheehy, Cody. University of Arizona; Bogner, Dave. University of Arizona

Desert fishes are cryptic, and infrequently seen by the public. Apathy of the public toward these fishes and their ecosystems hinders their conservation. Fortunately, advanced technological means to acquaint the public with these species is becoming increasingly common. High-definition underwater and aerial footage are now possible with affordable and user-friendly technology. We are creating low-cost, educational videography presentations featuring the unique and often rare desert fishes of Nevada and Death Valley. In these videos, we are testing the inclusion of various widely recognized social psychology principles to maximize presentation effectiveness. Low cost technology, especially when combined with the use of easy to include psychological principles, may provide spectacular visual results and could potentially serve as an effective tool to acquaint the public with rare desert fishes. Here, we will present preliminary results from this research of testing the relationship between the inclusion of social psychology principles and their impact on viewers' learning outcomes and endorsement of a "pro-ecological" world view.

Keeping the West Wild by Minimizing the Impacts of Aquatic Invasive Species

Should we be concerned about Brown Trout invading native trout habitat in the West?

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Non-native Brown Trout are considered one of the world's worst invaders yet also valued socioeconomically important sportfish. Although generally considered a species confined to lower-elevation, cool-water stream reaches, recent evidence indicates that Brown Trout distribution is expanding in numerous regions. With this changing distribution there remains growing concerns of the interactions with native species such as bull trout and cutthroat trout in the western United States. Here we used empirical field studies from Montana to investigate the competitive interactions between Brown Trout and bull trout and cutthroat trout. We combined these results with recent mark-recapture and trend data to consider the implications of further Brown Trout expansions. Our diet and stable isotope data indicate extensive overlap in forage patterns and trophic position with bull trout and Brown Trout; these patterns were consistent with data from cutthroat trout. The diet studies in combination with lower cutthroat trout growth rates and survival in the presence of Brown Trout highlight the potential risks to native salmonids in Montana. Given the socioeconomic importance of Brown Trout, our results question the need for

potential management actions, what are the biggest data gaps to inform management, which actions would be most cost- and ecologically effective, and which ecosystems may be targeted to facilitate robust populations of native salmonids, while still maintaining healthy Brown Trout populations.

Minimizing the impact of introduced Brown Trout on native salmonids in the Trinity River, CA.

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Brown Trout were introduced to the Trinity River in Northern California in the 1890's with the intent of establishing a self-sustaining population. This effort was successful, as is demonstrated by the healthy population over 100 years later. However, non-native Brown Trout introduction is another example of managing our rivers fish populations with imperfect knowledge. River management now frequently includes undoing practices of the past such as returning wood to the channels where it was removed to aid fish passage and assessing the impact of non-native species on the systems where they were introduced. Current goals of the Trinity River Restoration Program include recovery of tribally important native fishes including Chinook and Coho Salmon and Steelhead Trout. Brown Trout, a piscivorous species, have been observed eating the native fishes and there is concern that the non-native population may be hampering recovery efforts. Until recently Brown Trout in the Trinity River were only investigated incidentally during surveys targeting Chinook and Coho Salmon and Steelhead Trout. These studies suggested that the Brown Trout population was growing and with this observation there had been increased motivation to conduct a study to quantify their numbers and gather baseline information. We evaluated the population of Trinity River Brown Trout and estimated their impact on the native fishes using a bioenergetics approach. Having found a large impact to native fishes from Brown Trout predation, we are bringing multiple agencies together, and based on the results of the study and collection methods tested during field efforts, are developing a Brown Trout Management plan. This management plan will hopefully be implemented in the coming year.

Invasive Northern Pike Suppression in Alexander Creek

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Northern Pike are invasive to the Alexander Creek drainage in Alaska's Matanuska-Susitna Valley and became established through a series of illegal introductions in the 1960's. The Alexander Creek drainage is a large river basin encompassing thousands of square miles. This system is low velocity with numerous tributaries and encompasses several shallow lakes and ponds, thousands of acres of adjacent wetlands, and numerous side-slough and oxbow channels. Alexander Creek was once a very productive and popular Chinook Salmon fishery. Today, Northern Pike have expanded throughout this drainage, and native fish populations and sport fishing opportunities have consequently declined. This is the eighth year of a long-term Northern Pike suppression project in Alexander Creek. The primary goal is to reduce the invasive Northern Pike population to replenish depleted anadromous and resident fish populations and restore sport fishing opportunities. Preliminary findings are encouraging. Since the project's inception in 2011, approximately 20,000 Northern Pike have been removed from Alexander Creek's side-channel sloughs. During some project years, aerial escapement surveys of spawning

Chinook Salmon for Alexander Creek were the highest in over a decade while other neighboring systems received average to below average returns. In the past three years, recolonization of Chinook Salmon spawning areas in the upper reaches of Alexander Creek that had been devoid of spawning fish for years, were once again utilized by spawning Chinook Salmon. Aerial indices and information from local anglers also indicate that other salmon species are rebounding as well. Juvenile salmon were captured in minnow traps and observed in stomachs of Northern Pike in areas of the creek that, only a few years earlier, did not contain them. Lastly, resident fish catches in gillnets have increased substantially since the project's inception indicating increases in their abundance.

Assessing effects and probability of suppression of an illegally introduced Walleye population

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Buffalo Bill Reservoir is a 3,300 ha reservoir in northwest Wyoming that is managed as a wild Rainbow Trout *Oncorhynchus mykiss* and Cutthroat Trout *Oncorhynchus clarkii* fishery. Illegally introduced Walleye *Sander vitreus* were discovered in the reservoir in 2008. We investigated food web dynamics in the reservoir to identify primary piscivores and prey in the system and determine the potential predation effects of Walleye to the wild trout population. We then evaluated Walleye demographics under a variety of suppression scenarios that included electrofishing, gillnetting, and angler exploitation under a mandatory harvest regulation. Age-structured population models were used to estimate Walleye population growth rate for scenarios with and without Walleye removal. We determined that trout were a major prey for Walleye in Buffalo Bill Reservoir. Bioenergetics simulations indicated that a Walleye density of 4.3 fish/ha was capable of consuming all the biomass and production of prey-sized trout (age-1 and age-2) in the reservoir. This suggested suppression actions were necessary to protect the wild trout stocks. Mechanical removal of Walleye was conducted by electrofishing and gillnetting during the Walleye spawning period and reward tags were used to estimate angler exploitation. Mean population growth rate was estimated at 1.22 for the no suppression scenario, 1.18 for the electrofishing exploitation scenario, 1.04 for a gillnet exploitation scenario, 0.91 for an angler exploitation scenario, and 0.81 for a combined angler and gillnet exploitation scenario. These studies are guiding management strategies to protect the wild trout population from an invasive piscivore and may be applicable to others dealing with invasive piscivores.

Elodea Eradication in South Central Alaska

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Currently, *Elodea* is the only submerged freshwater invasive plant to become established in Alaska. *Elodea* was first documented in South Central Alaska in an Anchorage Lake in 2013 and in the Susitna Basin in 2014. *Elodea* is a particularly injurious aquatic perennial that compromises water quality, hinders boat traffic due to its dense growth, fouls

float plane rudders, and has the potential to severely impact spawning and rearing habitat of native fish. *Elodea* grows very well in Alaska all year long, including winter months. Because *Elodea* is thriving in infested water bodies and spreading further into the Alaska wilderness, it is critical to eradicate known *Elodea* infestations. Herbicide treatments have been both successful and unsuccessful due to hydrologic factors. Eradication efforts are necessary to eliminate infested water bodies to restore natural conditions and contribute to the restoration of the once thriving salmon resources of South Central Alaska.

Eradication of Invasive Northern Pike from Alaska's Kenai Peninsula

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Massengill, Robert. Alaska Department of Fish and Game, Division of Sport Fish

Invasive Northern Pike were introduced to Alaska's Kenai Peninsula in the 1970's and have decimated many wild and hatchery-stocked fisheries. The Alaska Department of Fish and Game (ADF&G) has conducted Northern Pike research and control work on the Kenai Peninsula for the past 17 years. Beginning in 2008 and continuing today, ADF&G is primarily utilizing piscicide (rotenone) treatments to restore waters invaded by Northern Pike. Over time, the scale and complexity of these restorations has greatly increased. The last two restoration projects (Stormy Lake and Soldotna Creek Drainage) both involved piscicide treatments of anadromous lentic and lotic waters and required substantial and unique efforts to restore wild native fish populations. To date, monitoring of wild fish populations to these restored waters has shown encouraging results. These restoration projects typically require multiple years to plan, permit, execute and monitor and are evaluated through a combination of netting surveys and eDNA sampling. Currently, ADF&G is planning to restore a series of eight lakes located south of Soldotna that support the last known Northern Pike populations on the Kenai Peninsula.

Capturing an Emerging Invasion: Status of European Green Crab in Washington's Salish Sea

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The ongoing spread of the globally-damaging invasive European Green Crab *Carcinus maenas* along the west coast of North America has been viewed with concern by managers. Though Green Crab have been present on the outer coast of Oregon, Washington, and British Columbia since the late 1990's, the Salish Sea might have distinct dynamics. Initial establishment of these inland waters was most likely human-mediated, as prevailing oceanographic conditions are not expected to favor import of larvae. Following the detection, in 2012, of an established population of Green Crab in Sooke Basin, B.C., Washington Sea Grant (WSG) launched Crab Team, a volunteer-based monitoring program in 2015. Crab Team currently engages 220 volunteer, tribal, and agency monitors in surveying a network of 52 sites throughout Washington's Salish Sea. This multi-stakeholder approach has enabled a much broader scope of early detection than would otherwise be possible. In addition, close advisory partnerships with management entities, including tribes, US federal and state agencies, facilitate communication and coordination of response and assessment efforts. Since 2016, 107 European Green Crab have been captured at five monitoring sites along Washington's inland shorelines, the majority at a single site - Dungeness Spit. Based on size, these are believed to be recent recruits arrived via larval dispersal in 2015 and/or 2016.

Though most of these populations are not yet fully established, there is potential for rapid growth without intervention. Yet the low numbers and apparent isolation of current populations indicate that the invasion is still in its early stages, providing an opportunity for effective intervention. While physical oceanographic modeling and genomic research are ongoing in an attempt to better understand the dispersal dynamics of Green Crab in the Salish Sea, continued monitoring efforts and cross boundary collaboration are imperative to protect ecosystems and natural resources.

Investigating the effects of fluridone on metabolism and host microbiota diversity in Threespine Stickleback *Gasterosteus aculeatus*

Hanson, Anastasia *

Lescak, Emily*; O'Brien, Kathryn; Milligan-Myhre, Kathryn; Tomco, Patrick

Fluridone (trade names SonarONE and Sonar Genesis) is a systemic herbicide that is prescribed for treatment of *Elodea canadensis/nuttallii*, an invasive plant species threatening Alaska's fish habitat and biodiversity. Regulatory agencies must balance the immediate need to eradicate *Elodea* with the potential adverse environmental impacts of herbicide application when creating Integrated Pest Management (IPM) plans. Many common toxicological and behavioral studies have been performed at prescribed and elevated exposure concentrations using non-target fish species; however, recent advances in technology provide an opportunity to probe the potential stress-response of exposed fish at the molecular level. In this study we measure two responses that have never been performed in fluridone studies, using indigenous Alaskan Threespine Stickleback *Gasterosteus aculeatus*: environmental metabolomics and host microbiota diversity. Using modern high-resolution NMR (Nuclear Magnetic Resonance), the abundance of low molecular-weight primary metabolites in muscle tissue can be tabulated to create a metabolic "profile". We will compare the metabolite profiles in fish exposed to 9 ppb fluridone, which is typically used in Alaskan waterways, to non-exposed control fish. This will identify changes in metabolism to describe sublethal physiological stress over a 96 hr exposure period. These data are coupled with simultaneous examination of microbiota diversity and membership as determined by sequencing and analysis of the bacterial-specific 16S rRNA gene to determine effects of fluridone on microbial community diversity and composition in the gut and aquatic environment. Metabolic and microbiota changes are rarely combined in stress-response studies and are a powerful system to identify adverse impacts experienced by exposed fishes at the molecular level in Alaska's unique subarctic climate.

Assessing Vulnerability of Salmonids to Invasion by Northern Pike in Southcentral Alaska.

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Northern Pike *Esox lucius* were illegally introduced to the Matanuska-Susitna (MatSu) basin in Southcentral Alaska in the 1950's and their populations continue to expand. The spread of this invasive hyper predator has been linked to population-level declines of salmonids and the extirpation of Three-Spined Stickleback *Gasterosteus aculeatus* from at least one location. The management of ongoing invasions requires knowledge of the location and quality of available habitat across broad geographic ranges. This project is the first to investigate the environmental landscape among introduced populations

of Northern Pike in Southcentral Alaska. We developed a Northern Pike intrinsic habitat potential (IP) model for the MatSu basin using NetMap, an integrated set of watershed terrain parameters and analysis tools. Attributes representing climatic, hydrologic and topographic features were generated across 24,300 stream-km and used to characterize and rank habitat suitability for Northern Pike. Presence data were compiled from the Alaska Department of Fish and Game's Northern Pike Waters Catalog and used to inform and evaluate the accuracy of the IP model. We used these predictions to assess the potential vulnerability of five Pacific salmon species to Northern Pike invasion across the MatSu basin as a function of distance to invaded waterbody, invasion likelihood via human transport, juvenile salmon life history, and the extent of overlap between high quality pike and juvenile salmon habitats. Results of this work will increase our understanding of the ongoing Northern Pike invasion in the MatSu basin and provide managers with the tools necessary to rank and identify vulnerable locations throughout Southcentral Alaska.

Invasive Northern Pike Suppression Begins in Lake Roosevelt, WA

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Silver, Alix O. Spokane Tribe of Indians*; McLellan, Holly. Confederated Tribes of the Colville Reservation; Lee, Charles. Washington Department of Fish and Wildlife

The Washington Department of Fish and Wildlife (WDFW) reclassified Northern Pike *Esox Lucius* as a Prohibited Species in 2011. The reclassification was partially in response to the establishment of a population within Box Canyon Reservoir, an impoundment of the Pend Oreille River. Introduced Northern Pike were negatively impacting the fish community. In response, the Kalispel Tribe of Indians and WDFW collaboratively implemented an aggressive and successful gill net suppression project which removed nearly 17,000 Northern Pike between 2012 and 2015. The Pend Oreille River joins the Columbia River in Canada upstream of Franklin D. Roosevelt Lake (Lake Roosevelt, WA). Prior to 2013 observations of Northern Pike within Lake Roosevelt were rare. However, incidental catch of Northern Pike in fishery monitoring surveys has been steadily increasing. In 2015 a burgeoning Northern Pike population was detected within Lake Roosevelt. The Lake Roosevelt co-managers (Confederated Tribes of the Colville Reservation, Spokane Tribe of Indians, and WDFW) responded promptly to this serious and immediate threat with baseline monitoring and suppression efforts. These efforts are complicated by the large scale of the reservoir and annual flood control operations of Grand Coulee Dam. In 2016 the Lake Roosevelt co-managers initiated Northern Pike suppression, removing over 1,200 Northern Pike and documenting age-0 recruitment for the first time. Throughout 2017 approximately 5,000 Northern Pike were removed, increasing geographic distribution was documented, and age-0 recruitment was again observed. A formal Northern Pike suppression project is currently under development. Northern Pike pose an immediate threat to the Lake Roosevelt subsistence and recreational fishery which is supported by annual releases of hatchery salmonids. Furthermore, a growing Northern Pike population threatens hundreds of millions of dollars of downstream investment in anadromous salmon, sturgeon, and lamprey recovery throughout the Columbia River Basin.

Current Status of the Invasive Signal Crayfish Population of Kodiak Island

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Lance, Thomas A. Sun'aq Tribe of Kodiak

In 2002, America's northern-most discovery of Signal Crayfish *Pacifastacus leniusculus* was made in Alaska, within Kodiak Island's Buskin Watershed. Since then, several local organizations have noted the presence of Signal Crayfish within the watershed, and because crayfish are not indigenous to Alaska, concerns were raised. In 2015, trapping efforts by Kodiak Soil and Water Conservation District found gravid female Signal Crayfish, indicating a breeding population. In 2016, the Bureau of Indian Affairs Invasive Species Program provided funding for Sun'aq Tribe of Kodiak to survey for crayfish within the watershed. To enhance success of Signal Crayfish detection and removal from the watershed, the Tribe's project utilized capture methods not previously used by others, including kick seining and electrofishing techniques. Trapping and kick seining for crayfish resulted in few specimens captured. However, electrofishing for crayfish proved more effective in numbers and age classes captured. In total, 1,130 Signal Crayfish were captured and removed from the Buskin Watershed over the duration of the project. This presentation will focus on results from the 2016 and 2017 fieldwork seasons, partnerships and collaborations, lessons learned, and upcoming genetic and population dynamics investigations.

More Cowbell, Not Invasives: a multi-stakeholder communications plan

Liebich, Katrina

Invasive species are a growing issue for Alaska with vectors of introduction and spread becoming more prevalent and geographically widespread. A variety of partners are already working towards proactively preventing high-risk invasive species from entering Alaska and spreading, detecting new infestations, and controlling/eradicating those species that have become established. These efforts can have an even larger impact with the participation and support of an aware and inspired public. A multi-stakeholder team was convened in fall 2017 to develop a coordinated approach to communicating consistently and effectively with key audiences that have the power to support prevention, early detection, and rapid response efforts. The process and progress to date is presented.

What limits invasions in arctic marine systems? Investigating the role of water temperature on survival and reproduction in the Bering Sea

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Cold sea waters and low shipping traffic are expected to limit biological introductions in polar ecosystems. We evaluated these expectations in the Bering Sea, a marine ecosystem characterized by a strong, subarctic-arctic latitudinal gradient, by (1) examining how water temperatures affect potential survival and reproductive habitat of invasive species; and by (2) examining vessel traffic and ballast water discharge into U.S. Bering Sea ports. We built taxa-specific, habitat suitability models by comparing species' temperature and salinity thresholds to conditions in the Bering Sea projected by regional ocean models. We quantified habitat suitability across two time periods: current (2003-2012) and mid-century (2030-2039) to investigate changes in habitat suitability under climate change projections. Under current conditions, 83% of the taxa assessed (n=42) have temperature tolerances that would allow them to survive year-round in the southern Bering Sea. Areas north of 58°N, which are annually covered by sea ice and have winter water temperatures below 0°C, are largely inhospitable. Future models predict a northward expansion of suitable habitat, largely favoring taxa that already have the ability to survive year-round. While suitable reproductive temperatures exist for many of the taxa considered, the short summer season may limit those that require more than six weeks to complete ontogenetic development. The port of Dutch

Harbor received the largest amount of commercial and fishing vessel traffic, and the largest volume of ballast water discharge. Taken together, our analyses indicate that there currently exists mechanisms for the transport of non-native taxa into the Bering Sea, and environmental barriers to biological invasions are expected to decrease in the near future. The southeastern Bering Sea, and the port of Dutch Harbor in particular, are high-risk areas for biological introductions and should be monitored.

Harnessing eDNA for early detection and removal of invasive Northern Pike and *Elodea* in Alaska

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Environmental DNA (eDNA) is organismal DNA found in an environmental sample (e.g., water). Molecular genetic methods for detecting eDNA are increasingly being used to detect organisms at low density because a physical sample or direct observation is not required. One of the applications of eDNA analysis is in detecting aquatic invasive species. In this presentation we describe the collaborative studies aimed at developing and applying eDNA tools for early detection of two invasive species in Alaska. First, we summarize the development and testing of an eDNA assay to detect invasive Northern Pike in southcentral Alaska. We show how, as a result of this multi-agency effort, eDNA is now routinely used as part of the Northern Pike detection and eradication effort led by the Alaska Department of Fish and Game. Second, we summarize the development and testing of multiple eDNA assays to detect the invasive aquatic plant *Elodea* throughout Alaska. This work is ongoing and we describe the field study designed to evaluate detection sensitivity and potential applications for an *Elodea* eDNA assay. In summary, the efforts to develop eDNA tools for Northern Pike and *Elodea* highlight the need for collaboration when testing and applying new tools to manage aquatic invasive species.

Aquatic Invasive Species Change Ecosystem Services Derived from Alaska's Sockeye Salmon Fisheries: A Bioeconomic Risk Analysis Informed by Expert Opinion.

Schwoerer, Tobias. UAA Institute of Social and Economic Research

This presentation links human and ecological systems research to analyze resource management decisions for *Elodea*, Alaska's first submerged aquatic invasive plant. The plant was first discovered in urban parts of the state but is being introduced to remote water bodies by floatplanes and other pathways. Once introduced, *Elodea* changes freshwater systems in ways that can threaten salmon. The analysis integrates multiple social and ecological data to estimate the potential future economic loss associated with its introduction. For estimating the effects on commercial sockeye fisheries, multiple methods of expert elicitation are used to quantify and validate expert opinion about *Elodea*'s ecological effects on salmon. These effects are believed to most likely be negative, but can in some instances be positive. Combined with market-based economic valuation, the approach accounts for a wide range of potential ecological and economic effects. A spatially-explicit model consisting of Alaska's Sockeye Salmon *Oncorhynchus nerka* producing watersheds simulates *Elodea*'s spread across Alaska. The model also accounts for *Elodea*'s known erratic population dynamics causing localized

Elodea extinctions. The presented simulation model accounts for the change in region-specific colonization rates as *Elodea* populations are eradicated. The most probable economic loss to commercial fisheries and recreational floatplane pilots is $97 million per year, with a 5% chance that losses exceed $456 million annually. The analysis describes how loss varies among stakeholders and regions, with more than half of statewide loss accruing to commercial Sockeye Salmon fisheries in Bristol Bay. Upfront management of all existing invasions is found to be the optimal management strategy for minimizing long-term loss. Even though the range of future economic loss is large, the certainty of long-term damage favors investments to eradicate current invasions and prevent new arrivals. The study serves as a step toward risk management aimed at protecting productive ecosystems of national and global significance.

Early detection of Dreissenid Mussels in Tiber Reservoir, MT

Sepulveda, Adam J. USGS

Amberg, Jon. USGS

Tools that bolster early detection of invasive Dreissenid Mussels are urgently needed to prevent their spread across western North America. Plankton tow sampling is the current standard for early detection of dreissenids in western North America, however interest in adding environmental DNA (eDNA) sampling into managers' toolboxes has peaked since this molecular tool can detect DNA of species sight-unseen. In this study, we examined the efficacy of plankton tow and eDNA detection tools in Tiber Reservoir (Montana), where Dreissenid Mussels were recently discovered. Replicated plankton tow samples were collected in June and July and eDNA samples were collected in June, July and October 2017 from ~ 10 sites. No dreissenids were documented in plankton tow samples in June or July and no dreissenids were documented outside of this study in 2017 despite intense survey efforts. However, dreissenid mussel DNA was detected in 1 sample in June and in October and in 15 samples in July. A subset of positive eDNA samples were analyzed by an independent lab and results were corroborated. We then estimated the effort needed for 95% probability detection of dreissenid DNA and found that as many as 27, 14, and 34 samples needed to be collected in June, July and October, respectively. Given that no dreissenids were observed in 2017, interpreting our eDNA results is not straightforward since eDNA approaches only detect DNA, regardless of the presence or state of the target taxa. Nevertheless, our results clearly underscore that eDNA deserves consideration as an effective early detection tool for Dreissenid Mussels.

Portable, onsite environmental DNA detection of invasive Northern Pike

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Environmental DNA (eDNA) has improved detection probabilities for rare and cryptic aquatic invaders but the lab-based methods for eDNA analyses slow opportunities for rapid response. Effective approaches that address this analytical bottleneck and improve capacity for rapid response are urgently needed. We tested the sensitivity of a portable, field-based eDNA approach relative to lab-based eDNA analyses for detecting invasive Northern Pike (*Esox lucius*; pike) in eight lakes in Alaska's Kenai Peninsula. The portable, field-based approach takes ~ 1 hr from sample collection to final results and uses a field-based DNA extraction kit, a shelf-stable assay, and a portable real-time PCR thermocycler. The lab approach takes days to weeks for final results and uses a lab-based DNA extraction kit, a lab-bound assay, and a benchtop real-time

thermocycler. We found that the portable, field-based approach was less sensitive than lab-based approaches and was more prone to inhibition, thus increasing the potential for false-negatives. Until sensitivity and inhibition issues can be resolved, this portable, field-based approach is best viewed as a complement to rather than a replacement of standard eDNA lab-based analyses.

Rapid response for invasive waterweeds in high latitude systems: assessment of collateral impacts from herbicide treatment

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Carey, Mike P. USGS Alaska Science Center; Morton, John M. U.S. Fish & Wildlife Service Alaska; Guerron-Orejuela, Edgar. Kenai Watershed Forum; Decino, R. Alaska Department of Fish and Game; Willette, M. Alaska Department of Fish and Game; Boersma, J. U.S. Fish & Wildlife Service Alaska

Invasive waterweeds have potential for high ecological and economic impact. Many species reproduce vegetatively, such that mechanical removal is costly and typically fails to eradicate infestations. As a result, a rapid eradication response with herbicides has been identified as a priority invasion control strategy for several waterweeds. However, concern for collateral impacts to native flora and fauna from herbicides remain an important management question. In this talk, we present results from a multi-lake monitoring effort to assess collateral ecological impacts from fluridone and diquat-based herbicide treatment for invasive *Elodea* in Alaskan lakes. *Elodea* is the first aquatic invasive plant to become established in Alaska and shares commonalities with invasive waterweeds currently impacting lower 48 U.S. systems such as Hydrilla. Variability in data was driven by seasonal dynamics and natural lake-to-lake differences typical of high latitude waterbodies, indicating lack of evidence for systematic impacts to water quality or plankton communities associated with herbicide treatment of *Elodea*. Impacts on native macrophytes were benign with the exception of some evidence for earlier onset of leaf senescence for lily pads *Nuphar* spp. in treated lakes. We observed a substantial increase in native flora richness after *Elodea* was eradicated from the most heavily infested lake, indicating potential for retention of native macrophyte communities if infestations are addressed quickly. While avoiding introductions through prevention may be the most desirable outcome, these applications indicated low risks of non-target impacts associated with fluridone- and diquat-based herbicide treatment as a rapid response option for invasive waterweeds in high latitude systems.

Management of the invasive aquatic plant *Elodea* spp. in interior Alaska

Shenoy, Aditi. Fairbanks Soil and Water Conservation District

Elodea is Alaska's first known submerged freshwater invasive plant, and poses an ecological and economic threat to Alaska's freshwater resources. In Alaska, *Elodea* infestations in water bodies can be expected to increase sedimentation, reduce native biodiversity, degrade fish habitat, and interfere with safe river travel. *Elodea* can be spread readily by boats and floatplanes, and because it reproduces vegetatively, a single fragment is all that is needed to start a new infestation. *Elodea* was first discovered in interior Alaska in 2009 in Chena Slough, and since then has been found in Chena Lake, parts of the Chena River, and Totchaket Slough. The *Elodea* infestations in Chena Slough and Totchaket Slough are particularly threatening because of the slough's connectivity to downstream river systems in the Yukon River drainage. As a first step towards eradicating *Elodea* in interior Alaska, herbicide treatment of the *Elodea* infestation in an 8-mile reach of Chena Slough was initiated in June 2017. The aquatic herbicide fluridone was applied to the waters of Chena Slough in pelleted

form in June and August, and in liquid form continuously from June-September. Fluridone concentration was monitored weekly, and a concentration of 2-9ppb was maintained over the course of the season. *Elodea* plants in Chena Slough are showing signs of herbicide damage throughout the treatment area. Herbicide treatments are planned over the next 3-4 years in Chena Slough, Totchaket Slough, and Chena Lake, until *Elodea* is completely eliminated from known infestations in interior Alaska.

Challenge, Change and Opportunities for Marine Fisheries

Assessing the Potential for Competition Between Pacific Halibut and Arrowtooth Flounder Throughout the Gulf of Alaska

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Beaudreau, Anne H. UAF College of Fisheries and Ocean Sciences; Ciannelli, Lorenzo; Mary E. Hunsicker

Pacific Halibut *Hippoglossus stenolepis* have supported culturally and economically important fisheries throughout the Gulf of Alaska for over a century. However, recent decreases in mean size-at-age have raised concerns among those who depend upon and manage the resource. A number of mechanisms have been proposed to account for these declines, including reductions in population-level means due to size-selective fishing, decreased growth rates resulting from changes in prey availability and/or metabolic rates, and density dependent effects due to intraspecific competition. Intensified competition with Arrowtooth Flounder *Atheresthes stomias* is also among the prevailing hypotheses for decreased halibut size-at-age. Arrowtooth Flounder is a voracious predator that has exhibited more than five-fold increases in biomass over the past 60 years. Because the two flatfish species occupy similar habitats and consume much of the same prey, a ubiquity of Arrowtooth Flounder is thought to have diminished the extent of suitable substrate and/or prey available to Pacific Halibut in Alaskan waters, resulting in slower growth rates and subsequent decreases in size-at-age. The overarching objective of this study was to estimate spatial and dietary overlap between Pacific Halibut and Arrowtooth Flounder throughout the Gulf of Alaska. We assumed that a negative relationship between overlap indices would confirm some degree of resource partitioning, thereby suggesting potential for competition between Pacific Halibut and Arrowtooth Flounder in the Gulf of Alaska, past or present. This study represents a first step toward evaluating the hypothesis that intensified competition with an ever-increasing Arrowtooth Flounder population has contributed to decreases in mean halibut size-at-age. More broadly, results from this work improve our understanding about complex ecological interactions among important groundfish species while elucidating how distributions and diets of these same species may change through time, in space, and under varying environmental conditions.

Optical Assessment of Weathervane Scallop Density and Abundance off Kodiak Island, AK.

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The continental shelf east of Kodiak Island is a diverse and productive region of the Gulf of Alaska, which includes several submarine canyons and supports commercial harvests of groundfishes and Weathervane Scallops *Patinopecten caurinus*. Despite extensive commercial fisheries, the spatial distributions of fishery species and their habitats in this region are poorly understood. This paucity of information has constrained the assessment of the weathervane scallop abundance to fishery-depended data (e.g. catch per unit effort) in this region. During the spring of 2014, the Alaska Department of Fish & Game collected more than one million high-resolution underwater photographs of the benthos with a sled-mounted camera in and around the Chiniak Gully (North and South), Christmas Tree, Barnabas, and Albatross Scallop beds to assess benthic habitats and scallop abundances. We selected approximately 150,000 of the georeferenced images using systematic (100m grid) random sub-sampling, scallops were counted, and their shell heights were measured. Benthic substrate were identified as sand, mud, shell hash, shell debris, gravel, cobble, boulder, and bedrock categories. Overall, mean scallop density was 0.13 scallops m-2 and we estimated that there were a total of about 27 million scallops in these beds. Chiniak Gully – North (64.77 km2) had 7,308,000 scallops, - South (45.89 km2) had 3,444,899 scallops, Christmas Tree (40.55 km2) had 10,373,518 scallops, Barnabas (27.14 km2) had 4,594,750 scallops, and Albatross (9.35 km2) has 1,518,680 scallops. Scallop size compositions were significantly different in the beds. For example, scallops in the Albatross bed were on average smaller (96.5 mm) than the scallops in the Christmas Tree bed (135.1 mm). All the beds were dominated by sandy substrate and coarse gravel – boulder and bedrock substrates were rare (observed at <5% of stations). These are the first estimates of scallop abundance, size distribution and substrate composition these scallop beds. Future work includes the characterization the abundance and distribution of other macroinvertebrates and the assessment of fishing impacts on vertical epifauna (e.g. sea whips).

Does fishing disturbance explain the spatiotemporal distribution of structure-forming benthic features in the central and eastern Bering Sea?

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Stationary biological, biogenic, or geological seabed elements represent an important refuge from disturbance and predation for juvenile Red King Crab *Paralithodes camtschaticus*. Fishing with bottom-tending fishing gears (e.g. trawls, dredges, pots, longlines) is a potential source of disturbance or removal of these structure-forming features. Risk to exposure from fishing disturbance is related to (1) a features inherent trait (e.g. size, height, body form), and (2) the frequency of feature exposure to fishing events. In 1996, the Red King Crab Savings Area (RKCSA) and Nearshore Bristol Bay Trawl Closure (NBBTC) were implemented with the goal of protecting juvenile red king crab from non-target fishery induced mortality. To date, no studies have examined the effectiveness of these closures for mitigating the impacts of fishing on presence of structural benthic features important for red king crab. Information on the presence and absence of the structural features since 1982 is drawn from the National Marine Fisheries Service (NMFS) trawl survey database. Exposure to fishing disturbances is assessed as a function of 1) area status (open vs. closed to fishing), 2) habitat disturbance as predicted by the North Pacific Fishing Effects model, and 3) the frequency of and time since last fishing disturbance. These relationships were explored with binomial generalized linear mixed effects models. This project leverages existing data products and modeling efforts to examine the spatiotemporal distribution of structure-forming benthic features in the RKCSA, NBBTC, and adjacent open areas relative to fishing disturbances. Initial results from the area status analyses indicated that the presence of structural benthic features increased in the RKCSA and NBBTC in the

years post closure. However, these results were not different from the increase observed in the reference open area in the same time period; suggesting that the change in structural feature presence is not related to area status.

Size-based patterns of energy allocation in juvenile Sablefish

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Sablefish *Anoplopoma fimbria* is an ecologically and economically important groundfish species in the Gulf of Alaska. Since the early 2000s the stock has experienced low recruitment, which has prompted effort to better understand the mechanisms driving year class strength. Juveniles start their first summer in surface waters before settling into coastal bays in the fall. Post-settlement juveniles migrate to deeper shelf and slope habitats starting in their second winter. We examine Sablefish nutritional condition through these juvenile stages using energy density. Nutritional condition is linked to recruitment in many demersal fish species, as individuals with high energy density have more reserves to draw on during periods of limited resources. The objective of the study was to evaluate ontogenetic shifts in energy allocation for juvenile Sablefish (ages 0-1). We hypothesized that energy density would increase with fish size and there would be a drop in condition over winter. Energy density of age-0 and age-1 Sablefish caught during the summers of 2014-2017 was analyzed. Energy density increased with length for both age-0 and age-1 fish; however, mean energy density was lower for age-1 compared to age-0 individuals, suggesting a decline in condition over winter. To better understand the mechanisms underlying these shifts in energy density over the first winter, our ongoing work will track Sablefish condition seasonally in conjunction with temperature and prey quality. Age-0 Sablefish were collected in the fall of 2017 to represent pre-winter condition. Sampling in April and July 2018 will attempt to capture age-1 post winter and summer condition of the 2017 year class.

Movement patterns of juvenile Sablefish within a nursery area in Southeast Alaska

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Sablefish *Anoplopoma fimbria* is one of the highest valued groundfish species targeted in Alaska's commercial fisheries. Most studies have focused on the larval, neustonic juvenile, or the adult stages of the Sablefish life cycle, while much less is known about the post-settlement juvenile stage (ages 0 to 2 years) in nearshore nursery areas, even though survival of post-settlement juveniles is thought to be important for determining year class strength. We used acoustic telemetry to monitor movement of post-settlement juvenile Sablefish in a nursery area in Alaska to better describe their period of nearshore residency. Acoustic telemetry allows for the long-term, fine-scale study of fish movement along with the ability to relate behaviors to environmental factors within the habitat. To investigate juvenile Sablefish movement within a nearshore bay (St. John Baptist Bay, Baranof Island, Southeast Alaska), 40 individuals were surgically implanted with acoustic transmitters and monitored on an array of eight acoustic receivers during the summer and fall of 2015 and 2016. We quantified movement in terms of displacement from the head of the bay, distance traveled, and duration of time spent within the bay for the 28 individuals used in analyses. During the summer, tagged juvenile Sablefish showed fidelity to an area

near the head of the bay, perhaps indicating an area of preferred habitat, prey, or environmental conditions. Individuals exhibited relatively high rates of movement throughout the bay; juvenile Sablefish traveled 9.4 km/d within the bay on average in 2015 and traveled 13.0 km/d within the bay on average in 2016. In addition, we categorized variation in movement patterns among individuals and examined horizontal movements in relation to environmental variables. This study provides insight into the early life history of Sablefish and reinforces the importance of nearshore bays for juvenile Sablefish prior to recruitment into fisheries.

Reduced portfolios in salmon populations in British Columbia

Hertz, Eric

Connors, Brendan; Connors, Katrina; Reynolds, John

Understanding the dynamics of salmon populations is important for conservation and management, but the factors driving spatial and temporal variation in many salmon populations remain poorly understood. Understanding these patterns is important for many coastal First Nations, who play an important role in the monitoring and management of salmon in their traditional use areas. Using data from 200 unique spawning locations on the Central Coast of British Columbia, we quantified patterns in abundance and coherence of salmon over space and time to measure the extent to which portfolio effects stabilize variation in populations. We found strong declines in Sockeye Salmon abundance across the Central Coast. This decline was accompanied by an increase in population synchrony among populations. Chum and Pink Salmon also showed generally similar patterns to Sockeye, though the odd-year lineage of Pink Salmon showed increased abundance in recent years. These changes in synchrony within salmon populations may be important as synchronization increases the risk of declines due to boom and bust dynamics. To explore possible drivers of changes, we test if factors such as changes in fishing rates, ocean conditions, or increased competition on the high seas explained changes in synchrony through time. Over the next several years, the Pacific Salmon Foundation will continue to work with First Nations communities on the Central Coast to better understand how these changes in dynamics can be factored into local decision-making processes. This future work will better position us to understand implications of these changes on local area management and monitoring.

Reproductive Biology Informs Fishery Management of Snow and Tanner Crabs in the Eastern Bering Sea

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Snow *Chionoecetes opilio* and Tanner Crab *C. bairdi* stocks support boom-and-bust fisheries in the eastern Bering Sea. Management of these male-only crab fisheries may be enhanced by improved understanding of functional relationships between male harvest and female reproductive potential. In the genus *Chionoecetes*, females possess paired spermathecae, an organ for sperm storage from previous matings. For Tanner Crab in Southeast Alaska, mean sperm cell counts of primiparous females by location were negatively correlated with an exploitation rate index, suggesting that male-only harvest decrease levels of stored sperm available for fertilization of a subsequent clutch. For Tanner Crab in the eastern Bering Sea, a 13-14 year cycle in recruitment and total population size may indicate that long-term environmental variability mediates recruitment strength. However, this cycle is also approximately double the estimated mean age of

maturity, suggesting the possibility of an endogenous rhythm associated with a stock-recruit relationship. For Snow Crab, fecundity increases with increasing female size and decreases for older multipara (age) likely due to senescence. We report on attempts to improve upon estimates of reproductive potential, which are affected by relationships with life history, female size, shell condition, temperature during embryogenesis, and other factors. Additionally, we pursue ongoing research to determine whether structures in Chionoecetes are retained through molting and whether band counts in these structures correspond to age. If so, results would provide a boon to estimates of age at maturity and rates of natural mortality and growth, which are critical for sustainable fishery management of these stocks.

Should fisheries biologists stop using the PDO and NPGO indices?

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Including climate indices like the Pacific Decadal Oscillation (PDO) and North Pacific Gyre Oscillation (NPGO) as covariates in most statistical models requires two assumptions: 1) that the indices provide stationary references for climate conditions; and 2) if the effects of multiple individual indices are of interest, that these indices are independent of each other. Here, we show that both assumptions are violated over recent decades. The PDO and NPGO patterns each result from multivariate sets of physical processes operating at different time scales, and identical index values at different points in time do not necessarily reflect identical climate conditions. For example, the Aleutian Low (AL), a primary driver of the PDO, has shown a marked decline in variance since the late 1980s. This decline in AL variance has resulted in nonstationary (declining) covariance between the PDO and climate processes thought to be related to early marine survival in Gulf of Alaska (GOA) salmon (sea level pressure gradients, freshwater input, coastal salinity, wind mixing, downwelling, and advection). Prior to 1988/89, the PDO index was correlated with all of these processes. After 1988/89, PDO-GOA climate correlations and PDO-salmon correlations largely disappeared. Similar nonstationary climate and biology covariance with both the PDO and NPGO after the late 1980s also occurred in ecosystems beyond the GOA. We also review evidence for increasing PDO-NPGO collinearity since the late 1980s, which exceeded r = -0.6 over the most recent 10-year period. This strength of collinearity is enough to preclude accurate model parameterization and interpretation, and suggests that the effects of the PDO and NPGO cannot be reliably distinguished. The PDO and NPGO indices are derived from principal components scores, and the problems we document likely stem from the shortcomings of a simple linear approach for summarizing climate systems that are fundamentally multivariate and dynamic.

Resolution of biodiversity and assemblage structure in demersal fisheries surveys: the role of tow duration

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This paper examines an experiment during a fisheries independent survey in the North Sea, in Europe which was carried out to test whether sampling effort could be reduced without a significant loss in data precision. To examine potential effects of reducing tow duration from the standard 30 minutes to a proposed 15 minutes estimates of species encounter rates, species richness, and estimates of abundance, biomass and body size were analyzed. Results show species richness estimates are lower in the short tow category, biomass and abundance at length and body size are significantly affected by the change in regime. The results presented in this paper suggest that a reduction of tow duration did not optimize the resolution of biodiversity, and it may affect other survey objectives, such as, providing estimates of abundance or biomass for assessment of commercial species.

A seascape scale fishing impacts model to assess tradeoffs between spatial closures and gear modifications

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Spatial closures and technological solutions such as gear modifications that lift gear components off the seafloor are two potential strategies fisheries managers may employ to reduce habitat impacts from fishing. Evaluation of the efficacy of any such policy requires a quantitative framework that can incorporate fleet dynamics, gear specifications, and habitat characteristics at seascape scales and produce outputs that are readily integrated into existing management workflows. To meet these needs, we developed a model that incorporates spatially and temporally explicit impact and recovery dynamics in a discrete-time framework to produce a timeseries of cumulative habitat disturbance across spatial regions of interest to fisheries managers. We implement the model in the North Pacific, producing monthly estimates of habitat disturbance on 5 km grid cells over a spatial domain encompassing 1.2 million km2. Domain-wide, we estimated that less than 2% of the North Pacific shelf is currently disturbed from fishing impacts, and that implementation of gear modifications in flatfish trawls beginning in 2011 have led to an estimated 28% reduction in habitat disturbance. As a tool to evaluate management policies, we used the model framework to assess the tradeoffs managers need navigate when evaluating the potential efficacy of spatial closures and gear modifications. We simulated fishing effort by modeling fleet dynamics using an ideal free distribution and considered a range of fishing intensity, habitat recovery, local abundance, local depletion dynamics, closure sizes, and gear modifications scenarios. We found that the efficacy of a spatial closure is determined primarily by the balance between reductions in catch efficiency and dispersion/aggregation of effort after implementation of a closure. Comparing closures to gear modifications, we found that reducing habitat disturbance from spatial closures tends to be most effective when fishing intensity is high, whereas gear modifications tend to be more effective where fishing intensity is low.

Declining condition of a key forage fish in the Gulf of Alaska during the North Pacific marine heatwave

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We examined changes in the body condition of a key forage fish species, Pacific Sand Lance *Ammodytes personatus*, to understand how energy transfer to predators may have been disrupted during the recent marine heatwave in the North Pacific (late 2013 to mid 2016). Warmer temperatures can disrupt energy transfer through forage fish by raising metabolic costs and shifting the base of the food web toward lower-lipid zooplankton species. Sand Lance were collected across five years that ranged in temperature from cool (summers 2012-2013) to extremely warm (summers 2014-2016) in Prince William Sound, Alaska, during July at the annual peak of lipid content. Length, energy density (kJ g-1 dry mass), and total body energy (kJ) were measured in age-0 and age-1 Sand Lance. Condition metrics of age-0 fish were relatively stable with only minor differences among years for body length and total body energy. In contrast, the body condition of age-1 fish declined substantially beginning in 2015 and by 2016 they were 38% shorter in length and had 13% lower energy density compared to years of highest condition (2012-2014 for length and 2013-2015 for energy density). The smaller size and lower energy density of age-1 fish contributed to declines in total body energy of 44% in 2015 and 89% in 2016 as compared to 2012-2014. Our results suggest the 2015 Sand Lance cohort experienced little growth or lipid accumulation from July 2015 at age-0 to July 2016 at age-1. The larger, higher quality Sand Lance had diminished condition in 2015 and were essentially missing from the ecosystem in 2016 when age-1 and age-0 Sand Lance became indistinguishable. The decline in Sand Lance body condition may link warming water conditions with predator responses to the heatwave including seabird breeding failures and the 2015-16 die-off of starving Common Murres *Uria aalge*.

Marine Mammal-Fishery Interactions: Conflicts, Management, and Innovative Solutions

A Natural Resource Management Conundrum: Interactions between Pinnipeds and Salmonids in the Pacific Northwest

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In 1972, the U.S. Congress enacted the Marine Mammal Protection Act (MMPA) to provide protection for all marine mammals in U.S. waters, ending centuries of exploitation for many species. As one result, the U.S. stock of California Sea Lions *Zalophus californianus* has increased from 88,924 in 1975 to as many as 257,631 in 2014, and recently the U.S. stock was determined to be within its Optimum Sustainable Population, thus meeting the conservation objectives of the MMPA. Over this same period, many salmon and Steelhead populations in the Pacific Northwest experienced significant declines in abundance and were consequently listed as threatened or endangered under the Endangered Species Act. These declines were initially and primarily a result of multiple factors unrelated to predation by pinnipeds. In the Pacific Northwest, where a relatively small but growing number of pinnipeds (sea lions and seals) have learned to exploit areas where migrating salmon and Steelhead are particularly vulnerable to predation as they congregate at fish passage pinch-points during their upstream spawning migration, concentrated predation by pinnipeds on many of these at-risk fish stocks has put their recovery at risk. Options for effectively managing these pinniped-fishery interactions are few. One management option in the MMPA available to the states is Section 120—Pinniped Removal Authority. Over the past twenty years the states of Oregon and Washington have received several MMPA Section 120 Letters of Authorization from the National Marine Fisheries Service, to, as a last resort, lethally remove predatory CSLs at several locations in the Pacific Northwest including Ballard Locks, Washington; and Bonneville Dam, Washington and Oregon.

Community Science and Cooperative Research: Addressing issues of Rebounding Marine Mammal Populations in the Northeast United States

Bogomolni, Andrea

Nichols, Owen

Since 1972, all marine mammals gained federal protection under the Marine Mammal Protection Act. This legislation has allowed many marine mammal species to come back from the brink of extinction. Harbor and Gray Seals, once bounty hunted and extirpated in Northeast US waters, are rebounding to near historical population numbers. While their return is hailed as a conservation success story, this success also brings many challenges in regions where seals have not been seen for generations. The recognition of these challenges, and the need to increase communication and facilitate discussion, led to the formation of the Northwest Atlantic Seal Research Consortium (NASRC). Since 2008, biennial meetings and workshops of NASRC have brought scientists, fishermen, researchers, students, landowners and business operators together to discuss issues surrounding seals in the northwest Atlantic. Many of these discussions center around fishery interactions. Following the recommendations of NASRC, several programs have developed to address fishery and seal bycatch, depredation, marine organism health risks for fishermen and general education on seals based on fishing community needs and interests. We have also developed novel bycatch sampling protocols in partnership with management agencies and fisherman. As a community we are working together to understand and address challenges, to understand the ecological role of seals, as well as understand role of these rebounding species as sentinels of ocean health. We will share our collaborative experiences, successes and lessons learned with a focus on the results of a recent workshop to address fishery/marine mammal bycatch issues.

Aquatic farming as an emerging industry in Alaska: Assessing impacts to marine mammals

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Shellfish and kelp farming are increasing in Alaska – both in the number of applications received and the size of farms. Prior to 2018, aquatic farms were mostly small (< 29 acres) operations where Alaskans could make a living farming near their homes. During 2017 the Alaska Department of Fish and Game (ADF&G) received an increase in the number of applications and the size of proposed farms, with four greater than 100 acres. Government and entrepreneurs see an opportunity in Alaska's nutrient rich waters as a means of closing trade deficits, growing jobs, and strengthening the competitiveness of Alaska seafood in the world marketplace. On February 26, 2016 Governor Walker signed Administrative Order #280, establishing the Alaska Mariculture Task Force. ADF&G is responsible for permitting and regulating aquatic farming, and ensuring it is conducted in a manner that protects the state's fish, game, and aquatic plant resources (including wildlife and habitat). Assessing potential impacts to marine mammals can be challenging. Based on the low number and density of farms in Alaska and unknown marine mammal species distributions, we currently do not know the potential risks these farms pose to marine life. Previous reports on aquatic farms and marine interactions have identified three key areas of potential impacts with marine mammals: competition for space, entanglement, and disturbance by underwater noise. State and federal agencies responsible for aquaculture regulation and the health and management of marine mammals must work collaboratively to identify or generate best-available data on marine mammal usage of potential aquaculture sites, agree on guidance aimed at avoiding negative interactions, evaluate potential interactions, and establish effective mitigation measures where indicated.

Understanding Sea Otter impacts on subsistence fisheries in Southeast Alaska

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Competition for resources between a growing Sea Otter population and humans in Southeast Alaska has led to food security concerns in rural subsistence-based communities. The Sea Otter population has increased exponentially in Southeast Alaska since reintroduction of approximately 400 animals in the late 1960's to 25,000 animals at last count in 2011. Sea Otters are voracious predators, consuming up to 25% of their weight per day in shellfish resources. Shellfish serve a significant role in Alaska Native subsistence culture and food supply, as these harvests maintain customs and traditions, supplement both communal and individual incomes, and provide healthy traditional foods. We conducted 48 interviews in three indigenous (Hydaburg, Kake, and Klawock) and one ethnically mixed community (Craig) in Southeast Alaska to document how the expanding Sea Otter population is affecting food security in rural communities. Additionally, we conducted intertidal surveys of Butter Clam (*Saxidomus gigantea*) abundance and size at sites that varied in both Sea Otter predation and human harvest to document how these two predators influence clam communities, an important food for both Sea Otters and humans. Interviews and intertidal surveys revealed decreases in availability and size of shellfish where Sea Otters are present. Interviews also revealed decreases in shellfish availability, abundance, size and number of harvest locations at locations near Sea Otters. During the interviews, respondents suggested the following community management strategies in response to increasing competition with Sea Otters: 1) coordinated Sea Otter hunting near villages to keep Sea Otter populations at low levels and protect subsistence foods and 2) relocating to new shellfish harvest locations away from Sea Otters. Understanding the complex social and ecological dimensions that define this human-Sea Otter conflict may help provide information that can be used to make sustainable and ecosystem-based management decisions.

Understanding the problem and working toward solutions: Steller Sea Lions and salmon troll fishing in Southeast Alaska.

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Marine mammal bycatch is the largest direct cause of marine mammal injury and mortality around the world. When marine mammals interact with fisheries, there are often considerable economic impacts for fishermen, including loss of gear, catch, and time. In Alaska, Steller Sea Lions (SSLs) are known to depredate fisheries, including charter, personal-use, and commercial salmon trollers. The Alaska Department of Fish and Game (ADF&G) has systematically surveyed SSLs at haulouts and rookeries throughout Southeast Alaska, collecting data on vital rates, entanglements, and fishery interactions. We have photo-documented >420 SSLs that interacted with fisheries from 2000-2017. The majority (~80%) of interactions occurred with salmon troll fishing (~80%) and secondarily with longline fishing (~20%). Fishermen have few effective options to deter SSLs from depredation, but progress is underway. NOAA Fisheries is developing a list of allowable nonlethal marine mammal deterrents. ADF&G and NOAA Fisheries have collaborated to disentangle SSLs using a recently-developed remote sedation technique that can safely immobilize a SSL, even if it enters the water. Our objectives were to dart and restrain SSLs, remove external gear from the mouth, and attach a satellite tag to learn whether SSLs are likely to survive if external gear (a fishing lure) is removed but the swallowed hook is left in place. From 2013-2017 we disentangled nine SSLs and deployed satellite tags on four sub-adult males we freed from a flasher. The four animals survived for at least

3.5-8 weeks, the length of time we expected the tag to remain attached before falling off due to molting. We have new tags from which we expect >6 months longevity to better evaluate survival. We hope information gained will be useful in working with the fishing community to develop gear modifications so that fishermen can retain their gear and catch while reducing SSL injury and mortality.

Sablefish mortality associated with whale depredation in Alaska

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Killer Whale *Orcinus orca* and Sperm Whale *Physeter macrocephalus* depredation (whales removing or damaging fish caught on fishing gear) can reduce catch rates and decrease the accuracy of fish stock assessments. This study advances our understanding of the impact of whale depredation on the commercial Sablefish *Anoplopoma fimbria* fishery in Alaska and evaluates the impact depredation may have on the annual federal Sablefish assessment. A statistical modeling approach was used to estimate the whale effect on commercial fishery and National Marine Fisheries Service longline survey catch rates; Killer Whale depredation was more severe (catch rates declined by 45%–70%) than Sperm Whale depredation (15%–29%). Correcting for Sperm Whale depredation in Sablefish stock assessment resulted in a 2% increase in estimated female spawning biomass in the terminal year and a 3% higher quota recommendation, valued at approximately US $3 million. Accounting for Sperm Whale depredation in the Sablefish assessment should be done in concert with estimating the increase in fishing mortality caused by depredation in the commercial fishery.

Will pingers reduce entanglement risk of Alaskan Humpback Whales in commercial fishing gear?

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Humpback Whales are recovered in Alaska and now constitute the most frequently entangled large cetacean. In Southeast Alaska, gillnet and crab pots are the most frequently reported gear types involved in entanglements, followed by seine and longline. Two thirds of the humpbacks in the northern panhandle exhibit gear-induced scarring, with an estimated 8% annual increase. Pingers offer a promising technology for bycatch reduction, and their efficacy is well established elsewhere for small toothed whales. Pingers are deployed in Alaskan fisheries, yet their effectiveness at large whale bycatch reduction merits further study. The challenge is to develop an observer blind, experimental apparatus that is minimally hazardous, easily deployed and handy to monitor. This study endeavors to test commercially available whale devices (Fishtek Marine, Future Oceans) by attaching them to fixed (non-fishing) temporary moorings (with safety weak-links) and comparing whale responses to un-activated pinger controls. Pingers will also be deployed from small boats and drift buoys to test responses (approach distance and magnitude). Testing a range of potential alerting sounds is also planned including playbacks of natural conspecific calls and synthesized sounds to test for auditory conspicuousness.

Efforts to Examine and Mitigate the Potential Effects of Motorized Watercraft Use on Cook Inlet Beluga Whale *Delphinapterus leucas* Activity in Alaska's Twentymile River During Seasonal Fish Spawning Periods

Steinert, Suzanne D.

Critically endangered Cook Inlet Beluga Whale *Delphinapterus leucas* (CIBW) activity in Alaska's Twentymile River has been confirmed by previous research and indicated via anecdotal observations. Heightened human activity on the river during seasonal fish spawning periods may coincide with increased CIBW use and need of access to the river and adjacent critical habitat during this time. Motorized watercraft use, the dominant use type in this location (primarily for the purpose of fishing), may adversely affect beluga whales as a source of noise and potential strikes. This pilot study initiated efforts to: 1) Document the extent of CIBW use of the Twentymile River; 2) Determine the potential effects motorized watercraft use may have on beluga activity and behavior in this location; and 3) Gauge boater knowledge of CIBW activity on the river. A final objective was engaging the boating community in a participatory manner to inform efforts to and mitigate impacts on belugas. Data was collected via: shore-based observation sessions (n=82) on 78 sampling days (May-October); recreational boater interviews (n = 49); and in collaboration with local commercial river guides (n=3). A total of 121 belugas were observed (including calves) and 160 boats (99% motorized). The highest levels of beluga and boating activity were observed during the salmon run period (August-October). Out of 15 total 'interactions' of belugas with watercraft observed or reported, 5 instances of belugas displaying acute behavioral shifts in apparent response to boats were documented. 41% (n=20) of boater interview groups displaying a lack of awareness regarding CIBW activity on Twentymile and the potential effects of motorized watercraft use on belugas, indicating a need for increased education to mitigate future impacts. To inform mitigation efforts, boaters were asked to reflect on the issue and provide useful suggestions to more effectively increase awareness and encourage 'beluga friendly' boating practices.

Monitoring, managing, and mitigating marine mammal and fisheries interactions under the Marine Mammal Protection Act and Endangered Species Act

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Many marine mammal populations worldwide are endangered or threatened due to extreme over-exploitation in past decades. While new management regimes in the U.S. have emerged to prevent over-harvest of marine mammal populations, the recovery of many of these populations continues to be threatened by anthropogenic activities. In the U.S., the Marine Mammal Protection Act (MMPA) offers protection to all marine mammals and prohibits acts that could result in mortality, serious injury, or harassment. Further, for those marine mammal species which are listed under the Endangered Species Act (ESA), there are additional protections in place to help promote recovery. Fishery interactions are among the greatest anthropogenic risks to marine mammal populations; however, they represent complicated issues and can be challenging to mitigate. The MMPA and ESA include exemptions for mortalities and/or serious injuries incidental to commercial fishing. The MMPA includes a process, called List of Fisheries, for evaluating and managing fisheries based on the relative impact of an individual fishery on a marine mammal stock's recovery. There are many misconceptions about the rules and regulations governing marine mammal bycatch. In this presentation, we will outline the process under the MMPA and ESA for monitoring, managing, and mitigating marine mammal and fisheries interactions.

Beating them at their own game: can fishermen use acoustics to spy on Sperm Whales?

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Depredation of longlines is a worldwide problem for fishermen and cetaceans. In Alaska, depredation of commercial longline gear in the Gulf of Alaska (GOA) increases harvesting costs and the risk of marine mammal entanglement. The Sablefish stock assessment estimates Sperm Whales depredate 5% of the Sablefish longline gear and remove 24% to 29% of the Sablefish annually. The Southeast Alaska Sperm Whale Avoidance Project (SEASWAP) was created in 2003 as a unique collaboration to evaluate depredation and develop practical deterrents. In 2016, SEASWAP began testing a cost effective avoidance solution. The goal was to assist fishermen in avoiding whale depredation by using acoustic listening devices to determine whale presence/absence prior to setting gear. A towed hydrophone array using passive acoustic monitoring (PAM) was deployed and retrieved from fishing vessels operating at normal transit speeds. The array system was tested for a total of 20 days during two cruises offshore and one cruise in the deep, inside waters of Chatham Strait. During a three-day off-shore survey 25 Sperm Whales were logged using the towed array system. Detections were possible at normal transit speeds (6-8 knots); however, noise decreased and detection range improved with slower vessel speeds. Whales were detected up to eight miles. This pilot work demonstrated that the towed array can be deployed and retrieved from longline vessels without the need to shift the vessel in and out of gear, which minimizes acoustic cues to attract Sperm Whales. The ability to detect Sperm Whales at distances of eight miles provides the vessel operator with a powerful new tool to identify “whale free” areas and reduces the opportunity for depredation. Placing towed array systems on vessels could provide information to map Sperm Whale distribution over a large geographic area, supporting a real-time reporting network to identify areas of high whale activity.

Marine Derived Nutrients in Coastal Watersheds: What is Myth and What is Reality?

Landscape heterogeneity mediates flows of salmon subsidies to consumers

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Salmon runs subsidize inland food webs with marine-derived trophic resources. At higher latitudes, salmon are still at their historical levels of abundance and provide the majority of seasonal energy gain for a variety of consumers. It's widely assumed that it is the abundance of salmon that mediates their significance to iconic predators such as brown bear and Rainbow Trout. However, accumulating studies are revealing that landscape heterogeneity and connectivity also play a large role. Here we describe the time constraints that prevent consumers from fully exploiting salmon subsidies and review behavioral and physiological tactics by which consumers exploit landscape heterogeneity to increase seasonal energy gain. We end by exploring how watershed development can alter the ability of consumers to exploit salmon subsidies, magnifying trade-offs between commercial salmon fisheries and inland food webs.

Can short-term nutrient additions lead to long-term recovery of Pacific salmon?

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In response to declining salmon populations, multiple restoration actions have been implemented in the freshwater tributaries where salmon spawn and rear. Among these is the addition of salmon carcasses or artificial nutrients to mimic marine derived nutrients historically provided by large spawning runs of salmon. The assumption is that the increase in nutrients will “jump start” a positive trend to population growth. Although immediate effects on aquatic ecosystems, such as increasing primary production, invertebrate biomass, and fish biomass and growth have been observed, it is unclear if nutrient additions can result in long-term population increases for salmon. To test this assumption and uncertainty, we linked a food web model with a salmon life cycle model to see if nutrient additions in a river reach would improve conditions for salmon in the long term. Preliminary results confirmed increases in biomass of periphyton, macroinvertebrates, and fish during carcass additions. In addition, the larger size of juvenile salmon improved survival and the abundance of smolts migrating to the ocean, which translated to a greater number of adults returning, further influencing the positive feedback of salmon on the food web. However, once additions ceased, biomass and abundance levels gradually returned to previous conditions, which, based on our model, may be due to factors outside the tributaries. For instance, if survival can be improved downstream, populations may increase and provide the benefits of marine derived nutrients over time. Moreover, out of basin actions would benefit multiple populations opposed to one represented with our model.

Movement response of juvenile Chinook Salmon *Oncorhynchus tshawytscha* to carcasses of Rainbow Trout *O. mykiss* and Pacific Lamprey *E. tridentatus*

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Fish carcasses provide nutrients to stream food webs, which support juvenile salmon via trophic pathways, but few studies have investigated indirect behavioral responses of fish to carcass subsidies. We investigated the effects of decomposing Pacific Lamprey *Entosphenus tridentatus* and Rainbow Trout *Oncorhynchus mykiss* carcasses on basal food web components and the behavioral growth and movement response of juvenile Chinook Salmon *Oncorhynchus tshawytscha* in an artificial flow-through mesocosm system. Decomposition pathways differed between species whereby lamprey carcasses were colonized by fungi to a greater extent than trout carcasses, gained wet mass during the first week of the experiment, and lost mass at a slower rate than trout carcasses. Carcasses provided short term release from nutrient limitation because chlorophyll a was significantly higher in unshaded treatments for both carcass types after one week, and was also significantly higher on shaded tiles in trout treatments relative to no-carcass control conditions. Chlorophyll a concentrations in trout treatments were significantly elevated over controls under both lighting conditions at the end of the four-week experiment. Mean macroinvertebrate biomass at the end of the experiment was not significantly different across treatments. We observed no growth response in juvenile salmon over the four weeks, but saw the greatest emigration under control conditions, moderate emigration with Rainbow Trout carcasses, and lowest with Pacific Lamprey carcasses. Taken together, we conclude that lamprey and salmonid carcasses create patches perceived as a resource by juvenile salmon in open stream systems and that density-related movement responses to trophic subsidies may exist even where biomass-related responses are undetected.

What We Know About Marine-Derived Nutrients and Riparian Vegetation

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As they return to spawn and die in their natal streams, anadromous Pacific salmon (*Oncorhynchus* spp.) carry nutrients from the Pacific Ocean to riverine ecosystems. These marine-derived nutrients are delivered to riparian vegetation via fluvial processes and the wastes of bears (*Ursus* spp.) and other fish-eating animals. Analyses of naturally-occurring stable isotopes and annual growth rings have indicated that trees growing near salmon spawning streams may derive as much as 24% of their foliar nitrogen from marine-derived sources, and that growth rates are significantly enhanced in trees that receive this nutrient subsidy. These findings are largely based on broad comparisons of watersheds with and without salmon, and some of this work has been called into question for pseudoreplication and not fully accounting for potentially confounding variables. Recent results from a long-term, controlled fertilization experiment corroborate those of earlier studies, indicating that nutrients from salmon carcasses enhance riparian tree growth, and that the growth response may occur within a relatively short period of time (i.e., two decades). Nonetheless, dendrochronological analyses have shown inconsistent temporal correlations between annual salmon escapement and riparian growth, suggesting that the importance of the marine-derived nutrient subsidy is not universal. Researchers have proposed using isotopic signatures from tree ring samples to reconstruct historical salmon abundances, but attempts to do so are confounded by interradial mobility of nitrogen within trees. Attempts to overcome this problem using solvent-based extraction to remove nonstructural, mobile nitrogen fractions have been unsuccessful.

The influence of fall-spawning Coho Salmon *Oncorhynchus kisutch* on growth and production of juvenile Coho Salmon rearing in beaver ponds on the Copper River Delta, Alaska

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Land, Dirk. Chugach NF

We examined the influence of fall-spawning Coho Salmon *Oncorhynchus kisutch* on the density, growth rate, body condition, and survival to outmigration of juvenile Coho Salmon on the Copper River Delta, Alaska, USA. During the fall, fish rearing in beaver ponds that received spawning salmon were compared with fish from ponds that did not receive spawners and also with fish from ponds that were artificially enriched with salmon carcasses and eggs. The response to spawning salmon was variable. In some ponds, fall-spawning salmon increased growth rates and improved the condition of juvenile Coho Salmon. The enrichment with salmon carcasses and eggs significantly increased growth rates of fish in non-spawning ponds. However, there was little evidence that the short-term growth benefits observed in the fall led to greater overwinter growth or survival to outmigration when compared with fish from the non-spawning ponds. One potential reason for this result may be that nutrients from spawning salmon are widely distributed across the delta because of hydrologic connectivity and hyporheic flows. The relationship among spawning salmon, overwinter growth, and smolt production on the Copper River Delta does not appear to be limited entirely to a simple positive feedback loop.

Effects of Pacific salmon on freshwater and riparian ecosystems

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Many studies have indicated effects of Pacific salmon on species of plants and animals in streams and adjacent forest ecosystems, potentially offering insight to fisheries managers interested in ecosystem-based management. These effects stem from nutrients dispersed from carcasses, and physical scouring of the substrate when spawning. First, we present case studies of nutrients and birds and plants in watersheds on the central coast of British Columbia. Then we summarize published relationships into individual, population, and ecosystem-level processes and identify the form of ecological responses to salmon densities, with a goal to identify threshold values (i.e. at asymptotes). We found 157 relationships from 47 studies that quantified the influence of salmon density on species abundance, diversity, food provisioning, growth, stable isotopic proxies of salmon use, nutrient enhancement, and phenology. We found that 17% of relationships between salmon density and an ecological response were asymptotic. Most of the other ecological responses showed a linear or curved non-asymptotic relationship with salmon density (46%), while 37% showed no relationship. Of the 142 relationships where the direction of the slope was ecologically meaningful, over half were positive (53%), and 8% were negative. These results were similar across aquatic and terrestrial realms. Stable isotopes, which measure the extent of marine-derived nutrients, were the most common relationship studied, reached asymptotes at lower salmon densities than food provisioning, and they provide no information about the potential ecological effects of those nutrients. The wide variety of quantitative relationships (and non-relationships) of salmon-ecological responses yet studied present a serious challenge for ecosystem-based management.

Have nitrogen stable isotopes led us astray in our efforts to understand salmon effects in watersheds?

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The burgeoning literature documenting the effects of salmon-derived nutrients on watersheds during the last 25 years has coincided with widespread use of stable isotope tracers in ecology, as these analyses have become increasingly economical to perform. Because adult salmon accumulate most of their growth in the ocean where nitrogen pools are enriched in 15N relative to watershed sources, it is possible that tracking changes in d15N through watershed nitrogen cycles provides an opportunity to quantify the effects of salmon on ecological processes in recipient ecosystems. Most papers that claim to demonstrate salmon effects on watershed processes have assumed that elevated d15N values are solely indicative of inputs of salmon-derived nutrients and that increased values of d15N can be equated to changes in process rates. These conclusions further assume that recipient ecosystems are N-limited and that biogeochemical processes in watersheds do not modify d15N in various watershed N pools. Simultaneous studies of N isotope tracers and ecological processes are rare in the salmon-derived nutrient literature. Where ecological processes and d15N tracers have been studied in the same system, it is often the case that changes in d15N overestimate the importance of salmon-derived nutrients for ecosystem processes. Situations where salmon-derived nutrients appear to be clearly important and reliably traced with d15N are where predators and scavengers directly consume salmon tissues. In many cases, the abilities of consumers to capitalize on salmon is constrained by geomorphic or hydrologic features of the ecosystem.

Patterns of Food Web Responses to Marine Nutrients in Stream Ecosystems

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Science has provided a plethora of new information in recent decades on the ecological effects of marine nutrients from anadromous fishes on land-based ecosystems. As is often the case with new scientific information though, the narrative on ecosystem effects may have outpaced the science in some regards. Nonetheless, our findings from several regions of Alaska and Idaho have consistently shown relatively strong and predictable ecological effects on stream food webs and stream-resident fishes from runs of Pacific salmon, with river-spawning salmon species (Chinook, Coho, Chum, Pink Salmon). Experimental designs that transcend from small-scale, highly replicated experimental channels that target mechanistic processes, to stream reach and watershed scale studies that target populations, have shown that marine nutrients increase stream-resident fish growth, body condition and size, marine isotopic signatures, omega-3 fatty acids, and energy reserves. Lower trophic levels (periphyton, macroinvertebrates) that support fishes have also responded similarly. Further, recent evidence from Western Alaska suggests that large runs of Pink Salmon increase returns of Chinook and Coho Salmon. Environmental factors including baseline nutrient levels, streambed substrate type, community composition, and physical disturbance play key roles on how ecological effects play out, but precisely how, when, where, and to what magnitude is uncertain. In spite of existing information gaps, and the need for more information especially at watershed and population scales across a broader ecological expanse, research efforts have made substantial progress helping us understand the ecological effects of marine nutrients on land-based consumers and ecosystems.

Pink and Chum Symposia

Population Structure of Even-year Pink Salmon from Prince William Sound, Alaska

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Pink Salmon *Oncorhynchus gorbuscha* are commercially and ecologically important in Prince William Sound (PWS). Along with natural production, four private non-profit (PNP) hatcheries in PWS also provide salmon for harvest. These hatcheries contribute 55% - 86% of Pink Salmon returning to PWS, and result in hatchery proportions in the escapement ranging from 4% to 15% (2013-2015). The scale of the hatchery programs raised concerns that hatchery fish may influence the productivity of wild salmon through domestication selection and erosion of local adaptations. Hatchery operators proposed that ADF&G organize a science panel of experts to design and implement a long term research project to inform future resource management decisions. The panel identified understanding population structure of PWS Pink Salmon as one of the primary research questions. Pink Salmon have a 2-year lifecycle and thus there are 2 separate lineages in PWS. Previous examination of population structure of PWS Pink Salmon in an odd year (2013) found low, but significant differences among population structured by geography. Here, we used variation at 16 microsatellite loci from approximately 6,500 samples collected across time from spawning Pink Salmon in 30 locations in an even year (2014). Population divergence in the even-year broodline (FST = 0.0008) was less than that of the odd-year broodline (FST = 0.0020). This pattern is similar to the structure found in both even and odd-year Pink Salmon in British Columbia and Washington.

Distinctions between early and late return timing (not tested with odd-year samples) were detected within several stream systems. Similar to the odd-year analysis, Solomon Gulch Hatchery in the northeastern region was most distinct of all regions. Future analyses will compare population structure of these contemporary samples to historic collections from the 1990's. This last phase will provide insights regarding introgression from hatchery to wild spawning aggregates.

Spawning Habitat Characteristics and Phenology of Fall Chum Salmon *Oncorhynchus keta* on the Teedriinjik River, Alaska

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Spawning site selection by Pacific salmon is influenced by physical and chemical habitat characteristics that influence embryonic developmental rates and can result in variation in hatching and emergence timing within and among species. In sub-Arctic rivers, groundwater-surface water interactions result in a wide variety of thermal habitat conditions, but the effects on early life history phenology are unknown. We measured water chemistry (conductivity, dissolved oxygen, and pH) and physical habitat characteristics (water temperature, water velocity, and substrate composition) at 11 sites representative of three geomorphic channel types (primary, flood, and spring), and used continuous water temperature data to assess overwinter thermal trends experienced by incubating fall Chum Salmon *Oncorhynchus keta* embryos along the Teedriinjik River, Alaska. Spawning habitat characteristics including mean temperature, conductivity, and vertical hydraulic gradient differed by channel type. Temperature was negatively correlated with dissolved oxygen and pH, and positively correlated with conductivity. Predicted hatching timing for primary, flood, and spring channels was 121 d, 142 (± 68 SD) d, and 149 (± 23 SD) d, respectively. The temporal extent of our data were only sufficient to predict emergence in flood channels, resulting in a mean predicted emergence of 222 (± 49 SD) d. The Teedriinjik River is a consistently strong producer of fall Chum Salmon in the Yukon River Basin, but nearby tributaries such as the Fishing Branch River have experienced drastic declines in fall chum numbers. Information provided by this study will assist natural resource managers in understanding the causes of this regional variation, and help them prepare for the effects of future climate and anthropogenic change in the region.

Comparative performance in migration and reproduction between natural- and hatchery-origin Pink Salmon *Oncorhynchus gorbuscha* in Prince William Sound, Alaska using stable isotope analysis

Gorman, Kristen B.

McMahon, Julia M.; Rand, Peter S.; Knudsen, E. Eric

We report on a one season pilot project conducted in 2015 testing the null hypothesis that hatchery-origin Pink Salmon *Oncorhynchus gorbusch*a are similar in their at-sea foraging strategies to natural-origin conspecifics in Prince William Sound (PWS), Alaska, and therefore similar in their migratory timing, body condition, and spawning performance. Research is based on tissue-specific carbon and nitrogen stable isotope (SI) values (13C and 15N) as biogeochemical proxies of foraging. Our work is motivated by studies of interactions among PWS natural- and hatchery-origin Pink Salmon by Alaska Department of Fish & Game that have focused on quantifying fractions of hatchery salmon on spawning streams and understanding possible impacts hatchery spawning has on the survival of natural-origin offspring. This project adds a mechanistic perspective by considering at-sea foraging determinants of performance in migration and reproduction that

might shape individual fitness. The at-sea life histories of Pacific salmon are not well understood and few studies have used SI techniques to test ideas about within-species variation in foraging and relationships with performance factors. We discuss results from Pink Salmon captured at the ocean entrances to PWS during migration, and on 11 streams throughout PWS during spawning. Ocean and stream analyses examined relationships between male or female body size and condition with foraging based on 13C and 15N variability in muscle and liver tissue, timing of migration, hatchery- or natural-origin status, and interactions between these variables. Ocean and stream datasets were further examined to assess relationships with fitness correlates including gonad mass, female fecundity and egg size. Our work lends insight on Pacific salmon oceanic ecology and relationships with migration and spawning performance factors. The work also provides an initial assessment of variability in life history parameters between hatchery- and natural-origin Pink Salmon in Alaska.

Detecting Spatial and Temporal Patterns of Covariation Between Ocean Conditions and Size at Age of Oregon Coast Chum Salmon Using Dynamic Linear Models

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I evaluated the relationships between 22 environmental indicators and variation in adult Chum Salmon size at age between 1996 and 2014 from five wild Oregon populations to a) determine the extent of spatial variability in marine growth rate in this species and b) estimate the temporal correlations between marine growth and ocean conditions. Most of the environmental indicators have been monitored each year since 1996 in coastal waters off central Oregon. I analyzed the spatial and temporal structure of these data with dynamic linear models, which indicated that the temporal trends in marine growth differed among the populations. Correlations between Chum Salmon growth rate and regional environmental indicators were observed as often during the year of final ocean residence as during the year of ocean entry, suggesting that the marine environment experienced during the final year of ocean residence is as important as that experienced during the year of seaward migration for Chum Salmon production in this area. The environmental indicators most commonly correlated with temporal variation in Chum Salmon growth were anomalies in the Pacific Decadal Oscillation index (PDO), Oceanic Nino Index (ONI), and Coastal Upwelling Index (CUI); copepod biomass and diversity; sea surface temperature; and summer abundance of juvenile Coho and Chinook Salmon sampled off the Columbia River. These patterns suggest that the influence of ocean conditions on variation in Chum Salmon growth are typically weak and short-lived but they are detectable. The strong environmental anomalies that were observed in 2015 and 2016 will likely have important consequences for marine survival and growth of Chum Salmon in this southernmost part of its range in North America.

Where did that Pink Salmon come from? Using thermal marks to identify and enumerate hatchery Pink Salmon strays to streams in Lower Cook Inlet

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With the recent reopening of the Tutka Bay and Port Graham hatcheries in Lower Cook Inlet (LCI), ADF&G staff in Homer initiated a sampling program to evaluate the potential of hatchery Pink Salmon *Oncorhynchus gorbuscha* straying into LCI area streams. Beginning in brood year 2012, thermal marks applied to the otoliths of all Pink Salmon raised in LCI hatcheries have allowed the department to identify returning adults to their hatchery of origin and release site. Since 2014, Homer staff have collected 6,634 otolith pairs from spawned out Pink Salmon carcasses on 17 streams in Kachemak Bay

and along the Outer Coast. The percentage of LCI hatchery strays identified in samples ranged from 0% in many streams outside of hatchery special harvest areas, up to 100% in a stream adjacent to the Tutka Bay Lagoon Hatchery (TBLH). The high incidence of TBLH marks in the Tutka Lagoon Creek sample was not surprising given that the creek provides both the water and the brood source for the hatchery. The relative absence of LCI hatchery strays in streams greater than 6 miles from hatchery release sites is noteworthy, as is our contrasting observation that some LCI stream samples had very high percentages (30–87%) of thermally-marked Pink Salmon from hatcheries in Prince William Sound (PWS) that are 150-250 miles away. This latter observation may represent the first time PWS hatchery Pink Salmon have been documented spawning in streams well outside of PWS and should be instrumental towards considering an expanded geographic scale for future hatchery-wild interaction research.

Why we need to know why wild Alaska salmon taste better.

Jordan, Eric

In thinking about this year's American Fisheries Society meeting theme, Communications and Modern Tools for Research & Management combined with the Pink & Chum Workshop, it dawned on me that Alaskans have been communicating about and doing research on a question regarding salmon for thousands of years: Which salmon taste best? Every individual, every village, and every region in Alaska has an opinion. Whether it is an opinion about white versus red king salmon in SE Alaska or Yukon versus Kuskokwim chum in Interior Alaska, or Copper River versus all other Alaska salmon, or Alaska Wild Salmon versus farmed salmon, the debate rages. But the research tools have varied little for centuries. You prepare two of the salmon identically and ask tasters which tastes the best. Because this is so important in marketing wild Alaska salmon I am humbly suggesting that individuals gathered here think about Modern Tools to research what makes Alaska salmon taste the best. I am not suggesting that we try to determine which Alaska salmon stock tastes the best. Just as I like a variety of fine wines, I love the taste of a diverse variety of wild Alaska salmon. I am often asked by crew members participating in the Crew Apprentice Program why the salmon they are eating on my boat taste so much better than the farmed salmon they have eaten. My answer is: sometimes we know the what, that salmon like to jump for example, but the why remains a mystery. In my presentation I will explain why figuring out why a whole variety of Alaska salmon taste better than farmed salmon is important. Eric Jordan Lifelong Alaskan salmon fisherman and taster.

Relative and Total Contributions of Hatchery- and Natural-origin Pink Salmon and Chum Salmon Returning to Prince William Sound, Alaska during 2013-2015

Knudsen, E.

Gorman, K.; Rand, P.; Buckhorn, M.; Bernard, D.

We report on results of the Alaska Hatchery Research Program (AHRP) focused on estimating the contribution of hatchery- and natural-origin Pink *Oncorhynchus gorbuscha* and Chum *O. keta* Salmon to Prince William Sound (PWS), Alaska (2013-2015). Data are from ocean test fishing at 9 stations and carcass surveys in 32 streams in PWS. We explained variability in the odds ratio (OR) of observing hatchery-origin salmon using a binomial general linear model across sampling strata (ocean stations and stream districts) in addition to other covariates. We produced unbiased estimates of the fraction of hatchery-origin salmon in the run by applying measures of abundance (CPUE from test fishing and carcass counts in stream surveys). We found significant differences in OR by year, day of year, ocean station and stream districts. We found

OR to be greater during 2014 for Pink Salmon that reflects lower returns of natural-origin salmon during even years. We observed greater use of the eastern-most stations by natural-origin Pink Salmon suggesting wild fish may select certain migratory paths for entering PWS. The western-most test fishing station in the eastern PWS entrance exhibited consistently high OR for Chum Salmon over the season and may be related to hatchery-origin fishing homing to the Point Chalmers remote release site (Montague Island). Results from OR for Pink Salmon across stream districts revealed a clear east-west pattern that indicates higher likelihood of observing hatchery strays in western PWS streams. The OR for Chum Salmon was highest in the Montague Island district in PWS. The hatchery fraction of the run measured by test fishing over three years was 54.9-86.4% (Pink Salmon) and 51.1-72.5% (Chum Salmon). Hatchery fractions in the escapement based on stream sampling ranged from 4.4-14.8% (Pink Salmon) and 2.8-3.2% (Chum Salmon).

Long term productivity trends in natural populations of Pink and Chum Salmon from Puget Sound, Washington, USA

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Puget Sound is home to seven anadromous Pacific Salmon (*Oncorhynchus* spp., Steller, 1743) and Trout species, including Pink *O. gorbuscha* and Chum *O. keta* Salmon. In this study, we investigated the effects of environmental variability on productivity in natural populations of Puget Sound Pink and Chum over five decades. Specifically, we used population dynamics and time series analysis to quantify temporal trends in productivity and abundance across local, regional, and basin scales. For Pink Salmon, we did not find any strong temporal trends in productivity, but there was evidence of regional covariance in productivity at fine spatial scales within Puget Sound, with populations increasing in central Puget Sound in recent years, and decreasing in south Puget Sound and the Strait of Juan de Fuca over the same period. Previous studies documented widespread declines in productivity of natural Chum stocks throughout Washington beginning in brood year 1996. Contrary to this result, we found productivity increases in Chum beginning in brood year 2006, and an overall significant increase in abundance over the time series. Increases in natural Pink and Chum populations in recent years is counter to population trajectories documented in other Pacific Salmon stocks within Puget Sound. We also found that regional and basin-scale environmental indicators, such as sea surface temperature and the North Pacific Gyre Oscillation Index, were positively associated with Pink and Chum productivity, a result that could help improve forecasts for these populations. Our results suggest that while environmental variability can drive productivity in natural populations of Pink and Chum Salmon within Puget Sound, other factors such as reduced competition during periods of poor ocean conditions may be equally important in determining productivity.

Ecological Barriers and Bridges to Introgression of Hatchery Produced and Natural Origin Pink Salmon in Prince William Sound, Alaska

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Hatcheries are integral to many salmon fisheries in the North Pacific, yet straying of hatchery produced salmon is of conservation concern because of competition and reproductive interactions on the wild spawning grounds may detrimentally affect wild populations, results in lost yield to harvesters, and can complicate management decisions. Enhancement hatcheries in Alaska are the largest in the world, with over 1.5 billion juveniles of all salmon species released annually, and no region releases more juvenile Pink Salmon *Oncorhynchus gorbuscha* than Prince William Sound (>630 million). Recent studies have reported consistently large numbers of strays on the wild spawning grounds of Prince William Sound, raising concerns of hybridization, outbreeding depression, and competitive interactions. While substantial work has gone into quantifying the rates of recipient straying (i.e., the proportion of a spawning population that is comprised by strays), comparably little is known about the ecology of those strays on the spawning grounds. In this talk I report on results of a pilot study in cooperation with the Alaska Hatchery Research Project, in which I tagged 200 Pink Salmon in Paddy Creek; 100 in early August and 100 in late August, and recovered 77 specimens with otoliths that were distinguished to origin by post season otolith readings (n=31 early, n=46 late). The individuals of the early release group were all of natural origin and a Bartlett's test of in-stream life span (a phenotypic trait associated with fitness) of recovered individuals showed that in-stream life span was highly variable in the early release group ($p<0.05$). This is most likely from increased risk of bear predation because this result is consistent with other salmon studies involving high bear predation rates in small streams. The later release group had both hatchery and natural origin individuals. There was homogenous variance of in-stream life-span and a t-test indicated that in-stream life span was significantly different by origin ($p<0.05$), with hatchery fish living 2 days less than natural fish on average. The sample size for these results is small and un-replicated, but it provides exciting preliminary results and framework to pursue a larger tagging effort in 2018.

Effects of Asian Pink Salmon and Chum Salmon on the Growth of Western Alaska Chum Salmon

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Poor returns in western Alaska stocks of Chum Salmon *Oncorhynchus keta* have been accompanied by reductions in growth, body size, and increases in age at maturity throughout the species' range. Western Alaska Chum Salmon reside in the Bering Sea during their summer foraging months where they overlap with abundant populations of Russian Pink Salmon *O. gorbuscha* (primarily wild origin) and Japanese Chum Salmon (primarily hatchery origin). Spatial and diet overlap suggests that inter- and intra-specific competition may contribute to reduced growth and increased age at maturity of western Alaska Chum Salmon. We investigated the potential for such competition to influence the growth of western Alaska Chum Salmon growth using retrospective scale analysis. Chum Salmon scale samples were collected through escapement and harvest projects in Bethel, Alaska, during 1973-2014, and from incidental catches of Chum Salmon in the Bering Sea Aleutian Island Walleye Pollock *Gadus chalcogrammus* fishery during 2001-2016. Linear mixed-effects models demonstrated a strong negative relationship between Bethel Chum Salmon growth and the abundance of Japanese hatchery Chum Salmon. Chum Salmon intercepted in the Bering Sea did not exhibit increased growth during 2012-2014, despite reductions in Japanese hatchery releases of Chum Salmon in 2011 as a result of the Tohōku Earthquake. We did not observe a direct relationship between Bethel Chum Salmon growth and the abundance of wild Russian Pink Salmon. Understanding how salmon populations interact while at sea has important management implications, particularly as Pacific Rim nations consider increasing production of hatchery salmon.

Who's catching what and where? Using otolith thermal marks to better understand and manage hatchery-wild Pink Salmon interactions in Lower Cook Inlet commercial fisheries

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Pink Salmon *Oncorhynchus gorbuscha* hatcheries in Tutka Bay Lagoon (TBLH) and Port Graham Bay (PGH) recently reopened and are expected to soon reach full production under their existing permits, releasing up to 200 million fry annually. To facilitate informed inseason management of commercial fisheries targeting wild and hatchery-produced Pink Salmon in the Lower Cook Inlet (LCI) area, managers with the Alaska Department of Fish and Game (ADF&G) need to distinguish between wild and hatchery fish in the commercial harvest and in spawning escapements to area streams with wild stock escapement goals. Every Pink Salmon raised in LCI hatcheries is marked with a series of unique thermal bands on their otoliths so returning adults can be identified to their hatchery of origin and release site. With representative spatial and temporal sampling of the commercial harvest, managers can determine where and when hatchery and wild salmon are harvested and can use that information to ensure wild stocks are not overharvested while targeting large hatchery returns. Homer staff have collected >2,800 otoliths from Pink Salmon harvested in commercial purse seine and set gillnet fisheries in Kachemak Bay since 2015. Preliminary results indicate LCI hatcheries contributed half of the Pink Salmon harvested in common property commercial fisheries in the Southern District during 2015–2017. Nearly 98% of the cost-recovery harvest inside the Tutka Hatchery Special Harvest Area (SHA) derived from hatchery production, indicating limited interception of wild stocks. Overall, Pink Salmon index streams in the Southern and Outer districts met their respective escapement goals throughout this recent period of increased harvests targeting large hatchery returns. We will discuss various management implications associated with our preliminary results and will describe plans to strengthen our otolith sampling program to improve our understanding of hatchery-wild Pink Salmon interactions in LCI.

Alaska Hatchery Research Program: overview of an ambitious examination of hatchery-wild interactions

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Ocean-ranching, private non-profit hatcheries produce one third of salmon harvested annually in Alaska. The vast majority of this hatchery production is of Pink Salmon in Prince William Sound and Chum Salmon in Southeast Alaska. Previous research on the potential fitness consequences to wild salmon due to hatchery-wild interactions is not sufficient, as most research has been conducted outside Alaska where the magnitude of releases, habitat quality, program goals, and species cultured differ greatly from the Alaska model. Given the commercial value of hatchery production, the mandate that hatchery production be compatible with sustainable productivity of wild stocks, and the uncertainties regarding impacts on wild stocks, the Alaska Department of Fish and Game organized a science panel of experts to design a long-term research project (Alaska Hatchery Research Program; AHRP) to address this issue. The AHRP is addressing three priority issues: 1. What is the genetic stock structure of Pink Salmon and Chum Salmon in each region? 2. What is the extent and annual variability in straying of hatchery-origin Pink Salmon and Chum Salmon in each region? 3. What is the impact on fitness (productivity) of wild Pink Salmon and Chum Salmon stocks due to straying of hatchery-origin salmon in each region? The

presentation will provide an overview of the AHRP in order to delineate the scope of the research and provide context for some preliminary AHRP results presented by other authors at this symposium.

An evaluation of collaborative salmon fishery management in Prince William Sound, Alaska.

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Collaborative decision-making is often promoted as a means to achieve socially acceptable and enduring solutions to natural resource management issues, and one that holds promise for resolving "wicked" problems. However, success rates for implementation of collaborative recommendations are unknown. The presenter's graduate program explored challenges to collaborative salmon fishery management in Prince William Sound (PWS), Alaska, based on experience made possible through internship service on the Prince William Sound Aquaculture Corporation (PWSAC) Board of Directors. Three constraints to collaborative salmon fishery management in PWS were identified, including: (1) PWS citizens' mistrust of public managers, (2) recent and ongoing reductions to the State of Alaska's budget, and (3) a lack of individual and organizational capacity among the area's prospective collaborators. The presentation then identifies several broad lessons to consider when collaborating, including: (1) the importance of selecting participants who possess relevant knowledge and who are willing to compromise, (2) an awareness and acceptance of the significant resources and time that collaborations require, (3) the availability of organizational capacity to support these endeavors, and (4) the availability of individuals with the credibility and skills required to effectively lead collaborations. The presentation concludes with some recommendations for the area's fishery participants to consider when attempting collaborations in the future.

Stress, straying, and performance on the spawning grounds by hatchery-produced Chum Salmon in Southeast Alaska

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Hatchery programs around the Pacific Rim release approximately five billion Pacific salmon each year into the North Pacific Ocean, prompting concerns about interactions with wild counterparts. Straying of hatchery-produced individuals mediates interactions with wild

spawning populations, though relatively little is known about neither the proximate factors shaping straying, nor the performance of strays on the spawning grounds. In this talk, we present results that explore the potential influence of stress on homing and straying rates of hatchery-produced salmon by comparing cortisol concentrations between those that have homed (correctly returning to imprinting location) to those that strayed (returned to location other than release site). Cortisol levels were associated with fitness-proxies such as the number of days a fish lived on the spawning grounds and extent of egg retention in females. As an additional proxy for stress, we quantified the frequency of abnormal vateritic otolith development between homing and straying hatchery-produced salmon. Finally, we assessed the potential for otolith thermal marking, a widely used approach that exposes developing individuals to abrupt temperature fluctuations to induce a visible

mark within the otolith, to influence rates of vaterite occurrence. No differences were found between hatchery-produced chum that had homed or strayed in cortisol concentrations of either males (stray = 113.4 ± 99.7 ng/ml; home = 124.66 ± 113.81 ng/ml) or females (stray = 329 ± 208.9 ng/ml; home = 294.12 ± 134.8 ng/ml) or rates of vaterite occurrence (stray = 40% vaterite; home = 45% vaterite). Instream lifespan was negatively correlated with cortisol concentrations, though egg retention rates were not related to cortisol concentration. There was a slight, though not statistically significant, increase in vaterite occurrence in individuals with high thermal mark intensities (low = 32%, medium = 32%, high = 39%). The lack of differences in cortisol concentrations and rates of vaterite occurrence between correctly homing and straying groups suggest that straying is not significantly linked to these physiological measures, at least on the spawning grounds. Although increasing mark complexity did not correlate with higher rates of vaterite occurrence, natural-origin fish had on average 24% lower rates of vaterite than their hatchery-produced analogs, consistent with results from other researchers.

Reweaving the Fabric of Nature: Changing Food Webs and challenges for Freshwater Fisheries Management

Glaciers and Salmon in Southeast Alaska: Can landscape complexity and mobility influence energy pathways to aquatic consumers?

Bellmore, J. Ryan

Fellman, Jason B.; Hood, Eran; Edwards, Richard T.; Caudill, Christopher C.

Landscape heterogeneity resulting in varying stream physicochemical conditions can create spatial variation in food web structure and dynamics. Watersheds in southeast Alaska typically contain a mosaic of glacier, snowmelt, and wetland-dominated rainfall streams that have distinct hydrologic, thermal, organic matter, and nutrient regimes. In turn, these diverse stream types may support food webs underlined by asynchronous patterns of resource availability to mobile consumers, such as fish. However, watershed deglaciation coupled with snow-to-rain shifts may simplify hydrology. Hydrologic homogenization could drive the loss of food webs unique to each stream type and synchronization of resource productivity, limiting the capacity of landscapes to support fish populations. To evaluate the potential importance of landscape heterogeneity on fish, we used an aquatic food web model parameterized with long-term physicochemical datasets from southeast Alaskan streams to explore patterns of resource availability (biofilm and invertebrates) to fish in glacial, snowmelt, and rainwater streams. We also collected food web data across these stream types to empirically evaluate the abundance and composition of biofilm, aquatic invertebrates, and fishes. Simulations suggest that glacial, snowmelt, and rainwater streams exhibit asynchronies in resource availability creating a more stable resource base for consumers that can track resource waves through time. Preliminary sampling showed that biofilm biomass was highest in rainwater and snowmelt streams in mid-summer, but declined in all streams during autumn, providing support to our model simulations. Additionally, summer fish abundances were lowest in the most glacially influenced stream and highest in the rainwater stream. Further field research is necessary to evaluate our model simulations of fluctuations in producer and consumer productivity across these stream types and implications for food web stability. This work can inform how climate change and anthropogenic homogenization of landscapes may influence linked food webs and the productivity of culturally, economically, and ecologically important species.

Contemporary phenotypic divergence among populations of an invasive apex predator: Northern Pike *Esox lucius* in its introduced and native ranges of Alaska

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Invading species are a leading cause of species extinctions and extirpations worldwide, but they also pose the opportunity to study contemporary evolution and ecological processes. Northern Pike are invaders of Southcentral Alaska, despite being native north and west of the Alaska Range. Starting with introductions in the 1950s, Northern Pike have subsequently spread to hundreds of non-native habitats in Alaska. This invasion process presents us with a natural experiment to explore evolution of these populations to novel environments. In this talk, I present results of a project that examined phenotypic divergence in Northern Pike in a suite of presumably adaptive traits. I performed a morphometric analysis of 187 sampled fish from 9 different habitats and reveal significant divergence in phenotypes that may be attributable to plastic phenotypic divergence or genetic adaptation to varying habitats and divergent selection. Since the point in time of the initial introduction of Northern Pike into Southcentral Alaska is known, I compared the rates of divergence to an established dataset of phenotypic evolution across taxa. I will address possible explanations for observed changes in population parameters such as body weight and length, and possible influences of founder effects or population bottlenecks. This work provides evidence that these predators can change over the course of only a few generations and warrant implications for future introductions and invasions.

Understanding the indirect effects of climate change on pristine arctic lakes and Arctic Char; delayed, multi-trophic level response to a long-term, low-level fertilization experiment.

Budy, Phaedra

Giblin, Anne; Kling, George; White, Daniel; Luecke, Chris

The climate in the Arctic is warming faster than any place on earth. Indirect effects of warming include thermokarst failures and tundra wildfires, which act as pulse disturbances on lake ecosystems delivering increased nutrients to oligotrophic lakes. Mimicking this disturbance, we fertilized one deep lake with fish and one shallow lake without fish for twelve years and monitored the food web and physiochemical changes over time, relative to paired reference lakes and through the recovery period. Fertilization significantly increased pelagic primary production (chlorophyll a) 4-fold in the deep lakes, resulting in a significant decline in water transparency and cumulative decrease in hypolimnetic oxygen (O2 < 3 mg/L in August of the final year of fertilization). Pelagic secondary production responded significantly to the increase in primary production in the fertilized deep lakes, but not until chlorophyll a levels had doubled (in 5th year). Arctic Char *Salvelinus alpinus* also demonstrated a delayed response to the increase in food availability (zooplankton); abundance of char increased 60% by the 5th year of the study, then remained stable, increasing again in the 10th year of the study to a final abundance 120% greater relative to either the reference lake or the beginning of the experiment. After char abundance reached a high threshold, the zooplankton population crashed in the fertilized deep lake (likely via predation pressure). We demonstrate arctic lakes are sensitive to the delivery of nutrients from climate-induced disturbance, but responses will be slow and may require thresholds of productivity be exceeded before a significant change occurs at the next trophic level. Conversely, physiochemical recovery after cessation of fertilization appears quite rapid, while higher trophic levels have

become dynamic and unstable. Our results demonstrate the importance of long-term ecological research, as many ecosystems will require long time-periods to respond to low-level pulse disturbance.

Climate change induced resource synchronization disrupts Kodiak Brown Bear and salmon food webs

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Climate change is altering the seasonal timing of life-cycle events in organisms across the planet, but the magnitude of change often varies among taxa. This can cause the temporal relationships among species to change, altering the strength of interaction. A large body of work has explored what happens when co-evolved species shift out of sync, but virtually no studies have documented the effects of climate-induced synchronization, which could remove temporal barriers between species and create novel interactions. We explored how a predator, the Kodiak Brown Bear *Ursus arctos middendorffi*, responded to asymmetric phenological shifts between its primary trophic resources, Sockeye Salmon *Oncorhynchus nerka* and red elderberry *Sambucus racemosa*. In years with anomalously high spring air temperatures, elderberry fruited several weeks earlier and became available during the period when salmon spawned in tributary streams. Bears departed salmon spawning streams, where they typically kill 25-75% of the salmon, to forage on berries on adjacent hillsides. This prey switching behavior attenuated an iconic predator-prey interaction and likely altered the many ecological functions that result from bears foraging on salmon. We documented how climate-induced shifts in resource phenology can alter food webs through a mechanism other than trophic mismatch. The current emphasis on singular consumer-resource interactions fails to capture how climate-altered phenologies reschedule resource availability and alter how energy flows through ecosystems.

Patterns of predation on juvenile salmon by Pacific Staghorn Sculpins and Dolly Varden in Southeast Alaska estuaries

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Pacific Staghorn Sculpins *Leptocottus armatus* and Dolly Varden *Salvelinus malma* are common to nearshore habitats along Alaska and British Columbia. In Southeast Alaska, these species are seasonally abundant in estuaries and known to consume juvenile salmon *Oncorhynchus* spp. out-migrating from freshwater streams and hatchery release sites. This raises the question of whether predation by these two species could be an important source of mortality for juvenile salmon as they enter marine waters. As a first step to addressing this question, we sought to 1) quantify the diet compositions of Pacific Staghorn Sculpins and Dolly Varden in estuarine environments, including the contribution of juvenile salmon; 2) assess differences in consumption of juvenile salmon among sites that vary in their proximity to hatchery release sites; and 3) evaluate size-based relationships between focal predators and their salmon prey. We used beach seines to sample predators and juvenile salmon at 4 estuary sites near Juneau, Alaska, from April to September of 2016 and 2017. A subset

of captured predators was retained for stomach content analysis (Staghorn Sculpin n=940, 92-329 mm TL; Dolly Varden n=452, 121-516 mm FL). Juvenile salmon made up 6% and 35% of Staghorn Sculpin and Dolly Varden diets by weight, respectively. Consumption of salmon by Staghorn Sculpins and Dolly Varden was highest in May when juvenile salmon were most abundant in beach seine catches. Our data also indicate that both predator species must reach a threshold length before they incorporate salmon into their diets. Predators consistently consumed shorter than average salmon when compared to length frequency distributions obtained from seine sampling. Ultimately, combining our diet data with consumption models will help us understand the potential magnitude of predation on juvenile salmon at our sites by Staghorn Sculpins and Dolly Varden.

Sensitivity of sculpin and trout to environmental change in small streams: a bioenergetics approach

Dunham, Jason

Jensen, Leslie; Bateman, Doug; Raggon, Mark; Leer, David; Hockman-Wert, David

Fish assemblages in smaller streams of the Pacific Northwest are characterized by two common groups of fish: trout and sculpins. We report preliminary findings from a study to evaluate how these species respond to changes in temperature and food availability using data from a 10-year study of the effects of upstream forest harvest in the headwaters of the Trask River, Oregon. Field surveys indicate that sculpins were the dominant fish in terms of biomass and abundance in three of the four study streams. Field data collected over the course of the study were used to parameterize a bioenergetics model, which we employed to evaluate the sensitivity of trout and sculpins to changes in food availability and temperature. Results indicated that estimates of relative consumption for sculpins were higher than for trout, but that net energetic gain (i.e., growth) for sculpins was lower due to greater physiological costs. Simulations imposing a range of temperature changes on these species similarly indicated that sculpins appear to be more sensitive, as compared to trout. These preliminary findings suggest that considering entire fish assemblages may be critical to understanding responses of fish to environmental change in small streams in the Pacific Northwest.

Riverine food webs and the contribution and quality of food sources to the threatened Australian Lungfish

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Understanding flows of energy and nutrients through food webs can provide insights into mechanisms influencing the structure and function of riverine ecosystems and ecological responses to human disturbances such as changing land use, river impoundment and flow alteration. This study aimed to determine: (1) the effects of human disturbances on basal food sources and food quality for aquatic consumers in Queensland sub-tropical rivers; and (2) the potential for poor food quality to be causing low recruitment of the threatened Australian Lungfish *Neoceratodus forsteri*. By analyzing fatty acids and stable isotopes, this study found that: (1) aquatic consumers were largely supported by algal basal sources, regardless of

the influence of human disturbance; (2) basal food sources and primary aquatic consumers varied in nutritional quality and possessed distinctive fatty acid profiles, but spatial variation was low and unrelated to human disturbances; (3) lungfish eggs had very low fatty acid concentrations, possibly due to the low availability of high-quality food sources, and may explain the low recruitment success of this threatened species; (4) river impoundment and flow alteration was associated with higher contributions of autochthonous pelagic food sources to consumers; (5) catchment land use increased the delta 15N values of food sources and consumers . This study has improved our understanding of river food webs to inform river ecosystem conservation and management.

Do small anadromous salmon populations recolonizing the Cedar River, WA influence the resident food web?

Kiffney, Peter

Naman, Sean; Cram, Jeremy; Pess, George

The structure and function of aquatic ecosystems partly depends on the free movement of animals and matter within, between, and among ecosystems. Anthropogenic barriers can restrict or stop this flow; the loss of which may have consequences for the recipient food web such as when dams block the migration of anadromous fish. We investigated the ecological consequences of recolonization by small populations of Pacific salmon on the resident food web above Landsburg Dam, Cedar River, Washington after a 100-yr absence following installation of a fish ladder. Results from two mesocosm experiments and a before-after field study allowed us to examine the functional relationship between adult salmon carcass biomass and the stream food web. For example, SIA indicated a 3-fold expansion of the isotopic niche space resident Rainbow Trout six years following salmon reintroduction relative to before salmon even though the density of spawning adults was low. We use these combined results to suggest the magnitude of salmon fluxes necessary to affect ecosystem processes in their natal watersheds following barrier removal.

Live Fish, Dead Fish, Fake Fish, No Fish: Effects of Alternative Marine-Derived Nutrient Subsidies to Streams in Central Idaho, USA

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Anadromous fishes that deliver marine-derived nutrients during their return migrations to freshwater habitats influence ecological productivity in Pacific salmon-bearing watersheds. These pulsed resource subsidies, and associated bioturbation, have been shown to influence the quantity and quality of freshwater and linked riparian habitats. However, extirpated or severely diminished returns of anadromous fishes to Columbia River tributaries above the Federal Columbia River Power System have potentially reduced aquatic and terrestrial productivity and associated carrying capacities for resident and anadromous fishes across large spatial scales. We investigated stream ecological responses, at multiple trophic levels (biofilm to fish), to the introduction of: 1) live spawning Chinook Salmon (Live Fish); 2) Chinook Salmon carcasses (Dead Fish); 3) salmon carcass analogs (Fake Fish); 4) and No Fish (Control) in four tributary stream habitats of the Yankee Fork Salmon River, Idaho. We highlight both similarities and differences in stream food web responses across trophic levels in

streams receiving animate (live salmon) and inanimate (carcass and analog) treatment forms of marine-derived subsidies. Our findings suggest that the ecological role anadromous fishes play in freshwater habitats is not wholly mimicked by mitigation strategies such as carcass or carcass analog additions.

Deciphering Changes in Seasonal Predator-Prey Relationships within a Mixed Fishery to Manage Kokanee Production

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Moore, Barry C. Washington State University; Cross, Benjamin K. Confederated Tribes of the Colville Reservation- Fish and Wildlife

Complex food web interactions in mixed warm- and coldwater fisheries can directly impact fish production. Buffalo Lake, located on the Colville Confederated Tribes Reservation in north-central Washington State, has a mixed fishery primarily managed for a sustainable, naturally reproducing Kokanee population. Secondary management goals are to provide Largemouth Bass and stocked Rainbow Trout fisheries. Excess trout stocking may reduce the production of both species through competitive interactions for zooplankton resources, and changes in seasonal food resource availability may alter competitive interactions. In addition, predation from Largemouth Bass could decrease Kokanee and Rainbow Trout production but increase bass production. Using stomach content analysis, seasonal food web interactions for all Buffalo Lake fish species have been studied through quarterly fish collections from 2014 to 2017. Largemouth Bass diets were dominated by crayfish. However, predation on Kokanee and Rainbow Trout occurred during October and May when Kokanee and Rainbow Trout occupied shallower waters. Rainbow Trout were generalists feeders with macroinvertebrates and crayfish consumption representing a dominant part of their diet for most of the year. When compared between seasons and years, the weight of Daphnia and other zooplankton found in Rainbow Trout stomachs was significantly greater in the winter ($P < 0.0001$) and summer of 2015 ($P = 0.035$). The sharing of zooplankton resources provided evidence for significant biological overlap between the diets of Kokanee and Rainbow Trout in February 2015. To mitigate potential competition, it would be advised to stock Rainbow Trout in the spring when diet overlap between Kokanee is minimal. To balance predator prey interactions within the lake's food web, we are currently developing bioenergetics consumption models to quantify the competitive fish interactions (i.e., production trade-offs between species) to guide future management strategies.

Investigating the trophic status of an invasive crayfish in an oligotrophic lake: bottom-up view of a warm and cold-water sport fishery food web

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Moore, Barry C. Washington State University; Cross, Benjamin. Colville Confederated Tribes

Northern Crayfish *Orconectes virilis* were illegally introduced to Buffalo Lake, a north-central Washington oligotrophic lake managed by the Confederated Tribes of the Colville Reservation. By 2002, Northern Crayfish were characterized as extremely abundant throughout the lake. Crayfish are a critical summer food source for Buffalo Lake sport fish and provide for a standalone fishery with no set season or daily bag limit. Despite the importance of this invertebrate to the Buffalo Lake food web, the dietary requirements of this crayfish population remain unknown. The long-term sustainability of this species

as a prey source and harvestable fishery is a question for resource managers because 1) crayfish are a critical subsistence fishery for the community and 2) collapse of the crayfish prey-base could cause Largemouth Bass to target the kokanee, impacting another popular recreational fishery in the lake. Liver tissue has a short isotopic turnover rate, making observations of adult crayfish seasonal trophic position and juvenile-to-adult life stage diet shifts possible. Seasonal δ15N/δ13C values of possible food sources were compared to δ15N/δ13C values of Buffalo Lake crayfish liver tissue collected twice-monthly, April-October 2017. We hypothesize that Northern Crayfish follow resource waves: targeting epiphytic algae, benthic invertebrates, Largemouth Bass eggs, and detritus opportunistically throughout the year. Using stable isotopes and a variety of potential diet sources we aim to describe the foraging behavior or this invasive crayfish population for the benefit of fisheries researchers managing this resource. By identifying the content and seasonality of Northern Crayfish diets we will 1) identify any niche overlap between crayfish and recreational fish species in Buffalo Lake 2) determine long term sustainability of the crayfish fishery which supports a subsistence fishery and is the primary food sources for the Largemouth Bass population.

Exotic species alter food web structure in Pacific Island streams

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The remote nature of Pacific Island streams has resulted in unique and endemic assemblages of flora and fauna that are particularly susceptible to invasion by non-native species. Two well established groups throughout Hawaii include non-native caddisflies (*Cheumatopsyche analis)* and poeciliids (*Poecilia reticulata, Xiphophorus helleri)*. Over the past few years, we have been comparing various ecological and biogeochemical parameters between poeciliid-invaded and poeciliid-free streams along the North Hilo coastline of Hawaii Island. Invaded streams had significantly lower densities of native gobies than non-invaded streams, which was attributed in part to direct predation on gobies by poeciliids as well as shifts in food web structure. Stable isotopes revealed that goby diets in poeciliid-invaded streams shifted from chironomids to a mixture of C. analis and benthic algae. Exotic poeciliids fed significantly more on chironomids (63.7 ± 1.1%) than gobies in poeciliid-invaded streams (40.7 ± 0.6%; $p < 0.001$, $F = 10.2$, $df = 3$). Lower C:N of C. analis suggested they were lower food quality than chironomids, and may have been partially responsible for decreased goby densities in poeciliid-invaded streams. Stable hydrogen (D) isotopes further revealed that increased consumption of exotic caddisflies by native gobies increased allochthonous inputs to food webs historically lacking detritivorous invertebrates and thus leaf litter inputs. Increased algal inputs in poeciliid invaded streams were due to significantly greater algal biomass, which was attributed to higher N availability from poeciliid excretion and thus N remineralization. Exotic poeciliids and caddisflies are altering native food web structures of invaded streams. Poeciliids out-compete native gobies for chironomids (an important component of goby diets) causing gobies to feed more heavily on caddisflies, an exotic and potentially less nutritious food resource. These results suggest that these non-native aquatic species are negatively impacting native fish assemblages in Hawaiian and other tropical streams.

Growth and Foraging Patterns of Juvenile Chinook and Coho Salmon in Three Geomorphically Distinct Sub-Basins of the Kenai River

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Changes in air temperature and precipitation affect juvenile salmon freshwater rearing habitat differently, depending on local habitat conditions. Water temperature acts as a key control on juvenile salmon growth, and some south-central Alaskan salmon streams already experience water temperatures approaching the thermal optimum threshold of 15 -17°C during summer months. However, food resources are an additional key control on growth, and temporal and spatial patterns of the aggregate influence these variables have on juvenile salmon growth is not well characterized. We sampled three drainages encompassing a lowland-to-montane spectrum of catchment types within the Kenai River watershed, south-central Alaska, with differing potential vulnerabilities to warming air and water temperature in 2015-2016. A total of 3159 juvenile Coho Salmon and 1273 juvenile Chinook Salmon were captured, with 720 and 261, respectively, sampled for scales and stomach contents. Air and water temperature data were monitored continuously at lower, middle, and upper sites in each study drainage throughout each sampling season. Temperature, diet, and growth data are being incorporated into bioenergetics models allowing us to determine the degree to which growth rates of juvenile salmon are limited by consumption rates and water temperature. Preliminary results indicate that juvenile Chinook and Coho Salmon rearing in low-elevation tributaries may be exposed to temperatures outside physiological optimum more frequently than montane habitats as summer mean air and water temperatures rise in the future. Our work underscores a growing consensus that diverse habitats within a watershed support diverse early-life history experiences for juvenile salmon, and that conservation of a broad portfolio of intact, interconnected habitats can help ensure the adaptive capacity of wild salmon populations in the face of climate and landscape change.

Foodweb response during and after removal of the Elwha River dams

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The recent removal of the Elwha River dams in Washington State provides a unique opportunity to study ecosystem restoration on a watershed scale. Over the last decade, we have collected data on water chemistry, periphyton, invertebrates, and juvenile salmonid diet to evaluate foodweb response to dam removal. By examining how changes in nutrient dynamics and physical habitat alter primary and secondary production, we are better able to interpret changes in salmonid prey availability and consumption. During the sediment-transport phase of Elwha dam removal (2012-2014), we detected a doubling of downstream total nitrogen and phosphorus concentrations and a ten-fold increase in fine sediment embedded in periphyton. During this same time period, benthic invertebrate densities decreased by 95% in the lower river. The effects of dam removal on salmonid prey availability and diet composition were similar across freshwater and estuary habitats. Prey availability decreased at sediment-impacted sites and salmonid diet composition shifted towards terrestrial sources. Following 2014, we observed recovery of benthic assemblages. As anadromous fish continue recolonizing previously inaccessible habitats, our research focus now turns to the effects of increased salmon subsidies on riverine foodwebs.

Developing and validating generalized bioenergetics-based habitat suitability curves for modelling flow effects on juvenile salmonids

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Accurately predicting the biological impacts of flow alteration is a key challenge given human water demand increasingly conflicts with flows necessary for viable stream fish populations. Traditional approaches for modelling flow impacts on fish often involve frequency-based habitat suitability curves (HSCs), which are biological models that describe the frequency of habitat use for a range of physical conditions (e.g., depth and velocity). While frequency-based HSCs are widely used, they have also been heavily criticized on the grounds that frequency of occurrence is a poor indicator of the fitness consequences of habitat use. For salmonids that feed on drifting invertebrates, drift-foraging bioenergetics models that link hydraulic conditions and prey abundance to net energy intake have been suggested as an alternative approach to generate HSCs. While bioenergetics-based HSCs show promise, they lack rigorous empirical validation and it remains unclear whether a bioenergetic approach generates equivalent or better predictions of habitat use relative to frequency-based HSCs. Here, we evaluate the performance of frequency vs. bioenergetics-based HSCs in predicting the abundance and production of juvenile salmonids (Steelhead and Coho) in Pacific Northwest streams. We also describe the development of user-friendly software to automate the generation of bioenergetics-based HSCs for general application. Because bioenergetics-based HSCs integrate the effects of physical habitat and prey abundance on the energetic costs and benefits of habitat use, they should provide a more rigorous approach to model flow effects on salmonids; however, many caveats associated with model parameterization still remain.

Riparian defoliation by the invasive Green Alder Sawfly influences terrestrial prey subsidies to salmon streams

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Invasive species in riparian forests are unique in that their effects can transcend ecosystem boundaries via stream-riparian linkages. The Green Alder Sawfly *Monsoma pulveratum* is an invasive wasp whose larvae are defoliating riparian thin-leaf alder *Alnus tenuifolia* stands across southcentral Alaska. To test the hypothesis that riparian defoliation by this invasive sawfly negatively affects the flow of terrestrial prey resources to stream fishes, we sampled terrestrial invertebrates on riparian alder foliage, their subsidies to streams, and their consumption by juvenile Coho Salmon *Oncorhynchus kisutch*. Invasive sawflies altered the composition of terrestrial invertebrates on riparian alder foliage and as terrestrial prey subsidies to streams. Community analyses supported these findings revealing that invasive sawflies shifted the community structure of terrestrial invertebrates between seasons and levels of energy flow (riparian foliage, streams, and fish). Invasive sawfly biomass peaked mid-summer, altering the timing and magnitude of terrestrial prey subsidies to streams. Contrary to our hypothesis, invasive sawflies had no effect on the biomass of native taxa on riparian alder foliage, as terrestrial prey subsidies, or in juvenile Coho Salmon diets. Juvenile Coho Salmon consumed invasive sawflies when most abundant, but relied more on other prey types selecting against sawflies relative to their availability. Although we did not find effects of

invasive sawflies extending to juvenile Coho Salmon in this study, these results could change as the distribution of invasive sawflies expands or as defoliation intensifies.

Incorporating food web dynamics into river restoration planning

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Ecological responses to river restoration are context dependent. Responses reflect the unique sets of physical and ecological conditions that exist at a given location. Although restoration planning efforts often account for site-specific physical conditions (discharge, channel form), ecological conditions such as local food web structure are often overlooked. We used a food web model to simulate how both physical conditions and local food web structure mediate juvenile salmon responses to three common restoration actions: in-stream habitat structure manipulation, riparian vegetation planting, and salmon carcass addition. We parameterized the model with physical and hydraulic conditions for 14 sites across the Methow River (Washington, USA). Sites within the same river network strongly differed in their sensitivity to restoration. Restoration substantially increased fish biomass at some locations, whereas other locations were relatively unresponsive due to factors such as low water temperature or limiting nutrients. To evaluate how food web structure influences restoration responses, we added populations of fish competitors and predators to the modeled web. Addition of fish competitors and predators strongly mediated responses to restoration by modifying pathways of energy flow through the food web. Juvenile salmon response to restoration was generally smaller in the presence of fish competitors and predators. Similarly, changes to the structure of food webs that accompany the spread of invasive species could strongly mediate, and potentially negate, desired restoration outcomes. In conclusion the model results illustrate that spatial variation in the structure of food webs—in addition to physical site conditions—should be considered during river restoration planning.

Salmon Enhancement in the Last Frontier

Evaluating Introgressive Hybridization Between Native and Artificially Propagated Non-native Steelhead *Oncorhynchus mykiss* spp. and Potential Use of High Head Dams As Wild Fish Sanctuaries.

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Artificial propagation has long been used to mitigate impacts on fisheries and has included introduction of non-native populations or species, which can impact native species directly and indirectly. We examined introgressive hybridization between ESA-listed Coastal Steelhead *O. m. irideus* native to the upper Willamette River and a hatchery population primarily originating from Interior Steelhead *O. m. gairdneri* produced as mitigation for dam impacts. Steelhead management in the system also includes downstream transport of hatchery-origin adult Steelhead after collection at hatchery facilities in some subbasins to enhance angling opportunity, and 'outplanting' of unmarked Steelhead above high-

head dams with the aim of establishing 'wild fish sanctuaries'. We evaluated effects on the populations using two approaches: a population genetic survey of adults returning to the upper Willamette Basin using microsatellites and a SNP pedigree study including adults and juveniles passed above Foster Dam on the S. Santiam River. The basin-wide survey indicated ~7.1% of the unmarked adult Steelhead were F1 hybrids and that some degree of introgressive hybridization was present in 27.4% of sampled adults. Hybrids were more frequently backcrossed to Coastal Steelhead than Interior Steelhead and more similar to Coastal Steelhead based on Fst values. Preliminary analyses from the Foster Dam pedigree revealed similar rates of F1 and backcross hybrids as the basin-wide survey (~6% and 25%, respectively). The parentage analysis indicated a majority of the sampled juvenile *O. mykiss* originated from outplanted Steelhead and at least 21%, and as many as 71%, of the adults outplanted at Foster Dam were produced from outplanted parents in the 2012 brood year. Reduced hybrid fitness may depress the population growth rate of native Steelhead. Current trap-and-transport above dams results in production of anadromous Steelhead and offers potential for wild fish sanctuaries. Future rapid genetic screening during outplanting could reduce hybridization rates above dams.

Alaska Mariculture Initiative-Tangible Indications of Progress as a Result of a Three-Year Comprehensive Planning Process

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Alaska produces over 50% of the seafood in the United States; its coastline is over 33,000 miles long; and Alaska has a reputation for responsible resource management. The potential for mariculture (enhancement, restoration, and farming of shellfish (marine invertebrates) and seaweeds (macroalgae)) in Alaska represents a tremendous opportunity for renewable, supplemental, and diversified economic development. However, industry growth is stagnant at around $1 million in annual production. In 2014, the Alaska Fisheries Development Foundation (AFDF) was funded through a NOAA Saltonstall-Kennedy grant to spearhead the Alaska Mariculture Initiative (AMI) in order to expedite development of the mariculture industry in Alaska. As a result of the initiative, Governor Walker established the Alaska Mariculture Task Force by Administration Order #280 in 2016 with the directive to deliver a comprehensive plan by March 1, 2018. This presentation will cover the highlights of this comprehensive plan, the unique components of the planning process, and the tangible indications of progress to date.

Steelhead Kelt Reconditioning and Reproductive Success Studies in the Columbia River Basin

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Pierce, Andy. Columbia River Inter-Tribal Fish Commission; Branstetter, Ryan. Columbia River Inter-Tribal Fish Commission; Fast, Dave. Yakama Nation; Bosch, Bill. Yakama Nation; Blodgett, Joe. Yakama Nation; Everett, Scott. Nez Perce Tribe

All populations of anadromous *Oncorhynchus mykiss* (Steelhead) in the Columbia River Basin are listed as either threatened or endangered under the Endangered Species Act. Populations of wild Steelhead have declined dramatically from historical levels in the Columbia and Snake rivers. This stock status necessitates novel approaches to rebuilding and restoring Steelhead populations. Toward this end, a research program was launched to investigate exploitation of iteroparity to help recover Steelhead populations. This presentation will introduce studies we have conducted to investigate baseline

iteroparity rates, Steelhead kelt stock composition, kelt collection processes, downstream and spawning migrations of kelts, artificial kelt reconditioning fish culture methods including diets and disease treatments, reproductive development in reconditioned kelts using blood hormone levels, kelt homing fidelity, and reproductive success of reconditioned and maiden Steelhead in hatchery and natural settings. Based on results to date, the efficacy of management approaches to increasing repeat spawner rates will be evaluated, including transport, short term reconditioning, and long term reconditioning.

Possible Roles of Hatcheries and Dams as Bridges to Conserve Salmon and Trout During Changing Climate

Pearsons, Todd N. Grant County Public Utility District*

Developing cost-effective and feasible solutions for reducing the probability of extinction of valued taxa is one of the most important challenges associated with climate change. The possible management options for conserving salmon and trout during climate change include technologies that have harmed these fishes. Hatcheries could be used as gene banks and simulate cold water refuges as well as serve as refugia from harmful flows. Dams could be used as surrogate glaciers and provide flows to achieve biological benefits. Predicted effects of climate change in the Pacific Northwest include warming water temperatures, higher fall, winter, and spring flows and lower summer flows, and alteration of biotic community structure and function. Extinction of many populations will occur without dramatic preservation techniques to bridge the period of inhospitable habitat caused by climate change. Some predicted changes are being observed now and alterations to hatchery and flow management are occurring to conserve valued populations. However, current facilities may be insufficient to accommodate more substantial climate changes in the future. For example, the design and distribution of facilities are not optimal. Existing facilities could be modified to use less water and to keep water cold (e.g., recirculation) and new facilities could be built in strategic conservation locations. The most important source populations could be identified for preservation and then infrastructure investments made to increase the probability of viability. There will undoubtedly be unintended and negative consequences of using these temporary technological bridges, but the alternative is likely to be extinction of highly valued populations in some highly valued locations.

Harvest of Southeast Alaska Wild-Origin Chinook Salmon in the Southeast Alaska Troll and Sport Fisheries, 2005–2017

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Chinook Salmon originating from Southeast Alaska (SEAK), Transboundary rivers (TBR), and SEAK hatcheries are harvested in the SEAK commercial troll and sport fisheries, along with stocks originating outside of Alaska. The Alaska Department of Fish and Game has used genetic stock identification (GSI) methods to estimate the stock composition of Chinook Salmon harvested in the SEAK troll and sport fisheries since 2004. Genetic mixed stock analysis (MSA) methods allow direct estimation of the major stock groups contributing to fisheries. However, while genetic MSA methods have been used to estimate the number of Alaska-origin fish harvested, genetic MSA cannot differentiate between wild and hatchery fish. Coded wire tag (CWT) methods are one of the only ways of detecting and estimating the contribution of hatchery fish because the numeric tags assign to a specific hatchery. Recent declines in the productivity of SEAK and TBR origin stocks

have been observed across the region, and this poor stock status has precipitated fishing restrictions. Hence, there is a need to quantify impacts on wild stocks. This project used a combination of GSI and CWTs to estimate the contribution of Alaska wild and hatchery stocks to troll and sport fishery harvests from 2005–2017. Results indicate considerable temporal and spatial variation of Alaska wild Chinook Salmon in the troll and sport harvests. These results provide valuable information to fishery managers in the face of conservation concerns.

Using Genetics and Coded Wire Tags to Better Understand Harvest of Southeast Alaska Chinook Salmon to Improve Management of a Diminished Resource

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Southeast Alaska (SEAK) has experienced a decline in Chinook Salmon productivity over the past decade, with abundance currently at an all-time low. While the decline in productivity is largely due to poor marine survival, heavy restrictions to commercial and sport fisheries have been imposed in SEAK to increase escapements. Recently there has been increased sampling and reporting of stock-composition using genetic mixed stock analysis and coded wire tags in a number of fisheries occurring across the Gulf of Alaska. Knowledge of the harvests of these declining stocks can improve fishery management. Here we attempt to synthesize data across these various programs to understand the magnitude and distribution of harvest in the Gulf of Alaska fisheries of Chinook Salmon originating from SEAK.

Stand Tall and Go Wild

Van Alen, Ben

In Alaska, it is impossible to maintain healthy salmon stocks and fisheries in the face of industrial-scale hatchery releases. There is only one ocean and the production of salmon from the ocean is ultimately limited by its carrying capacity. Wild and hatchery fish can fill this carrying capacity but only wild fish help to sustain it. It is the natural spawning and dying of millions of salmon in thousands of natal streams that helps maintain the productive capacity of our watersheds, estuaries, bays, straits, and ocean. Hatchery fish are elbowing their way into the ecosystem potluck without bringing a dish. The “nutrient mining” inherent with ocean ranching is lowering the productivity for all biota. The 1.6+ billion ”nutrient miners” now released from Alaskan hatcheries each year are in direct competition for space and food with wild fish. We observe declining and depressed runs of eulachon, herring, Chinook, Sockeye, Coho, Pink, and Chum Salmon wherever we have industrial scale hatchery programs. Why do we continue to think that the ocean is limitless and that we will have more salmon if we just release more salmon? Why allow hatcheries to employ whatever rearing and release strategies they can “afford” to provide their releases with a survival advantage over wild fish? Why allow hatchery strays? Why spend millions of dollars to supplant wild fish with hatchery fish? Instead of joining Japan and Russia as world leaders in ocean ranching nutrient mining we must stand tall and go wild for healthy runs and healthy fisheries. We all know the key to abundant salmon is to maintain

the habitat and maintain the spawners. Minimizing hatchery releases is critical to maintaining the habitat and maintaining the spawners – and completely under our control. How can a hatchery fish help a wild one?

The State of Alaska's Salmon and People: Results from a Large Interdisciplinary Research Initiative

Decision Support for Salmon Landscapes: Tool Development and Applications

Bentz, I. Syverine

Argueta, Jacob; Walker, Coowe; Simenstad, Charles; King, Ryan; Rains, Mark; Baird, Steve

In the Kenai Lowlands of Alaska, watersheds that support salmon have been examined to understand the ecosystem functions and land uses that may alter them. In this presentation, we will showcase products from our State of Alaska Salmon and People Kenai Lowlands workgroup and demonstrate applications for use both in the Kenai Peninsula, as well as lessons learned for application of ecosystem service concepts in other regions. The sociocultural landscape of the Kenai Peninsula depicts Alaskans' dependence on salmon for commercial and recreational components of the economy, as well as importance as a cultural touchstone. To connect these values and decision making, and understand tradeoffs associated with land use practices, it can be helpful to synthesize available information and visualize the important biophysical elements that support salmon. These connections are often hard to see on the ground but through spatial decision support tools we can identify and preserve landscape features that drive salmon habitat diversity and salmon stream productivity. It is critical to understand why these salmon support systems remain intact, and to communicate the scientific understanding of how our landscape works we have developed a Story Map and several videos. These products are meant as outreach tools that connect people with the state of salmon research in our region. Within the Story Map there are examples of how and when the spatial tool could be used by resource managers, landowners, permitters, and conservation entities. This work showcases how efforts by a synthesis workgroup, funded through the State of Alaska Salmon and People, will continue to inform decision making past the life of the project, engaging stakeholders from multiple perspectives.

Salmon Governance Dynamics: The Emerging Institution of the Kuskokwim River Inter-Tribal Fisheries Commission

Brelsford, Taylor. ISER-UAA

Williams, Mike. Kuskokwim River Inter-Tribal Fisheries Commission

Managers and users have cooperated in salmon management on the Kuskokwim River for decades, particularly through the Kuskokwim River Salmon Management Working Group established in the 1980s. Faced with a significant decline in the Kuskokwim River Chinook stock after 2010, managers and subsistence users initially agreed on management strategies to reduce the subsistence take, despite the hardship for many families who depend on this run. In June 2012, conflict eclipsed cooperation as Yup'ik fishing families set out their nets during a closed period, and state and federal enforcement officers responded with seizure of nets and fish, as well as citations. Lengthy court proceedings resulted in findings that subsistence fishing was a religiously-based activity and that the conservation measures adopted by ADF&G were reasonable. As suggested in the co-management literature, crisis often galvanizes new, innovative solutions. Subsequent seasons saw

agreement on a range of subsistence management provisions and improvement in Chinook escapement. The Department of the Interior responded with negotiations leading to an MOU with the newly established the Kuskokwim River Inter-Tribal Fisheries Commission in 2016. This paper describes the background leading to this emerging institution, the organizational structure and consensus-seeking processes of the KRITFC, and future uncertainties and challenges.

Salmon and People: Understanding Relationships and Disconnections Through Time

Carothers, Courtney. UAF*

Black, Jessica. UAF; Ringer, Danielle. UAF; Coleman, Jesse. UAF; Gavenus, E. UC Santa Barbara; Donkersloot, Rachel. Alaska Marine Conservation Council

Alaska's salmon and people have been closely entwined for at least 12,000 years, and by many Indigenous accounts, much longer. Salmon continue to be central to the ways of life of many Alaskans contributing to the physical, social, economic, cultural, spiritual, psychological, and emotional well-being of people in communities across the state. Our research team, guided by advisors throughout the state, conducted a synthesis of what is known about these diverse human-salmon relationships, drawing upon over 800 published scientific studies; Indigenous knowledge; state, federal and tribal data; archival materials; and oral histories. Pronounced inequities in the salmon-people system emerged as a critical point of consideration in this knowledge synthesis work. These inequities and sociocultural disconnects in Alaska's salmon systems are evident in the criminalization of subsistence, the dramatic loss of rural local fishing rights, and graying of the commercial fishing fleet. The loss of fish camps and legal battles over subsistence rights through time have caused deep stress between traditional practices and resource management systems. Statewide, commercial fishing rights have shifted toward urban and non-Alaskan residents and as a result many rural youth struggle to gain access to fishing livelihoods, leaving some rural fishing communities in a precarious crisis of sustainability. These equity issues have motivated a concerted effort by a group of committed scholars and advisors to better understand these issues and opportunities for improvement and also document the breadth of research that has already been conducted in an effort to improve the visibility of these often overlooked dimensions of our salmon systems.

Salmon Synthesis: Using open science to integrate and analyze Alaskan salmon data

Clark, S Jeanette. National Center for Ecological Analysis and Synthesis*

Cornejo, Jorge. National Center for Ecological Analysis and Synthesis; Kibele, Jared. National Center for Ecological Analysis and Synthesis; Dutton, Ian. Nautilus Impact Investing; Jones, Matt. National Center for Ecological Analysis and Synthesis

A wealth of data exist that are relevant Alaskan salmon, including not only biophysical data of salmon, but also salmon habitat data, socio-economic data, and qualitative data. As part of the State of Alaska's Salmon and People Project (SASAP), the "data task force," consisting of full time staff, fellows, and part time student interns, work together with salmon researchers to gather and integrate these disparate datasets in order to gain new insight on salmon through this data synthesis. The data task force uses modern open science techniques to ensure reproducibility and transparency. In this talk, the challenges of data synthesis will be discussed, along with how these challenges are addressed through open science best practices.

Unravelling how Climate and Competition Shape Sockeye Salmon Dynamics Across the Northeast Pacific Ocean

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Malick, Mike. Oregon State University; Ruggerone, Greg. Natural Resources Consultants; Rand, Pete. Prince William Sound Science Center; Adkison, Milo. University of Alaska; Irvine, Jim. Fisheries and Oceans Canada; Campbell, Rob. Prince William Sound Science Center

It is well known that both ocean conditions and inter- and intra-specific interactions can influence salmon growth and survival. However, to date there has been little analysis of the potential mediating effects of ocean conditions on density dependent interactions among salmon at sea. Such mediating effects may occur, for example, as a result of climate induced reductions in growth during early marine life leading to increased sensitivity to density dependent effects later in marine life. Alternatively, favorable ocean conditions during early and/or late marine life may mediate the consequences of density dependent interactions or mask their detection. We quantified the extent to which there is evidence for a mediating effect of ocean conditions on density dependent interactions among salmon at sea. Using data from over 40 Sockeye Salmon populations across the eastern north Pacific Ocean, along with information on ocean climate conditions and indices of potential salmon competitors, we found evidence to suggest that ocean conditions mediate the consequences of density dependent interactions among salmon at sea. The individual and combined influences of these stressors varied across large spatial scales that are characterized by groups of populations with differences in life history diversity (e.g., variability in age at ocean entry). Our findings provide a macroecological foundation upon which to consider how interactions among a changing ocean, inter-specific competition, and the erosion of life history diversity may shape the dynamics of salmon populations across their range.

Linkages between salmon diversity and habitat heterogeneity across the State of Alaska

Cornejo-Donoso, Jorge F.

Jones, L.; Jovanovich, M.; Sloat, M.; Rinella, D.; Westley, P.

It is widely accepted that diversity is a crucial aspect of ecosystem resilience, which in turn contributes to sustainability of natural resources and ecosystem services. Inter and intraspecific diversity of Pacific salmon can result in asynchronous population dynamics that buffer metapopulations in the face of environmental disturbance (i.e. portfolio effects). While biological diversity is thought to be the emergent result of divergent natural selection in different habitats, to date studies linking diversity of salmon to habitat features across the landscape are rare and often region-specific. This talk reports on a project aimed to provide the most comprehensive and robust analysis to link biological diversity in salmon to diversity in habitat across Alaska. To do so, we calculated diversity indices for species, age composition and freshwater availability (i.e., a proxy for run timing) across space and time, to characterize the salmon ecosystem across 12 regions of Alaska. We then combined them with a set of habitat descriptors (e.g. air temperature, precipitation, lake coverage, etc.) to quantify associations of diversity as a response of habitat heterogeneity. Emerging results suggest that salmon diversity in terms or species composition, age class composition and freshwater availability is high, with variation across regions, which is most related to some regions being dominated by species with inherently little diversity (e.g. Pink Salmon). Taken as a whole, this project provides evidence of the importance of maintaining a diverse mosaic of habitats across the state and can be used as

a baseline for future assessments of salmon diversity. The dataset used for this goal is a comprehensive compilation of escapement and ASL compiled across Alaska, as part of the State of Alaska's Salmon and people project (SASAP, https://alaskasalmonandpeople.org) by the Data Task Force at the National Center for ecological Analysis and Synthesis (NCEAS, https://www.nceas.ucsb.edu).

What is causing changes in the size of Alaskan salmon?

Cunningham, Curry J. NOAA Alaska Fisheries Science Center*

Both stakeholders and researchers have noted prominent examples of size declines of Alaska salmon. Many potential drivers of changes in the size and age of Alaska salmon have been hypothesized, but synthetic evaluations across both regions and species are limited. Building on results revealing that changing age structure has a major contribution to changes in salmon size, we explored the relative contributions of several potential causes of changes in salmon body size over time. For each of the four Alaska salmon species, we evaluated the relative contributions of marine and freshwater climate patterns, oceanographic processes, marine predators, and inter- and intra-specific competition at sea with wild and hatchery-enhanced stocks. Taking advantage of a dataset of unprecedented temporal (extending over half a century) and spatial scale (state of Alaska), we utilized mixed-effects models to evaluate the drivers of observed changes in size and the extent to which these responses are common across regions and populations.

Conceptualizing and measuring human well-being in Alaska's salmon fisheries

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Carothers, Courtney. University of Alaska Fairbanks; Black, Jessica. University of Alaska Fairbanks; Ringer, Danielle. University of Alaska Fairbanks

In Alaska, it is well understood that salmon plays a significant role in supporting rural and Indigenous livelihoods and contributing to the well-being of many coastal and in-river communities. At the community level, this can be measured in the number of locally owned vessels and permits, ex-vessel values, and pounds of salmon harvested and shared for subsistence. But we also know that the salmon resource is an integral facet of cultural health and well-being and forms a base for traditional livelihoods in Alaska. These practices, norms and values have been shown to be essential contributors to well-being but measuring such attributes of well-being in a policy relevant way remains limited. In this paper, we define well-being as "a way of being with others that arises when people and ecosystems are healthy, and when individuals, families, and communities equitably practice their chosen ways of life and enjoy a self-defined quality of life now and for future generations." This definition is inclusive of not only economic or material well-being, but also other important (but underappreciated) elements such as self-determination, generational continuity and more subjective dimensions including how a person might perceive their own situation (e.g. happiness, livelihood satisfaction). Drawing on the expertise and experience of a diverse workgroup of Indigenous and non-Indigenous researchers, practitioners and knowledge bearers, this paper presents key domains and indicators of well-being in the context of Alaska salmon systems and identifies a conceptual framework for better integrating well-being concepts into Alaska salmon governance. We discuss how salmon-human connections contribute to various forms of well-being in Alaska and the challenge of developing tools to empirically assess objective, subjective and relational dimensions of human well-being in a manner that can meet the needs of policy and management.

SASAP: An Interdisciplinary Approach to Improving our Understanding of Alaska's Salmon and People Systems

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Despite decades of investment into Alaskan salmon research and monitoring, there have been relatively few efforts to synthesize knowledge derived from those studies across disciplines, across regions and across marine and freshwater systems. There are many reasons for this including disciplinary bias that has favored biological sciences over social sciences, narrow funder goals and priorities, limited institutional capacity for interdisciplinary science in Alaska, few incentives and opportunities for engagement of indigenous knowledge experts, limited ability and incentive to access and share salmon datasets beyond custodian institutions and laboratories, and a general lack of support for "big picture" analyses by independent entities. In 2015, NCEAS and Nautilus Impact Investing commenced SASAP (State of Alaskan Salmon and People), a new interdisciplinary process, designed to inform the future of management of Alaska's salmon and people systems. The SASAP project specifically seeks to (a) connect knowledge across disciplines and agencies, between cultures and users, and across regions, to gain a fuller picture of these complex and dynamic systems, inform shared research priorities, develop and test indicators of system health and catalyze better management, and (b) create new institutional capacity for interdisciplinary salmon knowledge generation and establish a shared and credible baseline for integrated knowledge that can be built on over time. 110 academic, agency and independent scientists and tribal and non-government indigenous knowledge experts and have worked with a team of data scientists in support of eight working groups over the past two years. These teams have developed a regional scale understanding of salmon and people systems as well as more focused understanding of specific processes and phenomena affecting Alaska's salmon systems. The working groups have been supported by a novel data assembly and analysis process that will both inform future salmon database design and enable SASAP-related data to be publicly accessible over time through the NCEAS KNB. The presentation highlights preliminary results from working groups, data analysis innovations, and offers insights into how interdisciplinary science can increase the efficiency and impact of future salmon research investments.

Governance Systems for Subsistence Salmon in Alaska

Fall, James A. Alaska Department of Fish and Game, Division of Subsistence*

Alaska's salmon management system recognizes four categories of human uses: commercial, sport, personal use, and subsistence. State and federal laws prioritize subsistence over other uses. After providing a short overview of patterns and trends in the state's subsistence and personal use salmon fisheries, this presentation explores some of the regulatory concepts and processes these laws have created to provide subsistence salmon fishing opportunities within an overall goal of sustainable management. The statutory definition of subsistence as "noncommercial, customary, and traditional uses" requires regulatory boards to distinguish subsistence from other uses based on historical, sociocultural, and economic information through "c&t [customary and traditional] findings." Under state law, subsistence fisheries may only take place outside "nonsubsistence areas," identified by a set of demographic and socioeconomic characteristics, while under federal

law, only residents of “rural” areas may participate in subsistence fisheries. State law further establishes a standard of “reasonable opportunity” for subsistence uses, which entails determining in regulations “the amount of the harvestable portion [of the fish stock with customary and traditional uses] that is reasonably necessary for subsistence uses.” To make these “ANS [amount necessary for subsistence] findings,” the Alaska Board of Fisheries must review demographic patterns, regulatory histories, trends in participation, and harvest patterns. The presentation will describe several case studies, including one focusing on the Upper Copper River, that illustrate the challenges associated with developing ANS findings and applying these findings in management contexts. Issues include identification of stocks, time scales, data standards, and changing demographic patterns.

Characterizing salmon habitats and diversity across the state of Alaska

Jones, Leslie A. University of Alaska Anchorage*

Kibele, Jared D. National Center for Ecological Analysis and Synthesis; Shaftel, Rebecca S. University of Alaska Anchorage; Rinella, Dan J. U.S. Fish & Wildlife Service; Sloat, Matt R. Wild Salmon Center; Westley, Peter A.H. University of Alaska Fairbanks

Physical habitat diversity is of great importance to Pacific salmon populations, thought to have direct effects on life-history diversity, population dynamics, and the overall persistence of these species. Despite its importance, few efforts have been made to describe regional patterns of habitat heterogeneity supporting populations of salmon in Alaska. The paucity of broad-scale studies in part reflects the difficulties faced in quantifying heterogeneity across temporal and spatial scales and in obtaining the data needed to quantify relationships across such a large geographic domain. This data gap impedes our ability to make linkages with population data and understand how habitat availability effects salmon diversity. Here we synthesize existing data to describe physical habitat supporting salmon populations across Alaska, including the transboundary watersheds feeding Alaska rivers. Spatial summaries were used to describe patterns of habitat features (i.e., floodplain complexity, channel form, riparian vegetation, human impact, invasive species, hydrologic, and thermal variation) and factors impacting habitat quality. Physical habitat metrics were derived at regional, watershed, and stream reach scales allowing us to establish linkages between relatively fine scale floodplain habitats and coarser scale habitat drivers influencing the structure and function of these systems. We quantified salmon habitat by species and region and use a multivariate approach to describe intra- and inter-patterns of heterogeneity. Our results show that salmon habitat diversity is high, being driven by strong hydrologic linkages and complex floodplain habitats which promote salmon life-history diversity. This work is part of the State of Alaska’s Salmon and people project (SASAP, https://alaskasalmonandpeople.org) and was used in subsequent analysis to link salmon diversity with habitat heterogeneity. Datasets were generated by the Data Task Force at the National Center for ecological Analysis and Synthesis (NCEAS, https://www.nceas.ucsb.edu) and Leslie Jones at the University of Alaska Anchorage.

Using participatory modeling to empower community engagement in salmon science

Jones, Michael L. Quantitative Fisheries Center, Michigan State University

Connors, Brendan. Department of Fisheries and Oceans Canada; Truesdell, Samuel. Gulf of Maine Research Institute

Science-based fishery management is, wherever possible, informed by the use of models that interpret fishery assessment data and forecast the likely outcomes of alternative management strategies, measured in terms of meeting or failing to meet

management objectives. For salmon management the primary models used for this purpose either represent the relationship between escapement and future returns (stock-recruitment models), or simulate the management of the fishery within a given year (inseason management models). Although Pacific salmon are among the most data-rich fisheries in the world, there are salmon fisheries, most notably in Western Alaska, that are quite data poor. For these fisheries it is important to (1) determine the greatest information needs – to prioritize assessment investments; and (2) identify opportunities for stakeholder participation in assessment. We formed a SASAP working group to address and connect these two needs. We used a formal decision analytical procedure known as Value of Information (VOI) analysis, applied to both stock-recruitment and inseason management models, to identify sources of information which, if reduced, would make the greatest contribution to improving the quality of management decisions. We found, in general, that the greatest benefits would be realized when there is evidence for bias in existing data sources, rather than simply a lack of precision. To address the second need we engaged regional stakeholders and community-based monitoring (CBM) practitioners in our working group and explored opportunities for citizens to collect information that would address the critical needs identified by our VOI analysis. Our findings will inform a recently initiated CBM program in the lower Kuskokwim River.

Status of Alaska salmon: a review of escapement and management goals

Jovanovich, Madeline M. Jovanovich Consulting*

Clark, S. Jeanette. National Center for Ecological Analysis and Synthesis; Cornejo-Donoso, Jorge. National Center for Ecological Analysis and Synthesis; Rinella, Daniel. U.S. Fish & Wildlife Service; Westley, Peter. University of Alaska Fairbanks

In tandem with the maintenance of quality and quantity of habitat, ensuring a sufficient number of spawners in Alaska watersheds is the cornerstone of salmon management. To meet this goal, salmon systems have been monitored throughout Alaska since before statehood to help sustainably manage common property fisheries. Over 295 active salmon stock escapement goals are currently in place. In this presentation, I provide some highlights of a project that sought to describe the long term patterns of escapement from 1921-2017 and goal performance from 1981-present in 230 stocks of Alaska salmon. Status of these stocks was assessed by the proportion of time they met their escapement goals and how these goals have changed over time. The compiled dataset provides insights into the extent and consistency of monitoring across Alaska. These data have been synthesized as part of the State of Alaska's Salmon and People (SASAP) project from published Alaska Department of Fish and Game (ADF&G) sources and databases. Data were synthesized as part of an ongoing collaboration between the Data Task Force of the National Center for Ecological Analysis and Synthesis, researchers within SASAP, with consultation from advisors at ADF&G. I conclude the talk with a discussion of current challenges facing the sustainability of escapement monitoring projects and briefly ponder technological changes that may increase efficiency in the future.

As The Fish Swims with PyRiv: New Methods and Python Software for Calculating Minimum Aquatic Distance Across Marine and Freshwater Habitats.

Kibele, Jared

Wright, Haleigh

Minimum aquatic distance (MAD), the shortest path between two points that does not cross land, is a useful metric in the study aquatic organisms. However, MAD can be difficult and time consuming to calculate, particularly for anadromous species where both coastal and riverine distances must be considered. Researchers are often forced to choose between imprecise straight line substitutes and laborious manual path tracing techniques that don't scale well to large data sets. PyRiv is a free and open source Python library that was created to address this problem. It uses a novel network graph approach to find MAD paths around complex coastlines, and it employs existing hydrography datasets to navigate river networks. By combining these methods, PyRiv can determine MAD between any two points whether they're on the same river, different rivers, offshore, or any combination. Given a point shapefile as input, PyRiv can return a line shapefile representing MAD paths between all the points as well as a distance matrix in CSV format. Once a network has been prepared for a given area, PyRiv is simple to use and the calculations are fast. Examples will be presented from the State of Alaska Salmon and People (SASAP) project and from a study of river herring on the east coast of North America.

Governing Salmon and People in Alaska: Frameworks, Practices and Challenges

Langdon, Steve J. University of Alaska Anchorage/ISER

Among the objectives of the State of Alaska Salmon and People (SASAP) research project are to characterize and analyze the governance of salmon and people. Salmon are complex anadromous fish whose viability and health require that a number of environmental conditions be met. The current structure of salmon governance in Alaska is complicated as it is accomplished primarily in three institutional contexts: State of Alaska (constitution, laws, enforcement), ANILCA (rural subsistence priority on federal lands) and MSFCMA (salmon in the EEZ outside three-miles). The assessment of the necessary conditions and their maintenance for "sustainable fisheries" is a significant objective that governance must address. Salmon qualities have made them extremely important for various uses by humans, and other species, and excessive takings may compromise the presence and abundance of salmon. Human uses of salmon are an arena of policy and legal contests among various groups that take place in a number of institutions. This paper will present an overview of the frameworks (constitution and laws), practices (management, public participation, legal deliberation, enforcement) and challenges (resources, development, equity and institutional alignment) characteristic of contemporary salmon governance. The analysis of governance includes identification of standards (such as legality, transparency, equity, and protection) from which indicators are derived and metrics have been sought where available to characterize the indicator. Metrics will be presented on indicators of governance practices including Board of Fisheries members, Board of Fisheries proposals and outcomes by proponent and category, Advisory Board characteristics and functioning, enforcement activities, and habitat permits and monitoring. Metrics will also be presented for some characteristics of the FSB and the NPFMC. Examination of the characteristics of Alaska salmon governance reveals a number of important challenges currently requiring attention. A brief of discussion of four of these challenges: resources, development, equity and institutional alignment, will be offered.

Consequences of declining salmon size and age for fisheries management

Lewis, Bert

Salmon are getting smaller in Alaska and this trend has important implications for ecology and fisheries management. A primary ecological and management issue is the effect of smaller salmon on population productivity and reproductive potential. Escapement goals and harvest management are the foundation of Alaska's sustainable salmon policy, and changes in population productivity due to decreasing size and age may decrease escapement quality. Here we discuss

some of the challenges for fishery management presented by declining salmon size. Escapement goals, the foundation of sustainable fisheries management in Alaska, are commonly calculated using spawner/recruit relationships and the percentile method. Using these common methods with reduced escapement quality will result in less yield and potentially smaller escapement goals. Standard escapement goal management practice is to evenly space harvest through time. This allows proportional representation of the entire population to return to spawn. The location and amount of area open for harvest allows control of spawning population abundance. Furthermore, time and area management combine to control the amount of the spawning population that has not been subjected to size selective harvest. Size-selective harvest has the capacity to influence escapement quality. Gear type management allows some control of harvest size selectivity and thus influences escapement quality. For example, regulating gillnet mesh is widely used to target (or avoid) specific size fish. In summary, it is currently unclear how fisheries management may adapt to address smaller salmon size, though understanding the causes of the declines may provide some targets for management. Understanding declining salmon size and age trends and associated management implications is important to the future of sustainable salmon populations.

Widespread changes in the size and age of Alaska salmon

Oke, Krista B. University of California Santa Cruz

Prominent examples of changes in the size of Alaska salmon have recently been noted, but a broad multi-species analysis of size trends across species and regions is needed. Numerous consequences of declining salmon size could occur, including reduced marine-derived nutrient subsidies to freshwater and terrestrial ecosystems, decreased population abundance and stability, reduced food security to subsistence-based economies, reduced value to the sports, and commercial sectors. We synthesized salmon size and age data from across the state of Alaska to address three questions: 1) has size changed through time in Alaska salmon; 2) to what extent are patterns of size change consistent among species, populations, and regions; and 3) to what extent are changes in size due to changes in growth rate vs. changes in population age structure? To address these questions, we assembled and analyzed a dataset of unprecedented temporal and spatial scale, including size and age records from over 14 million individual salmon going back over half a century. Overall, our results agree with previous studies that, in general, salmon size across Alaska is in decline. However, the magnitude of change varies both among and within species, with Chinook Salmon populations showing the greatest magnitude declines. Among regions and populations, Sockeye, Coho, and Chum Salmon show reasonably consistent patterns, with Chinook showing less consistent trends across populations. Moreover, Alaska salmon are changing size primarily because of shifting population age structure, not because growth rates are changing at sea. Our results represent the necessary first step for ongoing research into the causes-and ultimately, consequences-of size and age decline in Alaska salmon.

Socio-economic Dimensions of Alaska’s Salmon System: A Preliminary Synthesis of Available Indicators.

Schwoerer, Tobias. UAA Institute of Social and Economic Research*

Tran, Trang. UAA Institute of Social and Economic Research

This presentation outlines ongoing research that searched and compiled relevant socio-economic data related to Alaska salmon available from various sources housed within the Alaska Department of Fish and Game (ADF&G), Commercial Fisheries Entry Commission (CFEC), Alaska Department of Revenue (DOR), Alaska Department of Labor (DOL) and other

institutions. Our analysis aims at (a) identifying key indicators of socio-economic characteristics to show historical trends; (b) integrating the identified socio-economic indicators with other indicators that describe the biophysical, socio-cultural, and governance system around salmon; (c) exploring important correlations and evolving historical relationships between salmon and salmon users to visualize trends that have been overlooked in the past; (d) providing synthesis and data accessibility for various salmon users and salmon stakeholders; and (e) informing and supporting evidence-based policy aimed at sustainable and equitable future decision making. Preliminary results include an analysis of risk associated with commercial salmon fisheries. Alaska's commercial salmon fisheries have historically been highly valuable but subject to the natural variability of their returns. Alaska residents have been able to retain a large share of the economic benefits generated by salmon. One measure of these benefits is the harvest value of Alaska salmon (ex-vessel value) captured by permit holders who reside in Alaska versus those who live elsewhere. Since earnings in fisheries are subject not only to variability in returns but also market forces and other factors, participation in salmon fisheries is risky business. One measure of risk is the variability in earnings. While Alaskans overall were able to hold on to roughly two thirds of the harvest value of commercial salmon fisheries since 1975, the share of Alaskans' earnings in various gear types is changing. Historically, earnings by Alaskans are less variable than earnings by non-residents, evidence of the value of local knowledge that reduces risk for local fishers.

Research in a Connected Salmon Landscape: Understanding and Opportunity

Walker, Coowe M. Kachemak Bay National Estuarine Research Reserve

Whigham, Dennis F. Smithsonian Environmental Research Center; Simenstad, Charles. University of Washington; King, Ryan S. Baylor University; Rains, Mark C. University of South Florida; Baird, Steven J. Kachemak Bay National Estuarine Research Reserve; Bentz, I. Syverine. Kachemak Bay National Estuarine Research Reserve

Watersheds that support salmon in many places are degraded and disconnected; for instance the majority of watersheds in the Columbia River Basin have lost more than 40% of the naturally accessible stream reaches. Recognition of this has driven intensive research and restoration efforts to reconnect salmon landscapes. Alaskan watersheds are largely unimpaired by comparison. However, the potential for degradation of Alaskan watersheds is clearly present. While Alaskan's value and feel strongly about salmon, these feelings don't always translate into salmon-friendly land use decisions, especially in landscapes with a complex patchwork of ownership, such as the Kenai Lowlands. The Kenai Lowlands include 4 major watersheds on the southern Kenai Peninsula that support significant populations of Coho Salmon, Chinook Salmon and Dolly Varden. Over the past 15 years, the Kachemak Bay National Estuarine Research Reserve has worked with experts in salmon, wetland, stream, groundwater, and estuarine ecology to build understanding of how landscape elements, such as alder patches, peatlands, riparian wetlands, groundwater flows, and estuarine marshes are connected, and functioning to support productivity of juvenile salmonids. In this presentation, we will show results from our work demonstrating that productivity in headwater streams is driven by nitrogen supplied by alders, carbon supplied by peatlands, and groundwater flows that connect the stream to these landscape elements and riparian habitats. We also show how Kenai Lowland estuaries provide opportunities for multiple rearing opportunities for juvenile salmon. This work provides the foundation for a synthesis workgroup, funded through the State of Alaska Salmon and People, with stakeholders from multiple perspectives working collaboratively to design decision-making tools for sustaining salmon supporting watersheds. Through this workgroup, we are synthesizing existing research and data that relate to how salmon habitats in the Kenai Lowlands are affected by landscape processes, and how human activities intertwine with these processes.

Alaska Salmon and People: Setting the Stage for the Symposium

Westley, Peter

In this introductory talk, I aim to set the stage for the Alaska Salmon and People symposium. To do so, I briefly provide a genesis of the project, its goals, and driving principles. Next, I introduce some of the emergent themes from SASAP including, but not limited to: diversity, equity and access, citizen engagement, and largely intact relationships between ecosystems, cultures and economies, and systems of law. I conclude with a brief horizon scan for the symposium and the Alaska Salmon and People system in the 21st century

Spatial-Stream-Network (SSN) Models: Recent Technical Advances and a Diversifying Set of Applications

The National Hydrography Infrastructure: Surfing Water Information Waves on the NHDPlus High Resolution Framework

Anderson, Becci. USGS*

Until recently, the USGS managed two discreet but related national hydrography datasets for the inland waters of the United States - the National Hydrography Dataset (NHD) and Watershed Boundary Dataset (WBD). In 2017, those datasets, along with high resolution 3D Elevation Program (3DEP) data, were used to produce the first NHDPlus High Resolution (NHDPlus HR) data for the country. To build on this integration into the future, the USGS is now shifting from the management of separate datasets toward an open and interoperable systems-based approach to national hydrography to support enhanced discovery of and access to water-related information both on and off the stream network. The concept for the National Hydrography Infrastructure includes a nationwide NHDPlus HR framework, increased web-based map services, and an improved ability to link and discover data referenced to the framework. This presentation will provide an overview of the National Hydrography Infrastructure concept and discuss its development to date.

Spatial Stream Network models and Isoscapes

Brennan, Sean R.* University of Washington, School of Aquatic and Fishery Sciences

Models that predict isotopic patterns across aquatic and terrestrial ecosystems, called 'isoscapes', have become a powerful tool spanning a diverse array of disciplines. Isoscapes quantify the transport of materials within and among aquatic, terrestrial, and atmospheric systems, which yields unique insights into their connectivity. A common application of these models is to trace the provenance and movements of migratory animals. Over the last two decades, researchers have produced relatively accurate isoscapes of terrestrial and atmospheric systems for multiple tracers (e.g., stable isotopes of hydrogen, oxygen, carbon, and nitrogen). These models have been used to trace migrations of diverse taxa (e.g., birds, bats, insects, and sea turtles) across a range of spatial scales. Isoscapes of aquatic systems, however, such as rivers, have been limited by conventional Euclidean approaches to geostatistics, which to do not account for the unique spatial dependencies of dendritic networks. Here, we show how spatial stream network models (SSNMs) are able to, not only improve isoscapes of strontium isotopes in rivers, but also quantify the degree to which landscape versus in-stream processes control the spatial patterning of this tracer through rivers. By generating an accurate river isoscape using SSNMs,

which also quantifies the spatially explicit prediction errors throughout the network, we demonstrate how such a model provides the foundation to reconstruct the complex provenance and movement patterns of migratory fish in the Nushagak River, Alaska.

Predicting the distribution of Yellowstone Cutthroat Trout in the upper Snake River using spatial stream network analysis.

Feldman, Cody J. Idaho State University

Keeley Ernest R. Peterson Idaho State University; Peterson Charles R. Idaho State University

Evaluating the status of species over large geographic areas can be difficult but recent compilations of fish distribution records may provide a more comprehensive analysis of the remaining range and extent of fish species. Geographic information systems (GIS) can be used to map the extent of a species distribution and identify important associations between habitat characteristics and a species range; however, traditional GIS analyses are primarily designed for terrestrial organisms that can move across a landscape. For fish species that are confined to a network of streams, rivers, or lakes, GIS analyses are needed to map habitat associations within a network of locations. In the Snake River watershed, Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* have declined in abundance because of various forms of habitat alteration, fragmentation and by invasion of non-native fish species. In this study, we used fish sampling records, remote sensing data, and GIS software to identify the current distribution of cutthroat trout in relation to habitat conditions. We used Spatial Tools for the Analysis of River Systems (STARS) and an R package, Spatial Stream Networks (SSN), to evaluate how environmental variables affect the distribution of Yellowstone Cutthroat Trout. Our study will map the extent of streams that have a high probability of containing populations of Yellowstone Cutthroat Trout based on habitat variables and identify areas that have low probability of supporting native cutthroat trout populations.

Controls on the spatial variation of mercury in the Kuskokwim River

French, David W. University of Washington School of Aquatic and Fishery Sciences

Brennan, Sean R. University of Washington School of Aquatic and Fishery Sciences; Schindler, Daniel E. University of Washington School of Aquatic and Fishery Sciences; Whited, Diane C. University of Montana Flathead Lake Biological Research Station

Mercury (Hg) is an environmental contaminant of concern in western Alaskan rivers because it biomagnifies up food chains that support species forming the basis of subsistence fisheries. Within western Alaskan rivers high Hg concentrations have been shown in aquatic biota, but key controls on contamination from watershed sources, atmospheric deposition, and mining activities are not understood. Using Spatial Stream Network models (SSNMs), we analyzed the spatial variation of Hg in Slimy Sculpin across a large boreal river basin, the Kuskokwim River, to estimate the effects of downstream transport, local loading from watershed sources, and how active and historical mining activities affect Hg in fish tissues throughout the watershed. Slimy Sculpins are a sedentary fish with small home ranges and should reflect local and upstream processes within river networks. By modeling dissolved organic matter (DOM) concentrations in parallel to Hg, we were further able to understand local biogeochemical effects on Hg bioavailability. SSNMs enabled us to partition local and distant watershed effects on Hg contamination to gain insights into how mining activity and other landscape processes shape the spatial

patterning of Hg across the Kuskokwim basin. These spatial models for Hg transport and loading provide a framework for assessing current and future risks to human health as the watershed is changed by new climate regimes and the expansion of mining activities.

The Global Stream Internet: Fusing data, spatial stream models, and social networks for stream science, conservation, and management

Isaak, Dan. US Forest Service

Peterson, Erin. Queensland University of Technology; VerHoef, Jay. National Oceanic and Atmospheric Administration; Nagel, Dave. US Forest Service; Young, Mike. US Forest Service

One way of viewing the Internet is as a system that interconnects people and facilitates efficient communication. User-communities exist around specific topics of interest and members of the community communicate through an infrastructure composed of computer hardware, software, fiber optic networks, and standard protocols for data viewing, sharing, and transmission. Many parallels exist in stream science where multiple user-communities exist (e.g., stream ecologists, species distribution modelers, water quality experts, hydrologists), collect data following standard protocols, and have available an increasing number of geospatial stream networks and covariates to organize and attribute those data. Many analytical techniques are usefully applied to develop information from stream data but only recently have spatial-stream-network (SSN) models and software emerged that recognize and incorporate stream network topology through valid covariance structures. SSNs are being applied to an increasingly broad suite of applications where they often offer improved performance and novel insights compared to other analytical techniques. Moreover, because SSNs are geostatistical models with autocovariance functions, they account for spatial correlations and redundancy among observations in close proximity while yielding unbiased parameter estimates and can use spatial structure in residual errors to boost predictive performance. Those features are particularly attractive because they enable data from multiple sources to be aggregated and used in model development, regardless of sampling design, if the observations have been accurately georeferenced. That reinforces global trends toward better archiving of historical datasets, crowd-sourcing of large new datasets, and the sharing of collective databases through public websites. Continuation of those trends, improving technical proficiency of researchers to work with large datasets, and stronger interactions between researchers and managers around spatially-explicit science will translate to ever-improving efficiencies of data collection, sharing, and information creation that rapidly advance stream science, conservation, and management this century.

Ecological Applications of SSN Models in 20 River Networks in Europe

Lois, Sabela

Cowley, David E. * Fish, Wildlife & Conservation Ecology, New Mexico State University

We illustrate two applications of SSN models: for conservation of interacting species in river networks and description of an ecosystem service of rivers. First, SSN models fitted separately to density of a parasitic freshwater mussel and biomass of its fish hosts explained about 75% and 77% of the variance, respectively (Lois & Cowley 2017). Host fish biomass was the most important predictor of parasite density. Significant watershed scale covariates differed between parasite and host models. The geostatistical ranges of spatial autocorrelation models were consistent with respective ecologies of parasite

and host. Model predictions from universal kriging were overlaid to visually identify important areas for conservation across the large study region. In a second application (Muise 2017) we fitted an SSN model to total fish biomass across 14 fish species. This initial SSN model for an ecosystem service (biomass production) yielded a poor predictive model and suggested a different scaling of the response variable. We are currently analyzing a new SSN object with the response variable scaled to river width.

Defining thermal niches of fishes in northern Canada by examining spatial and temporal variation of thermal regimes across stream networks

Mochnacz, Neil J. Fisheries and Oceans Canada, Winnipeg, Manitoba*

Teleki, Dan. DT Geoinformatics, Edgewater, BC; Isaak, Dan J. United States Forest Service, Boise, Idaho

The highest rates of climate warming are occurring in northern ecoregions, yet our understanding of biothermal relationships in river networks is lacking in northern Canada. To better understand these processes for climate-sensitive Bull Trout, we deployed temperatures sensors and conducted electrofishing surveys throughout streams in the Prairie Creek basin, Northwest Territories, Canada. Spatial-stream-network (SSN) models were fit to the temperature dataset using common predictors of river thermal regimes (e.g., elevation, discharge) and then used to predict a summer temperature map throughout the basin (r2 = 0.70; RMSPE = 1.12°C). Bull Trout survey site results were attributed with predicted temperatures and other covariates and this dataset was used to inform a spatial hierarchical species distribution model that predicted the probability of occurrence. The distribution model was used to develop a thermal response curve to describe the realized thermal niche for Bull Trout and predict how this species may respond to climate warming. Probability of occurrence was highest in streams with mean summer stream temperatures of 5.5 °C and ranged from 4 and 7 °C. The thermal suitability of stream habitat was not always consistent across seasons. Some sites had suitable temperatures during the summer but not during winter and these sites were typically unoccupied, which suggests the winter thermal regime may exert a strong forcing effect on persistence of northern Bull Trout populations. SSN models have proven to be a broadly applicable tool for developing accurate stream temperature models to define thermal niches for societally important fishes, like Bull Trout. This approach has been extended to Banff National Park in Alberta, where realized thermal niches will be defined for core Bull Trout populations in minimally-perturbed watersheds of central Canada. Identifying thermal refugia in wilderness areas will be critical for identifying habitat-based recovery targets for imperiled populations in Canada.

Thermal and Habitat Characteristics of a Headwater Fish Species: Predicting Population Success Under Climate Change

Turschwell, Mischa

Balcombe, Stephen; Peterson, Erin; Stewart-Koster, Ben; Steel, E. Ashley; Sheldon, Fran; Leigh, Catherine

Patterns of fish distribution are influenced by both biotic and abiotic variables acting at various spatial and temporal scales. An abundance of recent literature has focused on potential ecological impacts related to future climate and land use. Upland fish species are especially vulnerable to alterations in the climatic regime; they are already restricted to headwaters, where future temperatures are likely to exceed their physiological thresholds, leading to local extirpations. It is therefore critical to understand key drivers of fish distribution in upland systems to effectively manage and conserve populations. We sampled

blackfish abundance, and measured various physiochemical and habitat variables at electrofishing sites in the Upper Condamine River, QLD, Australia. Temperature data was also collected using in-situ sensors throughout the basin and spatial statistical stream-network models were applied to predict the temperature regime at unsampled locations. Ecologically relevant temperature metrics, along with physiochemical and habitat covariates were then used to identify the primary drivers of blackfish distribution and abundance. We then use a Bayesian Belief Network to test how predicted air temperature scenarios for the years 2050 and 2080, and catchment restoration scenarios would be expected to affect blackfish population success. Compared to current climatic conditions, climate warming scenarios reduced the probability of future population success by between 0.4 and 1.6%. These shifts were almost completely offset, and even improved when riparian zones were restored at the catchment scale, where changes ranged from an overall decrease of 0.2% to an increase of 1%. To achieve the highest probability of population success, the impacts of warming stream temperatures and the degradation of riparian zones must be mitigated.

Subsampling Ideas for Large Spatial Data Sets

Ver Hoef, Jay M. Alaska Fisheries Science Center*

Peterson, Erin E. Queensland University of Technology; Isaak, Daniel E. US Forest Service Rocky Mountain Research Station

Spatial data are among the most susceptible to a curse of sample size. Often, either sample sizes are too small to estimate covariance parameters well (sample sizes have been recommended to be greater than 125), or too large to invert matrices (required for kriging, or fitting models that assume a normal distribution) that are on the order of the sample size (iteratively inverting matrices with dimensions greater than several thousand is computationally infeasible). When sample sizes are large, an old idea is to use subsampling, or pseudo-likelihood, to estimate covariance parameters. Spatial prediction can then be done locally, using as data only sampled locations (say only several dozen) near the prediction location. However, ecologists are often interested in regression coefficients in the spatial linear model, which has received much less attention than prediction. I show how subsampling can be used to estimate the regression coefficients, and obtain appropriate confidence intervals, for large data sets. Predicting spatial averages (block kriging), rather than predicting values at specific spatial locations, is also of interest to ecologists. I show how subsampling can be used for block kriging. Block prediction is approximated over a grid, and that grid can be iteratively sampled to obtain the desired precision. For examples, I used simulated data to demonstrate the efficacy of the subsampling approach, and I compare it to the predictive process (also called reduced rank) approach. I then apply subsampling ideas to real temperature data on a stream network from the Pacific Northwest of the US, with nearly 10,000 data locations and hundreds of thousands of prediction locations. For this data set, I estimate regression coefficients, make point-wise predictions, and also use block kriging to predict average conditions throughout the network.

Testing for Types of Spatial Dependence on Stream Networks

Zimmerman, Dale

Liu, Zhijiang

Methods for characterizing spatial dependence on stream networks without assuming a particular parametric model have recently been developed (Zimmerman and Ver Hoef, 2017) to help inform model selection, but formal hypothesis tests for choosing between models do not yet exist. In this talk, I report on the recent development of tests for tail-up, tail-down, and other forms of dependence on the network. Theoretical properties of the tests and simulation results are presented.

Turning the Tides

Indigenous iNtegration of Aquatic sciences and Traditional-Ecological-Knowledge for Undergraduate culturally Responsive Education (i-NATURE): Piloting a culturally inclusive approach to STEM education for underrepresented minority undergraduates.

Alexiades, Alexander V. Heritage University

AI/AN students have the lowest college enrollment and graduation rates of any student cohort at mainstream U.S. colleges and universities, and are the least represented minority in the STEM fields. This project seeks to understand and address this enrollment deficit and prepare students for the future. The primary goal of i-NATURE is to develop and pilot a new, culturally-responsive, place-based model for Fisheries and Aquatic Science curriculum that can provide a seamless transition from high school to the STEM workforce for American Indian/Alaska Native (AI/AN). i-NATURE seeks to create this model for STEM education by establishing a strong collaboration between Heritage University (HU), the Yakama Nation Fisheries (YNF), and partnerships with several tribes, agencies, and universities around the PNW. The program is tailored to meet the needs of Native American and other URM students in a culturally responsive manner while simultaneously helping students acquire the skills and knowledge most critical for success in the STEM workforce and graduate school. The model aims to increase retention and learning outcomes in STEM fields and provide a strong foundation in data analysis and computing that will prepare students for graduate school and the 21st century workforce. The components of this model include: (i) an Experiential Project Based Learning Model with an emphasis on TEK, data analysis of culturally important aquatic and fisheries topics, and scientific communication, (ii) Intergenerational Mentoring, (iii) Summer Research Internships, and (iv) Regional Partnership Development to create programs uniquely tailored for AI/AN success in STEM (v) establishment of long term monitoring sites for classroom learning and student research (vi) pilot a fully online certification course in Indigenous Science and Research Methods for faculty and grad students seeking to work with AI/AN students.

Sing authentic science with fish to increase participation in fisheries

Broder, E Dale. University of Denver*

Guilbert, Katie. Bella Romero Academy of Applied Technology

Groups made up of diverse individuals are more effective, yet the field of fisheries biology is strikingly homogenous. The fact that diversity is the topic of a symposium at this year's meeting illustrates a fundamental shift in attitudes—we recognize that we must take action to increase diversity in fisheries. Unfortunately, there is no silver bullet that will boost participation in the field, but efforts at multiple scales can collectively catalyze change. My research explores relationships among science experiences, understanding of the nature of science, scientific self-efficacy, and interest in careers in science for K-12 students who identify as minoritized. Positive experiences with science at an early age are critical for shaping attitudes towards science. These experiences build scientific self-efficacy (belief in one's ability), which leads to increased

participation. I provide hands-on authentic science experiences that allow middle-school students to design and conduct original research with live fish. As part of the program, students present their findings at a regional conference. Participation in the conference and the act of disseminating their research increases their scientific self-efficacy. Community engagement programs that include authentic science experiences with fish should be a key part of our effort to increase participation in fisheries so that the next generation of biologists reflects the diverse background of our country.

A Look at Diversity and Inclusion Initiatives within AFS

Croxton, April, N. NOAA/AFS Equal Opportunities Section President

In recent years, AFS Chapters, Divisions, and Sections have increased their Diversity and Inclusion activities within the society. These activities include the dissemination of manuscripts, sessions at Chapter and Division meetings, workshops at annual meetings, and the participation in public/private partnerships outside of the society. The Equal Opportunities Section has been involved in several of these initiatives and our members continue to work towards the goal of increasing the representation and involvement of diverse ethnic/racial groups and females in the American Fisheries Society. This talk will focus on some of these initiatives, and the Society's involvement in the Diversity Joint Venture and how this will impact the Society as a whole.

Unity and Empowerment of Kuskokwim Youth as our Future Fisheries Leaders

Esquible, Janessa A. Orutsararmiut Native Council*

Gillikan, Dan. Native Village of Napaimute*

The Kuskokwim River is the second largest river in Alaska, and supports the largest subsistence Chinook Salmon fishery in the state. Chinook Salmon returns since 2011 have been insufficient to meet escapement goals and provide for subsistence harvest. Subsequently, subsistence users have been faced with extensive fishing restrictions that have not allowed them to meet their subsistence needs. The fisheries management participation "model" on the Kuskokwim is complex and inclusive of a variety of different interests. Currently, there are no less than six State sanctioned Advisory Committees or groups, three Federally supported Councils or Commissions, and at times, a split of Federal and State jurisdiction for inseason management authority. While this tapestry of public participation in the management of Kuskokwim salmon resources is unprecedented and wide-ranging, some voices remain underrepresented. Youth presence is minimal to nonexistent in the public participation process; the need for their involvement would not only provide a valuable perspective but also reinforce ownership in decisions made. Involving local subsistence users in fisheries management builds trust between stakeholders and trust in the overall decision making process. It allows for a more transparent process while instilling ownership and awareness of the associated consequences and fosters unity amongst all stakeholders. Through their Youth Outreach programs the Orutsararmiut Native Council, the Native Village of Napaimute, and several other partners have been striving to better prepare these young voices for a seat at the table when decisions are being made regarding management of their natural resources. Several successful programs and approaches will be highlighted in our presentation that engages our very youngest voices to those seeking advanced degrees or careers in Fisheries.

Native Alaska Women in Bristol Bay Fisheries

Lavoie, Anna

Sparks, Kim; Lee, Jean

Progressive research calls to incorporate gender into fisheries socio-ecological systems (SES) research, given that millions of women around the globe are involved in small-scale fisheries, yet under-represented in policy making. The Bristol Bay region of Alaska is ideal to advance such research given the nature of its fisheries which includes the largest Sockeye Salmon fishery in the world. We conducted a pilot study documenting oral histories of Native Alaska women in fisheries of the Bristol Bay region of Alaska to develop an understanding of women's roles in fisheries and their perspectives of environmental change. Nine interviews were conducted with twelve women of various age cohorts who have participated in commercial and/ or subsistence salmon fisheries. Our findings show that women play a major role in maintaining traditional native culture and values, including traditional fishing culture and knowledge, and maintaining fishing permits within families and communities. Women's contributions are critical to the cultural and socio-economic well-being, and resilience, of families and fishing communities in the region. In addition, the oral histories support cultural sustainability as they are documented for the long-term benefit of Native communities in Bristol Bay.

Engaging fishery stakeholders and communities: storytelling with oral history and visual ethnography

Lee, Jean. Pacific States Marine Fisheries Commission

Lavoie, Anna. Pacific States Marine Fisheries Commission; Sparks, Kim. Pacific States Marine Fisheries Commission; Lee, Jean. Pacific States Marine Fisheries Commission

Storytelling projects such as NOAA's Voices from the Fisheries offer opportunities to engage with fishery stakeholders and communities whose perspectives may be underrepresented in fisheries management processes. This engagement is of particular importance given increasing calls to incorporate local knowledge (LK) and knowledge co-production strategies into the federal fisheries management process. We describe one such project, undertaken by NOAA Alaska Fisheries Science Center in partnership with Bristol Bay Native Association, that applied oral history and video ethnography research methods to document the experiences of Alaska Native women involved in Bristol Bay salmon fisheries. We additionally describe methods for creating media products that can communicate research findings to broad audiences while also serving as outreach materials for project partners.

Public outreach in secondary schools, lessons from a teacher

McCormick, Patrick P. Anchorage STrEaM Academy

Public outreach is an important part of any fisheries project. Most education based outreach takes place in the primary grades (K-6) such as ADF&G's salmon in the classroom. Secondary students (grades 7-12) in your community are a tremendous resource that can be used in basic research answering important, yet often underfunded questions in local watershed. Working in schools is often challenging given the structures of jr. and sr. high schools in America. The goal of this talk is to explore the tremendous value of outreach in secondary schools and to educate scientist in how to best approach educators, what to expect in schools, and how best to interact with students.

Bristol Bay Guide Academy: A model for other rural communities?

Troll, Tim. Bristol Bay Heritage Land Trust

Williams, Nelli. Trout Unlimited-Alaska Program

In 2008, with support from Bristol Bay Native Corporation and Trout Unlimited, the Bristol Bay Heritage Land Trust launched an experimental project at the Ekwok Lodge on the Nushagak River to see if young people from Bristol Bay, primarily Alaska Natives, would be interested in fly fishing – for them a culturally unorthodox and unfamiliar method for catching (much less releasing) fish. The purpose of the experiment was to explore whether such a program might create job opportunities for local youth in the established local recreational fishing community and be an enjoyable means for teaching the future leaders of this remote region about fish habitat and how the diverse groups of businesses and people who depend on it might work to together to safeguard it. Since 2008, the Academy has grown significantly, and has now graduated more than 100 participants. Many graduates have found employment at lodges and a few have secured permanent positions. The 10th anniversary program will be held on the Naknek River in this June. This presentation will explore the success and challenges of the Academy and whether it provides a useful template for other rural fish-based education and employment programs. Note: We can add other speakers if a diverse perspective is wanted.

Seeking the mountain top-gaining ground and new perspectives on gender diversity in fisheries

Trushenski, Jesse. Evaqua Farms*

Throughout the world, women are underrepresented in the fisheries disciplines. Women employed in the field tend to be less well-compensated than their male counterparts and are less likely to hold positions of power and influence. Representation is greater in the fisheries sciences in the United States, but the profession remains predominantly male and largely monochromatic. Women comprise less than a quarter of the American Fisheries Society membership. Whereas many post-secondary education programs have achieved gender equality in enrollment and graduation rates, representation of women in the fisheries workforce, particularly in leadership roles, continues to lag behind. Although there is much yet to be done, much progress has been made. This presentation will review the current status of women in fisheries, highlight advances that have been achieved, and offer thoughts on the way forward for a profession continuing to seek the mountain top of diversity and inclusion.

Hooked on Aquatic Sciences: Using a fishing program to teach diverse youth about aquatic ecology and conservation

Ulrich, Taylor L. University of Arizona*

Liebich, Katrina. U.S. Fish & Wildlife Service

Inspiring excitement in youth about aquatic sciences can often be difficult. Perhaps one of the greatest ways interest in the sciences can be sparked is through hands-on experiences. However, youth have limited experiences in the outdoors and their connections with such environments are minimal, as there are many barriers to their involvement. Incorporating education into a summer fishing program is one method to teach kids about these environments and create excitement while providing hands-on experiences. This was one of the main goals of Creek to Plate, which is a U.S. Fish & Wildlife

Service program entering its sixth year that introduces Anchorage youth to safe fishing opportunities near home. Although Anchorage is a relatively when small city compared to larger urban centers such as New York, it is Alaska's largest and ranks 65th in size in the U.S. with over 380,000 people in the metropolitan area. It has big-city diversity with over 100 languages spoken in the school district, which is the most diverse in the nation. In 2017, 100 kids from this highly diverse city spent over 1,000 hours participating in this program that focused primarily on educating them about aquatic ecology in fun ways and on teaching them how to become proficient anglers. Here, we discuss the cultivation of the next generation of conservationists via Creek to Plate.

Introducing the Western Division Diversity and Inclusion Committee

Owens, Cheyenne. USFWS

Lee, Larissa. USGS Arizona Cooperative Fish and Wildlife Research Unit

As one of Western Division's newest committees, the Diversity and Inclusion Committee aims to bridge the gap between chapter efforts and national efforts geared toward bringing diversity and inclusion to the American Fisheries Society. This presentation will discuss the mission statement and objectives of the committee while highlighting upcoming committee efforts and ways members can get involved in building equity in the fisheries profession.

Understanding the Drivers of Chinook Salmon Decline in Western Alaska & Exploring New Approaches to Sustainable Salmon Management & Stakeholder Engagement

Linking Communities to Inseason Salmon Management: Kuskokwim River Community-based Salmon Monitoring Program

Bechtol, William R. Kuskokwim Inter-Tribal Fish Commission

Albertson, LaMont. Bering Sea Fishermen's Association; Spaeder, Joseph J. Bering Sea Fishermen's Association

Approximately 12,000 people, primarily Alaska Natives, reside within Alaska's Kuskokwim River drainage. This region is characterized by some of the lowest incomes in the state and a high production of wild foods. Salmon represent the single largest category of wild food harvests in most communities, with Chinook Salmon *Oncorhynchus tshawytscha* typically being the most important salmon species due to cultural, nutritional, and logistical factors. Chinook Salmon returns to the Kuskokwim River declined dramatically in the early 2010s, and 2013 exhibited the lowest return in nearly four decades. Prior to 2014 there has been little or no active inseason management of subsistence harvesting, and data collection of subsistence harvests has relied on post-season surveys. However, weak Chinook Salmon returns for the past four years runs have resulted in significant restrictions to customary subsistence harvest levels. In order to provide a conservative approach to the 2017 Chinook Salmon fishing season, a novel approach was adopted to collaborate with village councils to identify and employ community-based monitors from six lower Kuskokwim River villages to interview village residents and collect information such as catch, effort, and gear type, as well as to collect age, sex, and length (ASL) data from the catch. This is a region where cell phones are common and community monitors were able to upload harvest and effort data via smartphone. Monitors were largely successful in being able to compile and transfer harvest and effort data to managers within 12 hours of the closure following a subsistence fishing period. This information filled a critical inseason management void, helping to reduce uncertainty in management decisions. Through this process, the community monitors also served as

information conduits, transferring information on fishing opportunities to village residents while also relaying local concerns and observations to managers.

Does Quality Matter: Relating the Age, Sex and Length of Spawning Adult Chinook Salmon to Fecundity and Yield Potential

Boersma, James K. U.S. Fish & Wildlife Service*

The demographic structure of many Chinook Salmon *Oncorhynchus tshawytscha* populations have exhibited persistent shifts toward younger, smaller male dominated compositions. Accounting for changes in a population's demographic structure as it relates to fecundity, and recruitment, can provide clarity to the underlying processes driving productivity. Here, we employed an age structured Ricker spawner recruit relationship that incorporates the connection between a population's Age, Sex and Length (ASL) composition to fecundity and productivity. Our results indicate a strong effect of spawning stock population structure on recruitment dynamics. Our approach provides managers an illustrative tool for assessing the consequences of shifts in spawning stock quality on yield potential.

Strontium isoscapes as a tool to quantify production dynamics and life history diversity of Yukon and Kuskokwim Chinook Salmon

Brennan, Sean R. University of Washington, School of Aquatic and Fishery Sciences

Schindler, Daniel E. University of Washington, School of Aquatic and Fishery Sciences

There is a critical need to quantify production dynamics and habitat use patterns of Chinook Salmon in western Alaska rivers across the multiple spatial and temporal scales of biological diversity and environmental variation that influence the productivity of these populations. To this end, we have been generating strontium isoscapes (87Sr/86Sr) across these vast watersheds using spatial stream network models (SSNMs) to better understand how Chinook Salmon production shifts across space and through time in the Yukon, Kuskokwim, and Nushagak rivers. By coupling isotope information stored in otoliths with these watershed isoscape models, we have developed an analytical framework to accurately reconstruct patterns of production and freshwater habitat use of fish harvested in the fisheries conducted at the termini of these large rivers. Doing so has produced unique insights into the more elusive temporal and spatial scales that characterize the biocomplexity of these stocks - which are critical to their resilience. In particular, by linking individuals and populations to habitats through time, this framework has the ability to assess how variation in freshwater environmental conditions influences production of Chinook Salmon and the reliability of fisheries conducted within these rivers. Here, we present preliminary results from our projects on the Yukon and Kuskokwim rivers and demonstrate the isotope-based analytical framework by showing examples from Nushagak River Chinook Salmon. Our work on the Nushagak River illustrates how isotope-based provenance and movement information can evaluate how multiple dimensions and scales of biological diversity influence the reliability of fisheries.

Demographics of Chinook Salmon *Oncorhynchus tshawytscha* Spawning Runs in the Yukon River using Known-Sex Sample Data

Brown, Randy J. U.S. Fish and Wildlife Service

Ohlberger, Jan. University of Washington

There is a growing interest among some in evaluating Chinook Salmon spawning runs for measures of quality, such as size, age, and proportion of females, rather than simply numbers of fish. Most sampling programs in the Yukon River classify sex based on external morphology, but sex-specific morphology is not pronounced early in a spawning migration and considerable errors in sex assignment are known to occur. Sex misclassification can obscure quality of escapement assessments. Here we describe the demographics of Chinook Salmon spawning runs in the Yukon River using sample data from projects that handled dead fish and classified sex based on internal observations of gonads. Age, sex, and length (MEFT) data were obtained from the ADF&G online database for main stem test fishing, harvest, and carcass sampling activities. We collected over 36,000 known-sex records from the last 25 years or so that included both age and length data. We found that among known-sex collections, brood year age 4 fish (1.2) averaged over 98% male, age 5 fish (1.3), 74% male, age 6 fish (1.4), 67% female, and age 7 fish (1.5), 75% female. Length distributions of males and females were significantly different, with males averaging 741 mm with a left skewed distribution, while females averaged 840 mm with a normal distribution. We briefly compare these results with those from samples in which sex was classified based on external observations. Within age classes, males and females were similar in size with the exception of age 5, in which females were substantially larger than males. About 95% or more of the Chinook Salmon in Yukon River spawning runs are age 4, age 5, and age 6. We discuss these data in the context of improving our understanding of quality of escapement in the absence of reliable sex data.

The influence of time- and age-specific variation in per capita fecundity on estimates of management reference points for Kuskokwim River Chinook Salmon

Catalano, Matthew J.

Staton, Benjamin A.; Fleischman, Steven J.

Over the past several decades, declining trends in age- and size-at-maturity of many Pacific salmon *Oncorhynchus* spp. stocks have been observed across the western coast of North America, which have led to concerns about their genetic diversity, productivity, and overall sustainability. However, most salmon assessment models are focused on the aggregate abundance of returns and escapement, and thus changes in per capita reproductive contributions via trends in age- and size-at-maturity are not typically accounted for by these models. Here we present an age- and sex-structured assessment that incorporates fishery vulnerability and temporal changes in age- and- size-at-maturity for the Kuskokwim River Chinook Salmon stock, located in western Alaska. The model tracks the age and sex composition of various components of the population including commercial and subsistence harvest and spawning escapement. This structure allows for spawners of different sizes and sexes to contribute differentially to the spawning output of the population in terms of age- and year-specific fecundity. Our analysis found strong empirical support for differences in vulnerability to harvest among ages, between sexes, and between fisheries (commercial vs. subsistence). Furthermore, investigation of mean fecundity showed that the average spawner in recent years is contributing approximately 12% less to the annual egg production than one did 40 years ago. The combination of fishery selective forces and these changes in egg production indicate that the number of spawning fish to achieve maximum sustained yield is greater when these fishery and demographic characteristics are included compared to when they are ignored.

Longitudinal Patterns of Logjams and Occupancy by Juvenile Chinook Salmon in the Chena River, Alaska

Cathcart, Charles N. University of Alaska Fairbanks

Falke, Jeff. Alaska Cooperative Fish and Wildlife Research Unit; Crabill, Brian. U.S. Fish and Wildlife Service; Fox, Jimmy. U.S. Fish & Wildlife Service

Chinook Salmon *Oncorhynchus tshawytscha* are a significant commercial, ecological, and cultural resource in the Yukon River basin, yet their populations have declined in recent years. Because juveniles rear in freshwater for an entire year, information on their abundance and habitat preferences may be especially important. In boreal tributary streams, large wood (i.e., logjams) is thought to provide critical rearing and refuge habitat for juvenile salmon. However, the distribution and abundance of logjams along the riverscape and relationships between logjam characteristics and juvenile salmon habitat use are poorly understood. We measured habitat attributes (e.g., submerged area, formative fluvial process, etc.) for all logjams (N=429) and conducted fish snorkel counts for a randomly-selected subset (N=189) of logjams within the known distribution (283 stream-km) of juvenile Chinook Salmon rearing in the Chena River basin, Alaska, during summer 2017. Logjam density and potential wood recruits (i.e., downed trees) declined downstream (33 recruits/km, 6 logjams/km; 6 recruits/km; 0.3 logjams/km, respectively), particularly below Moose Creek Dam which is thought to intercept wood from the upper basin. Logjam size (submerged area; m2) increased downstream. In upstream reaches smaller logjams formed on fallen trees or gravel bars in higher velocity channel units (i.e., riffles, runs), and larger logjams downstream formed on fallen trees or meanders in pools. We found no evidence of snorkeling observer bias, and juvenile salmon were present at 68% of logjams and their density (fish/ m2) ranged from 0.0002 to 9.0. The highest densities occurred in the middle reaches of the network and corresponded with high quality adult spawning habitats. Finally, we modeled juvenile salmon density as a function of logjam characteristics and made unbiased population estimates using a spatial-stream-network model. Our results improve our understanding of juvenile salmon habitat preferences and offer a useful tool to index juvenile salmon production throughout the basin.

Structured Decision Making to Support Cooperative Inseason Management of Kuskokwim River Chinook Salmon

Coggins, Lew. U.S. Fish & Wildlife Service, Bethel, AK*

Staton, Ben. U.S. Fish & Wildlife Service, Bethel, AK; Bechtol, William. Kuskokwim River Inter-Tribal Fish Commission, Homer, AK

Beginning in 2015, the management of the Kuskokwim River Chinook Salmon subsistence fishery has been conducted in a cooperative relationship between the Yukon Delta National Wildlife Refuge, the Kuskokwim River Inter-Tribal Fish Commission, and the Alaska Department of Fish and Game. Managers have strived to use a Structured Decision Making (SDM) framework informed by preseason run size and run timing forecasts, inseason stock assessment, and inseason harvest estimates to consider and execute alternative management actions consisting of time, area, and gear-specific subsistence fishing opportunities. Key aspects of the SDM framework include: (1) precise definition of fundamental and means objectives expressed as escapement and harvest targets, (2) models to predict the performance of alternative management actions considering data from inseason run assessment projects, harvest estimates, and manager expert opinion, and (3) periodic meetings among cooperating managers to objectively assess the performance of past management actions and consider future management alternatives. A novel component of this SDM framework and management of Kuskokwim River Chinook Salmon is the production and use of inseason harvest estimates informed by

survey data collected within villages along the Kuskokwim River by tribal entities, and effort estimates informed by aerial surveys of fishing boats. These estimates inform progress towards harvest targets and fishery participation data also inform predictions of harvest during future fishing opportunities under consideration. Management structure improvements currently under development include methods to periodically update the annual harvest target as run assessment improves by jointly considering the preseason run forecast and the inseason information from the Bethel Test Fishery and the Kuskokwim River Sonar.

Incorporating harvest-population diversity tradeoffs into salmon management in large river basins: insights from Chinook in the Kuskokwim and Yukon River Basins

Connors, Brendan. Fisheries and Oceans Canada

Coggins, Lew. U.S. Fish & Wildlife Service; Staton, Ben. U.S. Fish & Wildlife Service & Auburn University; Walters, Carl. University of British Columbia; Jones, Mike. Michigan State University; Catalano, Matt. Auburn University; Harding, Joel. Fisheries and Oceans Canada

Variability among salmon populations in ecological characteristics and productive capacity (i.e., population diversity) can be critical to maintaining resilience to environmental change and to dampening variability in harvest for fisheries that depend upon them. However, when fisheries for multiple populations overlap in space and time there can be an inherent conflict between harvest rates and population diversity: high harvest rates, which can be sustained by the most productive populations, can come at the cost of increased risk of overfishing less productive ones. Despite the potential importance of these harvest-population diversity tradeoffs, salmon management, including in the large river basins of Western Alaska and the Yukon, does not often explicitly consider them. Over the past several years, through a series of AYK-SSI funded projects, we have characterized the degree of Chinook population diversity within the Kuskokwim and Yukon River basins and then used this to inform closed loop simulations that evaluate how well how alternative harvest policies meet population diversity and fishery objectives. Both basins have strong evidence of population diversity which gives rise to tradeoffs between maximizing yield and overfishing or extirpating the least productive stocks. Fixed harvest, basin scale escapement goal, and time varying harvest policies differ in their ability to meet conservation and fishery objectives. Harvest goals under any policy often have to be reduced to minimize risks to population diversity, but the resulting tradeoffs with fishery performance differ across harvest policies. Our findings provide general insights into how existing approaches to salmon management in large river basins might be modified to protect the population diversity inherent in them, while at the same time meeting fishery objectives.

Life cycle modeling of Yukon River Chinook Salmon reveals signals of large scale climate drivers, hatchery enhancement, and density-dependent juvenile survival

Cunningham, Curry J. NOAA Alaska Fisheries Science Center*

Westley, Peter A. H. University of Alaska Fairbanks, College of Fisheries and Ocean Sciences; Adkison, Milo D. University of Alaska Fairbanks, College of Fisheries and Ocean Sciences

Understanding what drives patterns in abundance and how species might respond to future habitat or climate change involves disentangling the influence of multiple, co-occurring factors on population dynamics, and is particularly difficult for

species that transcend multiple ecosystems. Debate surrounding the cause of recent declines in Yukon River Chinook Salmon *Oncorhynchus tshawytscha* abundance has often centered on whether factors in freshwater or marine environments control variation in survival, and how these populations at the northern extremity of the species range will respond to a changing climate. To evaluate the effect of environmental factors in marine and freshwater environments on Yukon River Chinook Salmon survival, we constructed a stage-structured assessment model that incorporates all available data for the Chena and Salcha river populations, estimates the magnitude and selectivity of bycatch mortality in trawl fisheries, and applies Bayesian model selection methods to quantify support for alternative hypotheses. We describe which factors best explain past variation in survival and hypothesize what these relationships suggest about population responses to projected climate change for this region.

Nushagak River Chinook Salmon assessment program, management structure, and stock status

Erickson, Jack. Alaska Dept. of Fish and Game*

Buck, Greg. Alaska Dept. of Fish and Game; Sands, Tim. Alaska Dept. of Fish and Game; Maxwell, Suzanne. Alaska Dept. of Fish and Game

The Nushagak River in southwest Alaska supports an average (1975–2017) annual run of approximately 237,000 and a spawning escapement of approximately 162,000 Chinook Salmon. The commercial, subsistence, and sport fisheries are managed to achieve the sustainable escapement goal of 55,000–120,000 provide for long-term sustainable harvest. Management decisions are based on inseason estimates of salmon passage at a sonar upstream of the commercial fishery as well as inseason estimates of commercial harvest within the Nushagak fishing district. This presentation, by the Alaska Department of Fish and Game, will discuss the current status and trends of Nushagak River Chinook Salmon as well as two recent research projects that were conducted to assess the Nushagak River sonar project that uses netting apportionment to index Chinook Salmon run strength.

Is early growth opportunity linked to alternative migration strategies? A spatially-explicit bioenergetics model in Chinook Salmon

Gillies-Rector, Katherine E. University of Idaho Department of Fish and Wildlife Sciences

Kennedy, Brian P. University of Idaho Department of Fish and Wildlife Sciences

Understanding the drivers for life history diversity can play an important conservation role. Historically, the majority of juvenile Snake River fall Chinook Salmon expressed a subyearling migration strategy typified by initiating seaward migration within the hatch year. Recent studies have demonstrated that a yearling juvenile migration strategy has emerged in the Snake River Fall Chinook population and that a significant proportion of juveniles now overwinter in reservoir habitat. The recently expressed yearling strategy seems to be disproportionately expressed by fish originating in the Clearwater River, and results from our lab suggest that early juvenile growth may be a key factor linked to expression of this migration strategy. We hypothesize that if growth opportunity varies spatially within the population, it will occur at measurable levels in the early season growth of fish from a single year class. In this study we collected juvenile Chinook Salmon from the Snake, Clearwater and Grande Ronde Rivers between May and June of 2017. We extracted otoliths which we analyzed to reconstruct daily growth using increment analysis and collected stomach samples to determine diet composition and prey

energy density. Growth, diet, and average daily water temperature (°C) were analyzed using Fish Bioenergetics 4.0 in R. While bioenergetics analysis is ongoing, results from growth reconstruction suggest a spatial component to early growth. Otolith increment width (as a proxy for growth) differed significantly in fish originating in the upper Snake River, the Grande Ronde, and the Clearwater for the period between late March and early May ($p<0.05$) suggesting that growth opportunity differs among rivers within the basin. These results support the hypothesis that growth opportunity is spatially structured within the Snake River fall Chinook ESU and may provide variation in migration strategies across years with high variability in growth potential.

Assessing the Limits to Production for Upper-Yukon Chinook Salmon

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Milligan, Marina L. Fisheries and Oceans Canada

Significant knowledge gaps exist about early life-history and survival of Chinook Salmon *Oncorhynchus tshawytscha* in Yukon and Alaska. Variation in early fresh water survival may exert a large influence on recruitment within the Yukon River drainage. While assessing adult salmon stock provides valuable information on returns for fisheries management, a greater understanding of the link between adult spawner abundance and juvenile survival can help identify limits to production and guide approaches to restoring and managing Canadian-origin Chinook Salmon in the Upper-Yukon River. This project aims to quantify the relationship between juvenile Chinook Salmon and their parental adult spawners in the Big Salmon River system, a major spawning tributary to the Canadian portion of the Yukon River. Annual juvenile abundance estimates (derived via mark-recapture and Bayesian time-stratified Peterson population analysis models) are paired with an existing adult enumeration project, which enables direct comparisons between adult spawning abundance and the resultant abundance of outmigrating juveniles the following year. Based on current data, an average production of 154 0+ juveniles per adult female is estimated for the Big Salmon River system. Estimates of 1+ juvenile production are contingent on genetic analyses confirming what proportion of 1+ fish are non-natal to the Big Salmon drainage. Although this work may not represent productivity at the watershed scale, it does provide a consistent multi-year index that will contribute to our understanding of factors that influence productivity during freshwater life-stages and identify key relationships between adult spawning escapement, freshwater conditions and juvenile abundance.

Monitoring Chinook Salmon smolt in Western AK to evaluate freshwater density dependency.

Harper, Ken C. USFWS Kenai Fish and Wildlife Field Conservation Office*

Boersma, James K. USFWS Kenai Fish and Wildlife Field Conservation Office; Coggins, Lewis G. USFWS Yukon Delta Nation Wildlife Refuge

Kuskokwim River Chinook Salmon management relies heavily on a manager's ability to anticipate a populations stability and growth rates. Many AYK adult Chinook Salmon spawner-recruit relationships have shown evidence for strong density dependence and are used to predict their respective populations' productivity. Partitioning density dependent effects between the freshwater and marine life history phases may highlight the relative importance of the two periods and may help anticipate the overall productivity of the population. We investigated the freshwater productivity of Kwethluk River Chinook Salmon by pairing spawning and resulting smolt abundance. We used an adult weir to estimate spawning

escapement and a rotary screw trap and mark-recapture techniques to estimate smolt abundance. The data collected has yielded a high contrast in the relationship between spawning adult and smolt abundance. During the short span of this study, spawner abundance has increased 10 fold, while, smolt per spawner have shown the antithesis, decreasing from approximately 200 to 50 smolt per spawner. These results suggest some fresh water density dependence and highlights the importance of the freshwater juvenile life history phase for Kwethluk River Chinook Salmon. However, because of the short study duration there is still a high level of uncertainty about the implication of density in this population's spawner to smolt relationship, which warrants further investigation.

Beyond Mortality of Individuals: Population-Level Indices Informing Estuarine/Marine Drivers of Yukon River Chinook Salmon Productivity

Howard, Kathrine G. Alaska Department of Fish and Game

Murphy, James. Alaska Fisheries Science Center, NOAA Fisheries

Juvenile Yukon River Chinook Salmon abundance information, when paired with data from the adult life stage, provides a powerful tool for distinguishing between potential sources of mortality for individual fish and potential drivers of population-level fluctuations. Relationships between juvenile and adult Yukon River Chinook Salmon abundance suggests cohort strength is largely driven by processes occurring prior to September of their first year in the ocean (freshwater and/or very early marine life) for brood years since 2001, while later marine processes are contributing relatively little to the variability in cohort strength. For example, size-selective mortality after the first summer at sea, presumably during the first winter as sea, has been demonstrated in Yukon River Chinook Salmon stocks. However, this source of mortality does not appear to significantly influence cohort strength or productivity patterns. Energy allocation rates of northern Bering Sea Chinook are higher than those observed in lower latitude stocks, and may facilitate increased resiliency to survival during the first marine winter than is typically present in lower latitude stocks in the Gulf of Alaska. Although sources of mortality can be important at an individual fish level, they may not be able to explain population-level changes in productivity patterns over time. Mortality processes occurring during early life-history stages of Yukon River Chinook Salmon such as environmental mechanisms structuring timing of ontogenetic changes, or timing and availability of prey at critical early life stages are believed to have a greater impact on population-level variability in cohort strength.

Barriers and bridges to implementing management strategy evaluation in a data limited system

Jones, Michael L. Quantitative Fisheries Center, Michigan State University

Management strategy evaluation (MSE) is rapidly becoming a standard tool for informing the development of fisheries policy throughout the world. MSE involves using simulation tools to evaluate the performance alternative management strategies for a fishery while explicitly considering key sources of uncertainty that make such an evaluation challenging. Recent experience with MSE points to the importance of effective stakeholder engagement in the process. In Western Alaska, where subsistence salmon fisheries are a vital component of the regional culture and economy, uncertainty about salmon population dynamics and fishery performance is large, relative to other important US fisheries. Since 2009 we have been exploring the application of MSE to these fisheries, where historically management was guided by a limited recognition of uncertainty. An AYK-SSI expert panel introduced the concept of MSE to state and federal biologists and managers, and developed preliminary models between 2009 and 2012; the approach has been recognized as a useful step forward, but

managers expressed concern about stakeholder capacity to engage in an MSE process. In response we have begun to focus effort on building this capacity to facilitate meaningful involvement in an engaged, participatory MSE process. Our efforts in the Kuskokwim River watershed have benefited from the coincident emergence of the Kuskokwim River Intertribal Fish Commission, and early efforts to engage local citizens in monitoring activities to inform management. We are at an earlier stage of engagement for the Yukon River, but have used a preliminary MSE for the Canadian-origin population of Chinook Salmon in this river to increase awareness of the MSE methodology and recently initiated capacity building efforts in collaboration with the Yukon River Intertribal Fish Commission.

Otolith shape revealing life history traits of Chinook Salmon in Patagonia and Oregon

Koeberle, Alex L. Oregon State University*

Arismendi, Ivan. Oregon State University; Di Prinzio, Cecilia. National Scientific and Technical Research Council

In southern Chile and Argentina (Patagonia) introduced salmon and trout support commercial and recreational industries and attract anglers from around the world. In particular, multiple propagations of Chinook Salmon *Oncorhynchus tshawytscha* in this region have resulted in genetically diverse populations. Yet, few studies have documented specific life history traits contributing to the success of Chinook Salmon in Patagonia. This begs the question, can invasive species express multiple life histories, and if so, are these histories potential mechanisms for successful establishment? Here, we use otolith morphology to contrast among introduced Chinook Salmon populations in South America. In addition, we include otolith samples from wild and hatchery origin populations in Oregon. Northern Patagonia and Oregon have similar environmental conditions, physiography, and latitudes, and thus, we can compare life history strategies across hemispheres. Determining specific life history characteristics of Chinook Salmon in novel systems like Patagonia will help to better understand conservation strategies for wild and hatchery fish in their native range in the Pacific Northwest. Sampling efforts involve a network of local collaborators of scientists, volunteers, and anglers in Chile and Argentina as well as collaboration with Oregon Department of Fish and Wildlife for otolith samples in Oregon. This research has implications for future scenarios as better understanding life history plasticity will support management and conservation in the face of climate change and increased competition among native and non-native species, both in Patagonia and in North America.

Effective population size of Chinook Salmon in Yukon and Kuskokwim river tributaries

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Over the last 10-15 years, the number of Chinook Salmon returning to the Arctic-Yukon-Kuskokwim (AYK) region has been significantly below the long term average. These declines in abundance could negatively influence the genetic diversity and long term viability of populations in this region. To examine this influence, we used genetic data to estimate effective population sizes (Ne) of AYK Chinook populations and compared these estimates to census sizes (N). Effective population size is a measure of genetic health that roughly corresponds to the number of individuals contributing offspring to the next generation. Some factors that can contribute to variation in Ne include skewed sex ratios, large fluctuations in abundance, and high variance in individual reproductive success. Comparing Ne to estimated census sizes (N) can shed light on how these processes are impacting individual populations and can provide important information on genetic health. We used

genetic and genomic data to estimate Nes and compared these data to estimates of N obtained using weir counts, counting towers, and aerial surveys. Our results provide important information on the genetic health of Chinook populations in the AYK region that will be useful for developing future conservation and management strategies.

Yukon River Chinook Salmon assessment program, management structure, and stock status

Liller, Zachary

West, Fred; Carroll, Holly

The Yukon River is the largest river in Alaska and supports an annual run of Chinook Salmon that return to spawn in tributaries throughout the United States and Canada. Chinook Salmon fisheries are managed to achieve escapement goals that provide for long-term sustainable harvest. Yukon River salmon fisheries are cooperatively managed in Alaska by the Alaska Department of Fish and Game and U.S. Fish and Wildlife Service, with extensive consultation with public stakeholders, advisory groups, and the Department of Fisheries and Oceans Canada. Management decisions are based on the best available data from a complimentary suite of inseason and postseason assessment projects. This presentation, by the Alaska Department of Fish and Game, will discuss the current status and trends of Yukon River Chinook Salmon. We will also provide an overview of the collaborative assessment program, management structure, and efforts to include stakeholders through active partnerships and outreach.

Kuskokwim River Chinook Salmon assessment program, management structure, and stock status

Liller, Zachary

Smith, Nicholas; Tiernan, Aaron

The Kuskokwim River is the second largest river in Alaska and supports an annual run of Chinook Salmon that return to spawn in nearly all tributaries throughout the drainage. The largest subsistence harvest of Chinook Salmon in Alaska has been historically taken from the Kuskokwim River. Chinook Salmon fisheries are managed to achieve escapement goals that provide for long-term sustainable harvest. Kuskokwim River salmon fisheries are cooperatively managed by the Alaska Department of Fish and Game and U.S. Fish and Wildlife Service, with extensive consultation with advisory groups and public stakeholders. Management decisions are based on the best available data from a complimentary suite of inseason and postseason assessment projects. This presentation, by the Alaska Department of Fish and Game, will discuss the current status and trends of Kuskokwim River Chinook Salmon. We will also provide an overview of the collaborative assessment program, management structure, and efforts to include stakeholders through active partnerships and outreach.

The influence of beavers on juvenile salmon ecology: Do beavers negatively impact freshwater habitat for Chinook?

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Beavers have the ability to strongly modify freshwater salmon rearing and spawning habitats. We hypothesized that beavers increase floodplain complexity and production of juvenile salmonids in the parafluvial zone (close to the main channel) of large alluvial rivers because salmon grow faster in beaver ponds, but that beavers may reduce salmon production at the floodplain scale because of decreased connectivity to orthofluvial habitats (farther from the main channel). We contrasted habitat use and production of juvenile salmon on the Kwethluk River (with beavers) to a geomorphically similar river in Kamchatka, the Kol River (without beavers). We examined important rearing habitats in each floodplain, including springbrooks, beaver ponds, beaver-influenced springbrooks, and shallow shorelines of the river channel. Through satellite imagery analysis we found that beavers modified 50% of off-channel aquatic habitats on the Kwethluk. The presence of beavers increased the complexity of habitats and hydrological connectivity in the Kwethluk and juvenile salmon densities were highest in early-successional beaver ponds in the parafluvial zone vs. very low in mid- and late-successional beaver ponds in the orthofluvial zone (0.78/m2 vs. 0.18/m2 and 0.03/m2). YOY Coho and Chinook grew faster and larger in early-successional ponds than in spring brooks, increasing production from the parafluvial zone in the Kwethluk. However, in the Kol salmon were able to use the entire floodplain and densities were equal in the parafluvial and orthofluvial zones. Chinook condition was also highest in orthofluvial springbrooks. If beavers were not present on the Kwethluk, floodplain habitats (i.e. springbrooks) would be fully interconnected and theoretically could produce greater biomass and numbers of juvenile salmon if spawner escapement is high enough. The effects of beavers on salmon are variable and site dependent and many factors can determine how beavers influence juvenile salmon populations (e.g. stream order, hydrology, habitat availability, dam location and permeability, etc.).

Potential effects of late marine mortality on Chinook Salmon populations

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Populations of Chinook Salmon *Oncorhynchus tshawytscha* have declined in abundance throughout their range. Additionally, recent studies have highlighted decreases in age-at-maturity and size-at-age in many populations this has been observed most strongly in western Alaska. These concurrent changes across the range of this species suggest that a perturbation in the marine environment may be responsible. One hypothesized cause of these changes is increasing marine mortality risk for older life stages. Marine mortality can be due to a number of factors including environmental conditions and fisheries; however, a recent tagging study in the Bering Sea Aleutian Islands region showed considerable proportion of tagged fish were consumed by predators. The status of Chinook Salmon combined with the tagging results led to the question: could predation late in the ocean stage affect the demographics of Chinook Salmon? To evaluate this question, we utilized an existing stage-structured population dynamics model to simulate the potential impacts of late marine mortality on the age structure of an indicator Chinook Salmon population. The simulations showed that the age structure of the population was very sensitive to additive mortality in the marine phase, particularly on older individuals. Here, we present these simulation results in the context of the ecological implications of the loss of the oldest, largest fish, such as changes in egg production, swimming speed, and sex ratio. These simulations demonstrate that mortality late in the marine phase could easily influence Chinook Salmon demographics, however the extent to which this potential is realized will depend on the size selectivity and additive or compensatory nature of the mortality.

Estuarine ecology of juvenile Chinook Salmon on the Yukon River Delta

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Chinook Salmon, *Oncorhynchus tshawytscha*, that spawn in the headwaters of the Yukon River undertake one of the longest fish migrations in the world. The juveniles spend a year in freshwater before migrating to sea. The long downstream migration differentiates Yukon River Chinook Salmon from other Chinook Salmon stocks in the U.S. and Canada and may have a disproportionate influence on production. Outmigration is a physiologically stressful phase during which salmon are growing and adapting to new food resources. A substantial body of research suggests that growing faster and attaining a larger size positively affects ocean survival and recruitment to the adult population. From 2014 through 2017, juvenile Chinook Salmon were surveyed in the three main tributaries of the lower Yukon River with the objective of obtaining information on their outmigration phenology, size, and energetic condition. Sampling commenced at ice breakup and each station was sampled three times per week through the end of July. Data collected to date has provided new information on the spatial distribution of juvenile salmon in the Yukon Delta and expanded on the only previous research, conducted in the late-1980s, on salmon distribution, timing, and abundance in this area.

Natural Indicators of Salmon Run Timing and Abundance

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Fishers' specialized and adaptive local knowledge can provide long-term observational data to fisheries managers and scientists and aid in understanding environmental variability that influences fluctuations in populations of Pacific salmon. Yukon River fishers have long relied on this knowledge to guide them in preparation for the salmon arrival. Investigators sought to understand the historical abundance, distribution, and health of salmon in subsistence communities in the middle and lower Yukon River through documentation and analysis of local and traditional knowledge (LTK). Ethnographic research focused on natural indicators of salmon run characteristics to explore patterns in Chinook, summer chum, and fall Chum Salmon runs. For this project, natural indicators are defined as empirical observations that correlate with specific ecological phenomena. Results of this study suggested that fishermen implicitly separate their observations of natural phenomena into either causal or correlative indicators. Causal indicators are those events that make something happen with the fish run: they are directly tied to how the salmon run develops. For example, wind direction and intensity at specific times of the year affects when fish run and which mouth of the Yukon River they enter. Correlative indicators are observations that occur at the same time as the salmon run. Correlative observations are useful as they provide information to the fishers about the salmon run, but do not have any effect on the run. Examples of these indicators include migrating birds and the appearance of certain flora and fauna. Throughout this study, participants expressed concern about environmental changes that make natural indicators less predictable or reliable. The changes include weather shifts, warmer winter air temperatures, an increase in sandbars, and reduced salmon abundance. Most residents believe that these changes affect both how people fish and the fish themselves and have implications for the flexibility and adaptability of subsistence economies.

Proximate Composition and Bioelectrical Impedance Analysis of Yukon River Chinook Salmon

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Chinook Salmon *Oncorhynchus tshawytscha* undertake energetically demanding migrations wherein they must have adequate energy reserves to survive to spawning locations and successfully reproduce. Stocks in Alaska, including Yukon River populations which travel up to 3000 km to spawn, have recently undergone a period of decline. It is important to understand if changes in energetic status through time and across the migration period may be contributing factors, and non-lethal and accurate energetic status estimation methods are needed for these sensitive populations. We sampled 129 Chinook Salmon from four populations in Alaska, of which two were located in the Yukon River basin (N = 69 individuals), to examine variation in energetic status pre- and post-spawning migration and create a model to non-lethally predict energetic status using bioelectrical impedance analysis (BIA). Electrical measurements were taken in the field and total body lipid, water, and protein percentages were estimated using proximate analysis for fish collected from the mouth of the Yukon River at Emmonak, Alaska and the Chena River near Fairbanks, Alaska. Populations sampled at the beginning of their freshwater spawning migration (Emmonak, AK) had 22.8% higher lipids ($P < 0.001$) relative to those collected near the spawning grounds (Chena). Individuals also had significantly lower water and higher protein earlier in their spawning migrations ($P < 0.001$). Lipid, water, and protein content did not differ between sexes. Lipid and water were precisely predicted as a function of BIA measurements using a generalized linear model (RMSE = 5.33; RMSE = 2.43, respectively). The results of this study will provide researchers with benchmark estimates of lipid, water, and protein content for Chinook Salmon in Alaska and a method to non-lethally and accurately estimate energetic status for sensitive populations such as those in Yukon River basin.

Feeding Ecology of Juvenile Chinook Salmon in the Chena River, Interior Alaska

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Chinook Salmon *Oncorhynchus tshawytscha* are critical to subsistence and commerce in the Yukon River basin, but several recent years of low abundance have forced devastating fishery closures and raised urgent questions about causes of the decline. The Chena River subpopulation in interior Alaska has experienced a decline similar to that of the broader population. An analysis of population data suggested a strong relationship between years of poor recruitment and high stream flow during the summer Chinook Salmon spend as fry drift feeding in the river. To investigate behavioral mechanisms underlying this relationship, I used a stereo pair of high definition video cameras and the 3-D analysis software VidSync to analyze the fine-scale behavior of schools of juvenile Chinook Salmon associated with woody debris along the margins of the Chena River. Juvenile Chinook Salmon spent 91% of their foraging attempts investigating and rejecting debris rather than capturing prey, which affects their energy intake rate and makes foraging attempt rate an unreliable indicator of foraging success. Even though Chinook Salmon were found in closely-spaced 3-D aggregations, some were highly territorial within these groups, and many others maintained exclusive space-use behaviors consistent with the population regulatory effects of territoriality observed in other salmonids. However, analysis with a new mechanistic model of drift feeding behavior suggests that each fish also misses much of the food that passes within each reach, and this imperfection may be important to the success of subdominant competitors whose resources are not depleted by their

upstream neighbors. The observed territoriality may explain the population's density dependence, and the effect of debris on foraging efficiency represents one of many potential mechanisms behind the negative effect of high stream discharge.

Population coherence and environmental impacts on population productivity in Alaskan Chinook Salmon

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Average returns of Chinook Salmon to Alaskan rivers have declined considerably during the early 2000s, causing hardship to many people that rely on this resource. In some region declines have led to closures of commercial fisheries and limitations to subsistence harvests. Here, we aimed at understanding how Chinook Salmon populations respond to environmental drivers by characterizing temporal coherence in productivity dynamics and by parsing the effects of local drivers of population dynamics from regional and global drivers that are shared among populations. Management actions that typically occur locally would benefit greatly from being able to distinguish these effects operating at different spatial scales. We applied Dynamic Factor Analysis (DFA), a dimension reduction technique designed for multivariate time series analysis, to a dataset of productivity time series from 15 Chinook Salmon populations covering a broad geographical range in the eastern North Pacific Ocean. We find that productivity dynamics of Chinook Salmon populations strongly covary at the regional scale, and to some extent throughout Alaska. The timing of river ice break-up was identified as an important driver of regional productivity dynamics, especially in Western Alaska. Broad-scale variability in population productivity was linked to the North Pacific Gyre Oscillation (NPGO), a dominant pattern of sea surface height variability in the Northeast Pacific. Our results suggest that populations within regions do not respond consistently to the same climate variables, suggesting intraspecific variation in population responses to the same environmental drivers.

Four decades of changing demographic structure in Chinook Salmon across the Northeast Pacific

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Populations respond to a multitude of natural and anthropogenic drivers such as exploitation, climate change, and shifts in species interactions. Previous work and anecdotal knowledge suggest that the average size of Chinook Salmon returning to their natal rivers is declining. These trends are of concern because Chinook Salmon are highly valued for their exceptional size, and because the loss of the largest individuals may cause reduced population productivity. Using long-term data series from wild and hatchery populations, we analyzed changes in the demographic structure of Chinook Salmon over the past four decades across the species' North American range. We asked whether declining mean sizes are caused by changes in the size-at-age and/or the age composition at return, whether similar changes occur along the west coast of North America, and what may cause the observed demographic change. Our results show that both wild and hatchery Chinook Salmon are returning at smaller sizes and younger ages throughout most of the west coast. Whereas the size of older fish (ocean-4 and

-5) has declined over the past few decades, the size of younger fish (ocean-1 and -2) has increased over time. Our spatial analysis of changes in size-at-age revealed that the dominant trends are remarkably consistent across most of the North American range. Changes in age proportions showed more region-specific trends, with the strongest decline in the proportion of older ocean ages among Alaskan populations. While it remains to be tested whether the declining size-at-age of older fish is caused by changes in climate, ocean conditions, size-selective fishing, or increased predation pressure, our findings suggest that the selective removal of large fish has likely contributed to the widespread apparent declines in average body size of Chinook Salmon.

Integrating Rural Residents into Co-Management and Rebuilding of Kuskokwim River Chinook Salmon

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Chinook Salmon returns to the Kuskokwim River declined steadily beginning in 2005, reaching the lowest return on record in 2013 and bringing a new focus on management for subsistence harvests. The Kuskokwim River drainage has historically supported the world's largest subsistence fishery for Chinook Salmon, representing an annual average need of 88,500 fish as estimated by the Alaska Board of Fisheries. Approximately 88% of these harvests occurred within waters of the Yukon Delta Federal Wildlife Refuge. Under Title VIII of the Alaska National Interest Lands Conservation Act (ANILCA), the taking of fish and wildlife for non-wasteful subsistence uses on federal public lands is prioritized over taking for other purposes. The subsistence priority is based on: (1) customary and direct dependence upon the populations as the mainstay of livelihood; (2) local residency; and (3) the availability of alternative resources. In 2014, the U.S. Deputy Secretary of the Interior announced plans for a Partner Project to more meaningfully integrate Kuskokwim River Tribes and federally qualified users into federal fisheries management of the Kuskokwim River drainage. The Kuskokwim River Inter-Tribal Fish Commission (KRITFC) was created in 2015 to integrate federally qualified users more meaningfully into federal fisheries management, and in 2016 a Memorandum of Understanding between the U.S. Department of Interior, the U.S. Fish and Wildlife Service, and the KRITFC formalized the fishery management partnership. As currently implemented, inseason fishery management decisions for Chinook Salmon harvests on the Kuskokwim River are made through a consultative process between the KRITFC and USFWS. In this presentation, we describe the structure of the KRITFC, and how inseason management decisions have evolved to provide some subsistence harvest opportunities in the face of conservation measures.

Assessing the relative contribution of genetic sub-stocks to the lower Kuskokwim River Chinook Salmon subsistence fishery

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Restrictions to the subsistence harvest of Kuskokwim River Chinook Salmon in 2014-15 coincided with an increase in the proportion of fish spawning in upper river tributaries (e.g. above McGrath). This, combined with the earlier run timing of upper river spawning salmon and the tendency of subsistence fisheries to focus effort on the beginning portion of the annual

run, suggested that the subsistence fishery could be disproportionally targeting upper river spawning salmon. To evaluate this, we used DNA as a natural tag to estimate the relative contribution of the upper river sub-stock to the Kuskokwim River subsistence harvest over 5 years prior to subsistence fishing restrictions (2003-2007) and compared these estimates to the results of tagging studies conducted during these years. The goal of this study was to inform future strategies for sustainable management while creating a new tool for understanding the contribution of sub-stocks to Kuskokwim River Chinook Salmon fisheries.

Building a vision for tribal involvement in management of Yukon River Chinook Salmon

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Chinook Salmon on the Yukon River support one of the largest traditional and indigenous fisheries in the state of Alaska, where salmon can account for over 60% of a person's protein intake living in rural Alaska. This heavy reliance on Chinook Salmon, along with a large geographic region, overlapping species runs, a mixed stock fishery, allocation issues among users, and trans-boundary treaty obligations with Canada create a complex management scenario. Currently, state and federal agencies co-manage the in-river salmon fisheries on the Yukon River, making decisions jointly as the salmon migrate upriver through a mosaic of state and federal waters. However, Tribes along the Yukon River have been advocating for a larger voice in the fishery management decisions and, in response to declining Chinook Salmon populations, formed the Yukon River Inter-Tribal Fish Commission in 2014. The Fish Commission commits to conserve, restore, and provide for tribal use of fisheries based on indigenous knowledge systems and scientific principles. The overall objective of the Fish Commission is to have an equitable seat at the management table with the state and federal agencies. The Fish Commission has been laying the groundwork for tribal involvement in the management of Yukon River Chinook Salmon by meeting annually to develop pre-season management recommendations that are communicated to the fishery managers and by building capacity, improving communications and relationships with partnering organizations, and fostering Tribal unity among member Tribes. Inclusion of Tribes in the management of Yukon River Chinook Salmon will help to ensure long-term sustainability of the resource and those who depend on it.

Do Pink Salmon affect the structure of the North Pacific ecosystem and contribute to the declining Chinook Salmon populations in the Arctic-Yukon-Kuskokwim region of Alaska?

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Pink Salmon have never been more abundant than now. During 2005-2015, Pink Salmon abundance averaged nearly 500 million fish with peak abundances of ~650 million in 2009 and 2011 (~76% of all Pacific salmon). This growing abundance of Pink Salmon in the North Pacific Ocean and the declining abundance, size-at-age, and age-at-maturation of Chinook Salmon in Alaska raises the question: Have Pink Salmon altered the offshore North Pacific ecosystem and contributed to the decline of Chinook Salmon? We present new evidence indicating Pink Salmon cause a trophic cascade in the Bering Sea. We hypothesize that the declining growth, age-at-maturation, and abundance of AYK Chinook Salmon is related to

higher than normal mortality during late marine life, i.e., the period when Chinook Salmon are influenced by Pink Salmon in offshore areas. We quantify the evidence for these ideas using growth, age, and abundance data from Yukon, Kuskokwim, and Nushagak Chinook Salmon. Using measurements of scale annuli and a Bayesian mixture-model approach, we found strong evidence that slower growth leads to delayed maturation of individual salmon, as expected, such that declining growth should lead to older not younger Chinook Salmon. However, we also found evidence that lower percentages of older Chinook Salmon (age 6+) were associated with reduced growth during the second and third years at sea and/or increased abundance of Russian Pink Salmon. Furthermore, we found some evidence for a negative relationship between survival of Yukon and Kuskokwim Chinook Salmon and the abundance of Russian Pink Salmon. Food consumption, diet, growth, survival, and percentage of older Chinook Salmon exhibit a biennial pattern consistent with the Pink Salmon hypothesis. Our findings highlight the potential for increased mortality during late marine life, especially females, and the need to further examine the relationship between high Pink Salmon abundance and declining Chinook Salmon in Alaska.

Genetic diversity of Chinook Salmon populations inhabiting the Yukon and Kuskokwim rivers

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Characterizing genetic diversity has enabled population-based management for salmon in Alaska for nearly three decades. While substantial progress was made with some species, defining subpopulation structure for Chinook Salmon in western Alaska remained elusive until the Chinook Salmon Research Initiative that was commissioned to address the widespread shortfalls in escapement and catch that first became evident in 2007. As a part of that initiative we applied map-based genomics and genotyping-by-DNA sequencing strategies to screen 20,000 single-nucleotide polymorphisms (SNPs) in populations from western Alaska. These efforts yielded modest but incremental improvements that will enable ADF&G and others to use a panel of more than 800 informative SNPs for genetic stock identification to study marine survival, perform Yukon and Kuskokwim river run reconstructions, and better understand composition in the BSAI and GOA bycatch.

Development and Evaluation of a Run Timing Forecast Model For Kuskokwim River Chinook Salmon

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Annual variation in adult Pacific salmon migration timing makes the interpretation of inseason assessment data difficult, leading to much uncertainty for inseason decision-making regarding adequate harvest targets and fishing schedules. We developed and evaluated a run timing forecast model for the Kuskokwim River Chinook Salmon stock, located in western Alaska, intended to reduce this source of uncertainty. The forecast model used climatic variables that have been previously been linked to Pacific salmon run timing including: (1) sea surface temperature, (2) sea ice concentration, (3) air temperature, and (4) the Pacific Decadal Oscillation index. An objective and adaptive approach was used to produce annual forecasts from these variables, which involved annually-calibrated sliding climate window algorithms to select predictive time periods and model-averaging to deal with model uncertainty. Forecast cross-validation over the years 1995-2017 was used to evaluate the performance of two forecasting approaches: the null (i.e., intercept only) model and a model-averaged

forecast across 16 nested linear models. As of 2017, the null model had the lowest mean absolute error when predicting the median run date (2.74 days), although the model-averaged forecast performed as well or better than the null model in the majority of retrospectively evaluated years and had similar mean absolute error (3.14 days). The model-averaged forecast had a consistent mean absolute error regardless of the type of year (i.e., average vs. extreme early/late) the forecast was made for, which was not true of the null model. Though when accounting for statistical prediction uncertainty in the environmental variable forecast model, the prediction variance of daily run timing was not substantially lower than under the null model, indicating that the forecast model's utility for reducing run timing uncertainty may be limited.

Diet Reconstruction of Juvenile Chinook Salmon using Stable Isotope Bayesian Modeling: The Role Diet Plays on Condition

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The early marine diet of juvenile Chinook Salmon *Oncorhynchus tshawytscha* is critical to their survival, development, and condition; however, it is currently poorly understood. Carbon and nitrogen stable isotope analysis (δ13C and δ15N, respectively) can be used to investigate juvenile Chinook Salmon diets at multiple time scales without the potential biases associated with more traditional assessment techniques, such as stomach content analysis. This research used δ13C and δ15N analysis to a) evaluate the diets of juvenile Chinook Salmon sampled in the northern Bering Sea, and b) explore the relationship between diet and body condition at this critical phase in the salmon life cycle. During the fall of 2015 and 2016, juvenile Chinook Salmon and potential prey items were sampled using a surface trawl, and epidermal mucus and dorsal muscle tissue were collected from each fish for δ13C and δ15N analysis. Differences in the isotopic incorporation rates between the two sampled tissues allowed for reconstruction of juvenile Chinook Salmon diets for two distinct temporal scales: weeks for epidermal mucus and months for dorsal muscle. Body condition of Chinook Salmon was assessed using energy density (kJ/g) of homogenized whole-body samples determined by bomb calorimetry. Dietary source contributions and trophic habits of juvenile Chinook Salmon during the two timeframes were determined using a Bayesian implementation of a stable isotope mixing model to describe prey contributions to juvenile Chinook Salmon diets and a Bayesian approach to assess trophic niche width using standard ellipses area. Preliminary findings suggest that juvenile Chinook Salmon condition is enhanced by consuming a wider array of prey, and that Salmon with higher body condition values tend to be dietary generalists as compared to fish with lower body condition values.

Overview on Chinook salmon bycatch management measures in the Bering Sea

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The walleye pollock fishery in the Bering Sea is one of the largest fisheries in the world. The North Pacific Fishery Management Council (NPFMC) provides management advice for this fishery including the development of measures to minimize salmon bycatch to the extent practicable, one of the stated objectives of the US Magnuson Stevens Fishery Conservation and Management Act National Standards. Salmon have a unique cultural and nutritional importance in the State of Alaska and are the subject of fully allocated mixed commercial, recreational and subsistence fisheries. Given the

extensive scientific National Marine Fisheries Service's (NMFS) observer data collection program, the NPFMC has developed bycatch management measures which place limits by fishery sector on the allowable catch of Chinook salmon. Part of this program includes industry-proposed incentive programs designed to encourage lower bycatch. The extent that the current system continues to minimize bycatch is evaluated by applying updated genetics results for Chinook salmon (Oncorhynchus tshawytscha) based on samples collected by scientific observers. These and data on the size composition allow estimates of the impact on specific regional stock groups (RSGs). A simple model provides estimates of the impact on Chinook salmon RSGs given seasonal and spatial variability in the bycatch and accounts for observed in-river age compositions, uncertainty in age-specific oceanic natural mortality of Chinook salmon and between-year variability in genetic information. New data result in slight changes in previous estimates while lower overall Chinook salmon bycatch since 2008 has resulted in lower impacts to the main western Alaskan RSGs. Vessel behaviour was also investigated to inform improved management measures for bycatch reduction. Outreach activities by the NPFMC to interior Alaskan and coastal communities continue to increase awareness of, and ongoing efforts toward, improved bycatch management in the pollock fishery.

Creatively Communicating Salmon Fisheries Management in the Alaskan Context

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Fisheries management bridges the divide between the science of stock assessment and the day to day realities of harvest on the fishing grounds. However, managers often struggle to strike the right balance between scientific accuracy and public accessibility in a complex discipline rife with technical terminology. For many harvesters, fisheries science can be a foreign language, and much may be lost in translation. Interpreting key fisheries management concepts into a more universal visual language helps to make these ideas more accessible for a much broader audience and lowers the barriers for harvesters' understanding and participation in deeper discussions of resource management issues and trade-offs. Moreover, visual messages are quick to absorb, easy to share, and cut through the noise of a communications channel often crowded with bulletins, technical reports, peer-reviewed papers, and other dense texts for resource users, managers, and researchers alike. Here, we will: (1) introduce some of the key benefits and best practices of visual science communication, (2) review helpful tools and resources for crafting visual messages, and (3) explore example visualizations of salmon management issues in the form of figures, infographics, and short films created for the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative.

Assessing heat stress in migrating Yukon River Chinook Salmon

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Yukon River Chinook Salmon *Oncorhynchus tshawytscha* have been in decline since the 1990s for unknown causes. Freshwater migration corridors have warmed with temperatures now routinely exceeding thresholds (18—21 °C) that have been associated with heat stress and prespawn mortality in other salmon populations. We examined heat shock protein

(HSP70) levels and a gene transcription panel to assess the presence of heat stress in migrating Chinook Salmon in summer 2016. Chinook Salmon were captured near the river mouth (Emmonak; n=42) when temperatures were cool (daily means <18 °C), a weir with cool temperatures (<18 °C; Gisasa River; n=37), and a weir with warm temperatures (16—20 °C; East Fork Andreafsky River; n=46). HSP70 levels suggested 5% of individuals at the Gisasa weir and 52% of individuals at the Andreafsky weir were stressed, assuming a threshold that classified all fish captured in Emmonak with normal HSP70. Linear Discriminate function Analysis (LDA) was used to identify the genes that best separate fish among three categories of recent (24—48 hr) temperature at collection locations (cool, <18 °C; moderate, 18-20 °C; or warm, >20 °C). LDA classifications were correct in 88% of samples, but misclassifications were high among fish collected during moderate temperatures (44% error rate, n=18). Gene transcription response of large heat shock proteins (HSP90) was distinct for the few salmon collected during persistent warm temperatures and resulted in strong classification (0% error rate, n=5, all from Andreafsky weir). Results agree well with observations from the field as weir staff suspended age-sex-length sampling due to heat stress concerns for 8 or 35 days at the Andreafsky weir, while sampling was uninterrupted at the Gisasa weir. A captive temperature-controlled experiment scheduled for June 2018 will further examine the HSP70 levels and gene transcription responses associated with cool, moderate, and warm temperatures.

Probability and implications of incorrectly detecting over-compensatory recruitment dynamics when they are not present

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Spawner-recruit relationships are critical tools for setting management targets of fisheries, particularly for optimizing sustainable harvest levels. Kuskokwim River Chinook Salmon are a highly valuable subsistence resource and, like many Alaskan Chinook Salmon stocks, have experienced a prolonged period of very low run sizes, limiting harvest opportunities and challenging management structures. Spawner-recruit relationships developed from run-reconstruction model estimates suggest that Kuskokwim River Chinook Salmon recruitment dynamics demonstrate strong over-compensation with declining total recruitment at high spawner abundances. This relationship indicates that maximum recruitment would occur at escapement near the lowest levels estimated in the period of record. The estimated relationship suggests that high harvest rates can be maintained even at low spawner abundances, as increasing escapement would produce fewer recruits. As the Kuskokwim Chinook Salmon have demonstrated low productivity for an extended period, managing for low escapement levels has raised conservation concerns among stakeholders. Additionally, the lack of over-compensatory dynamics in other regional Chinook Salmon stocks has raised questions of what may be driving the detected relationship in the Kuskokwim. Here we use a simulation modeling approach to examine the probability of detecting over-compensatory recruitment dynamics in stock-recruit relationships when no over-compensation exists in the true underlying relationship. We include environmental drivers (e.g., regime shifts) that might lead to population dynamics that give the illusion of overcompensation. We produce population dynamics for multiple sub-populations with specified spawner-recruit relationships and generate “observed” data sets. Using the actual Kuskokwim River run-reconstruction model, we estimate annual runs and ultimately fit spawner-recruit relationships to the estimates from the run-reconstruction model, which are aggregated across all sub-populations. We examine multiple biological and estimation scenarios to determine the conditions that increase the potential to detect over-compensatory recruitment dynamics when they are not present. Finally, we examine how such misspecification of the spawner-recruit relationship can impact management strategies.

Approaches to sustainability for Chinook local populations: Exploring a Place-¬-Based Management Paradigm in the Pacific Northwest, Alaska and the AYK

Williams, Rick

Lichatowich, Jim

Wild salmon are place-based animals and their sustained recovery requires a reinvigorated sense of place and a management paradigm that recognizes the importance of place. Salmon management planning and actions often take place at larger geographic scales, such as a watershed, rather than at the local salmon population level due to the very real constraints of budget, time and personnel. Management at that level is necessary and will continue; however, it needs to also include linkages downward into local salmon populations and local peoples. Creating the hierarchical linkages down to the local scale will be labor intensive and expensive, but coarse-scale salmon management has a long history of failure, as demonstrated by experience in the Columbia River and Pacific Northwest. The impoverished state of salmon today is the result of managing at an aggregated coarse scale. We cannot continue down the same path and expect an improvement in the status of salmon. True sustainability of Pacific Northwest and AYK stocks including Kuskokwim Chinook Salmon, can only be achieved by management planning, prescriptions, and actions that occur at the local population level. The place-based management approach we present offers a collaborative community-based model that can bring the responsibilities and authority of state and federal management agencies into cooperation with local interests and knowledge, especially that of indigenous peoples who rely on the salmon for their livelihood and subsistence.

Patterns of Chinook Salmon Declines: The story of growth at age

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Chinook Salmon declines are occurring across Alaska but these trends are not uniform across the state. Recent years have seen fewer older fish returning, and those that do are smaller. To better understand Chinook Salmon size declines in Alaska, we are developing a series of hierarchical models to explore patterns of Chinook Salmon growth, at levels ranging from individual fish to state-wide. Hierarchical models are an appropriate framework for modeling growth because they include fixed and random effects, and can account for correlations across maturation ages, life stages, years, populations, and areas. We applied this hierarchical approach to an extensive set of scale growth measurements from fourteen stocks, including growth during each year of life (incremental) and growth achieved through each year of life (cumulative). Alaskan Chinook Salmon growth was life stage-dependent, varied with maturation age, and varied among populations. Growth rates were higher starting in the second year of marine growth for younger maturing fish. Stock effects generally increased from southeast to western Alaska. Growth varied across regions, and this pattern changed across years of marine residency. Fish size after the first year of marine residence was greater in eastern stocks than western. Central Alaska Chinook Salmon were larger than non-central Alaska Chinook Salmon through their second year of marine residency. Also, central Alaska Chinook Salmon grew more during their third year marine residency. For four stocks with measurements available starting in the 1960s, a notable shift occurred in 1978 for growth during the first year of marine residency and in size after

first year of marine residency. A second notable shift in fish size after the second year of marine residency occurred in 2008 for non-central Alaska Chinook Salmon.

Rampart Rapids Student Data Collection Project 2001-2013

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Due to concerns of fishermen over an emerging disease and the decline in average size and numbers of Chinook Salmon in the upper Yukon River and a number of other fisheries issues in the late 1980's and 1990's, a student data collection project was run between 2001 and 2013. Student technicians were trained by experts in the related fields and successfully collected fishermen's catch data for 13 years in the Rampart Rapids area (Yukon River mile 731) in Alaska. This project collected data comprised of random Chinook Salmon sex, length, weight, girth and genetics information, as well as visible *Ichthyophonus* disease prevalence during the entire Chinook Salmon season. Chum Salmon were also visually inspected for flesh color and related fat content and genetically tested resulting in a traditional knowledge, yet scientific confirmed fall chum timing arrival date each year. This aiding fishermen and fall chum run assessment projects in the area. Hundreds of students had an opportunity to participate in the project and learn meaningful data collection techniques, with older students teaching the younger in the later years. During the project 10,000 Chinook Salmon were sampled, providing a wealth of size, sex, genetic and disease information using easily repeatable specifications for comparison to future projects. Voluntary salmon and whitefish samplings for a number of agencies and researchers were also accomplished each year. This amounted to important genetic, size, and lifecycle information on thousands of fish in addition to those covered directly in this project. Project efforts to provide laboratory confirmation of *Ichthyophonus* disease positives led to a number of separately-funded studies during the course of the project and partnerships with many of the top pathology researchers in this field. A paper has been written and published in a major AFS journal using these students' data.

Water Quality in Fisheries: Keeping an Eye on a vital Resource

Mother Nature isn't always kind: impacts of periodic landslides and acidic runoff on biological communities in the Red River, New Mexico

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Biological communities in stream systems can be vulnerable to disturbance events. Geological instability in portions of a watershed can lead to periodic and sometimes lasting impacts on aquatic communities and habitats. The Red River system in northern New Mexico is a prime example of a stream system prone to these events. Hydrothermal scars, comprised of oxidizing, sulfide enriched rock, are found in some locations along the north side of the river valley. These scars lack vegetation and are highly erosive, and during intense rainfall events can cause substantial landslides and heavy sedimentation within the Red River. Similarly, this runoff is highly acidic and can cause temporary but significant drops in the pH within the river. In conjunction, these two factors can cause drastic fluctuations in Brown Trout populations as well as in sensitive benthic macroinvertebrate taxa within the stream system downstream of these scars. In this presentation, we examine fish, benthic macroinvertebrate, and habitat data collected from 1997 to present at 11 study sites within the basin.

We correlate percent substrate embeddedness and fish biomass at various locations in relation to two major hydrothermal scars within the watershed, and examine the role of peak runoff and high magnitude storm events near the scars with these metrics. We also discuss predictions of future climate modeling, which anticipates prolonged periods of drought interspersed with high intensity storm events, likely increasing stress upon trout populations within the region.

Roads to ruin: the threats of urbanization to conservation of a sentinel species

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Urbanization poses a global threat to virtually all ecosystems, which is a challenge to species conservation. Our understanding of the impacts of anthropogenic ecosystem engineering is focused on physical habitat, as agricultural and forested lands are replaced with urban infrastructure. However, aquatic habitats are also chemically degraded by urban development, often in the form of toxic stormwater runoff. Since the late 1990s, Coho Salmon adults returning to their natal urban streams in Puget Sound experience high rates of spawner mortality syndrome. Evidence to date suggests that toxic urban stormwater runoff is the likely causative agent and that this high mortality may pose a threat to wild Coho Salmon populations. The ability to identify stream basins currently at risk for this syndrome is critical to conservation efforts. In this presentation, I will summarize our understanding of the landscape ecology of this syndrome across an urban gradient in the Puget Lowlands, based on analyses that identify relationships between in situ Coho spawner mortality time series data and climate and landscape scale characteristics of the associated built environment. We found that the urbanization gradient was largely defined by road density and traffic intensity, among other variables, and positively related to mortality, which is consistent with other studies that suggest motor vehicles are the likely source of chemical mixtures that wash off urban landscapes into Coho streams. We used the output from our statistical models to generate a predictive mortality risk map for the entire Puget Sound Basin. The map identified likely hotspots for Coho spawner die-offs in unmonitored basins across Puget Sound. Our analyses improve our understanding of the interplay between urbanization and climatic drivers of the mortality syndrome, are easily transferable to other regions, and can be used for siting green stormwater infrastructure in the current built environment and in future development scenarios.

An Analysis of the Potential Impacts of Selenium on Fish Populations in Thompson Creek, Idaho

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Current and historic mining has exposed selenium rich sediment and mine tailings near the headwaters of Thompson Creek in Clayton, Idaho. Trout and sculpin populations have been observed in Thompson Creek over the past 37 years, and data suggests that these populations are able to tolerate some degree of existing body burden of selenium. Biological monitoring began in 1980 and has expanded over the years to incorporate six total monitoring sites and selenium analyses. Monitoring has included electrofishing surveys for fish, as well as macroinvertebrate population sampling and selenium analyses of sediment, fine particulate organic matter, macroinvertebrates, and fish. The potential elevated selenium concentrations within the Thompson Creek watershed raises concern for potential harm to the biological communities. These data suggest that bioaccumulation of selenium poses slight risk to the biological communities in Thompson Creek.

Municipal and industrial effluents contributing to mass fish mortality and harmful algal blooms in coastal waters of Arabian Sea, Indian Ocean, Pakistan

Khan, Muhammad Naeem

The environmental sustainability of the famous Indus Valley, draining Himalayan Indus River in Arabian Sea basin is threatened by the huge population explosion of over 200 million, urbanization & coastal development, industrialization & release of untreated effluents, municipal waste & agriculture runoff and the melting of Himalayan glaciers due to climate change, causing occasional flash floods, drought and increasing episodes of algal blooms in the coastal waters of Arabian Sea, near Karachi.

PICES Goteborg Symposium (2015) postulated that the ambient physical, chemical, and biological environments play an important role in the production of these algal blooms. Moreover, the anthropogenic activities like aquatic pollution etc. contribute to the generation of these algal blooms. In the case study it was found that in 2014, soon after the monsoon rains, Karachi coast witnessed massive fish mortality, when thousands of dead fish were found floating into the backwaters of the Karachi harbor. Ironically 435 million gallon of the sewage produced in Metropolitan City of Karachi is dumped in Arabia Sea; untreated, resulting in degradation of marine habitat, decline in fisheries resources, threat public health and the potential rise in algal blooms.

Pakistan, ranked third in the Climate Risk Index countries, having the lowest adaptive capacity to climate change, can face decline in its traditional artisan fisheries, rise in algal blooms related threats to public health and marine ecotourism (Khan, 2015). The paper will review the anthropogenic activities contributing to the decline of artisan fisheries and the production of harmful algal blooms in the coastal waters of Karachi, Arabian Sea, Pakistan.

Total dissolved gas and gas bubble disease in the lower Clark Fork River: What have we learned in the last 20 years?

Kusnierz, Paul C. Avista*

Spill over Cabinet Gorge Dam can result in high levels of total dissolved gas (TDG) in the lower Clark Fork River. In 2003, two papers that described TDG, gas bubble disease (GBD), and fish behavior in the lower Clark Fork River were published. The main findings of these papers were that GBD incidence was less than expected relative to the TDG values observed and that fish typically resided at depths >2 m, behaviorally reducing the physiological effects of high levels of TDG. In 2000, 2006, 2008, and 2017, fish captured during the spill season within 1.7 km downstream of Cabinet Gorge Dam were

evaluated for GBD. Over this time period, 3,698 fish of 22 species and one hybrid were evaluated. Gas bubble disease incidence by species ranged from 0% to 75% with seven species having no evidence of GBD. Severity was typically low with < 6% of fins or eyes covered with bubbles. Total dissolved gas levels varied within and between years with mean spill season TDG values that ranged from 107% to 120% saturation. Mean GBD incidence (all species combined) ranged from 0% to 17% and was highly correlated with mean TDG. The relationship between GBD incidence and 7-d mean TDG prior to fish capture was highly variable. Total dissolved gas and GBD incidence plots in conjunction with logistic regression demonstrated higher GBD incidence prior to peak mean TDG values. Correlation analysis indicated no negative associations between the population estimates of four fish species and the number of hours with mean TDG >110% saturation during the previous spill season. These updated analyses support the findings of the 2003 studies of GBD in the lower Clark Fork River and when considered with TDG reduction measures implemented at Cabinet Gorge Dam indicate decreased likelihood of observing GBD in the future.

Nutrient flux in Sawtooth Valley Sockeye Salmon nursery lakes, Idaho

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Snake River Sockeye Salmon *Oncorhynchus nerka*, the southernmost spawning populations of Sockeye Salmon in the world, once returned in large numbers to five nursery lakes in the Sawtooth Valley in central Idaho. In recent years, anthropogenic impacts to migratory, spawning, and rearing habitats, harvest, and interactions with hatchery fish have collectively decimated Snake River Sockeye Salmon, and led to their listing as “endangered” under the United States’ Endangered Species Act. A potentially important consequence of Sockeye Salmon population declines is the associated reduction in marine-derived nutrient subsidies and bioturbation in nursery lakes, which may compromise lake primary productivity and spawning habitat quality and quantity. Sawtooth Valley lakes have received limited marine-derived nutrient loading and bioturbation from natural sources over the last 20+ years, and have been stocked with hatchery juvenile and adult releases (biotic nutrient inputs) and fertilized with supplemental nutrients (liquid ammonium phosphate and ammonium nitrate applied at an ~22:1 N:P ratio by mass). Anadromous juvenile production has also been monitored at lake outlets to estimate smolt migration (nutrient outputs). Here, we will discuss salmon nutrient transport in three Sawtooth Valley lakes: Redfish, Pettit, and Alturas lakes, and the potential role of anadromous fishes and marine-derived nutrient subsidies in Sockeye Salmon recovery planning.

Identifying and Addressing Water Chemistry Differences Affecting Post-release Survival of Snake River Sockeye Salmon Smolts

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The recovery plan for Snake River Sockeye Salmon includes annual releases of up to 1 million hatchery-reared smolts. A new purpose-built hatchery was constructed (near Springfield, Idaho) and began releasing smolts to Redfish Lake Creek (near Stanley, Idaho) in 2015. Various complications associated with fish transport contributed to reduced survival in 2015 and 2016, but post-release success of Springfield Hatchery-reared smolts remained uncharacteristically low following

optimization of fish transport protocols. Evaluation of smolts released in 2017 suggested that differences in water chemistry between the hatchery and release site may have contributed to morbidity and mortality observed after release. Follow-up experiments with pre-smolts confirmed that direct transition from hard, high-alkalinity water at Springfield Hatchery (~230-250 mg/L hardness, ~190-200 mg/L alkalinity) to soft, low-alkalinity water at Redfish Lake Creek (~10 mg/L hardness, ~1-15 mg/L alkalinity) caused a significant physiological stress response. Plasma cortisol was elevated following fish handling and transport (~5 h) indicating an acute response to these stressors, but levels rose dramatically after fish were transferred from hard to soft water. Plasma glucose and lactate levels rose similarly after release and remained elevated through 24-h post-release, indicating the transition to soft water is physiologically difficult and the associated stress response is slow to resolve. Coping with a dramatic shift in water chemistry is difficult under any circumstances; coupled with the other challenges facing hatchery-reared smolts at release (e.g., disorientation, irregular but generally faster water flows, predators), it may be physiologically unmanageable. A variety of modified release strategies have been evaluated, including acclimation to water with an intermediate chemistry profile, water mixing at release, and in-transit water softening. The relative merits and feasibility of these strategies are still being evaluated. Results of ongoing experimentation will be discussed, along with implications for future rearing and release strategies for Snake River Sockeye Salmon smolts.

Western Native Fishes

Waterfall formation at a dynamic desert river delta isolates endangered fishes

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Unforeseen interactions of past dam construction and declining water availability have formed new obstacles to recovering endemic and endangered big-river fishes. During a recent trend of drying climate and depressed reservoir water levels in the southwestern United States, a large waterfall has formed on two separate occasions (1989-1995 & 2001-present) in the transition zone between the San Juan River and Lake Powell reservoir as a result of deposited sediments. This waterfall potentially blocks upstream movement of two large-bodied endangered fish species, Razorback Sucker *Xyrauchen texanus* and Colorado Pikeminnow *Ptychocheilus lucius* that have moved downstream from the river into the reservoir. To quantify abundance of endangered fishes downstream of the waterfall we remotely monitored and sampled in spring 2015, 2016, and 2017 when these fish were most likely to move upstream to spawn. We used a POPAN model applied to PIT tagged fish in 2017 to obtain a population estimate for razorback sucker. Total detections and captures of Colorado Pikeminnow usually consisted of subadult fish and were so few (< 30 individuals) that population estimates were impossible. Razorback Suckers comprised the majority of total individuals captured (n = 336) and detected (n = 943) across all three years. The Razorback Sucker population estimate for 2017 alone (N = 755 individuals) suggests a substantial population exists downstream of this barrier in late-winter and early-spring. Although this situation is somewhat unique, the formation of this waterfall barrier exemplifies how water development and hydrology can interact to cause unforeseen changes to a riverscape.

A conceptual model framework to hypothesize pathways of stress in large rivers – A case study exploring factors affecting age-0 White Sturgeon recruitment in the Columbia River

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Understanding the response of natural resources to management actions and stressors is needed to effectively assess progress towards management objectives. Properly designed monitoring programs can provide a way to assess the status and trends of resources. Conceptual models are useful to guide the design of question-driven monitoring programs. Since 2012, scientists involved in large river monitoring programs across the U.S. have participated in a forum to improve our understanding of large river ecosystems. As this group of scientists worked toward linking changes in fish populations and fish communities to anthropogenic sources of stress, a need to develop a framework for developing causal hypotheses that detail stressor mechanisms was identified. The goal of this collaborative effort is to demonstrate how a structured, yet flexible, conceptual model framework can be used to hypothesize pathways of stress and identify the types of information needed to understand the effects of stressors on large river resources. In this presentation, we will briefly discuss the structure and formation of the conceptual model and the application of the conceptual model to a case study that hypothesizes proposed pathways through which anthropogenic drivers influence age-0 White Sturgeon recruitment in the Columbia and Snake rivers. We then provide an assessment of the strength of our current understanding of the relationships identified and what types of, and at what spatial and temporal resolution, data are needed to assess the effects of anthropogenic stressors on age-0 White Sturgeon recruitment.

PIT tag expulsion in a small-bodied native catfish

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Members of the freshwater catfish family Ictaluridae are capable of trans-intestinal expulsion of foreign bodies through encapsulation, migration, adhesion, absorption and passage. Studies have shown that internally implanted tags used for marking catfish can be shed through this expulsion process. We are currently implanting PIT tags to examine movement and survival in wild Stonecat Catfish *Noturus flavus* populations. We were concerned that trans-intestinal expulsion and subsequent tag expulsion would bias movement and survival estimates in the field. Therefore, we evaluated tag expulsion rates in a laboratory setting to assess potential tag loss. PIT tags were surgically implanted into the peritoneal cavity of Stonecat Catfish ranging from 71mm to 213mm through an incision closed with a single Braunamid suture. One hundred fifty seven fish were used in the experiment over 120 weeks. Our best model included the covariates tag age, group (a proxy measure for technician experience with tagging), fish length, and tag type as well as the interaction between fish length and tag type. Results will be used to inform survival and movement estimation as well as habitat selection in our field study.

Habitat selection and movement of Stonecat in St. Vrain Creek

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The ecology of Stonecat Catfish *Noturus flavus* is relatively unknown, especially at the western extent of its North American distribution. There are two Stonecat populations in Colorado, including a population of particular interest in St. Vrain Creek, a transition zone stream running through the city of Longmont. The Stonecats in the St. Vrain are the only extant population in a Colorado transition zone stream. In addition to occupying a unique transitional habitat, the population is in an urban setting that is undergoing several modifications to reduce the potential impacts of flooding. Managers are concerned that proposed changes to the stream channel could have detrimental effects to Stonecat Catfish and other native fishes. Our study seeks to evaluate habitat preferences and movement of Stonecat to better understand the potential effects of instream channel modifications on this species. We have PIT tagged 682 Stonecats and are using a combination of static and mobile PIT tag antennae to characterize their habitat preferences and movement ecology over a 5.3 km long section of St. Vrain Creek. Initial analyses indicate that Stonecats can move long distances (up to 1.5 km) but most individuals are relatively sedentary, moving less than 100 meters. Stonecats appear to prefer riffle habitat at a depth of 1.01 feet, flow of 0.29 meters per second and large substrate. Understanding Stonecat movement patterns and habitat preferences are crucial for upcoming stream restoration and management.

Captive Propagation of the Devils Hole Pupfish at the Ash Meadows Fish Conservation Facility

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With a total wild population of fewer than 200 fish, restricted to a single geothermal pool in the Mojave desert, the Devils Hole Pupfish *Cyprinodon diabolis*, seems a prime candidate for captive propagation. However, despite decades of attempts, propagation in aquaria has never been fully successful, and while refuge populations have fared slightly better, ultimately all ended in failure. We will describe the history, successes, and challenges faced rearing this species at the Ash Meadows Fish Conservation Facility, a state-of-the-art aquaculture facility located in the Ash Meadows National Wildlife Refuge in Nevada. Utilizing eggs collected from Devils Hole, we achieved a greater than 80% larval survival to adulthood. Juveniles and young adults are stocked into a 100,000 gallon refuge tank designed to simulate the challenging conditions of Devils Hole. All life stages, including eggs, larvae, and multiple generations of adults have been found in the tank. Although the population in the tank has maintained steady numbers, the explosive growth that was hoped for has not yet been realized, and breeding in aquaria continues to be problematic. Extremely limited genetic diversity may be a contributing factor, as the wild population has twice reduced to fewer than 40 fish in recent years.

Translocations lead to the establishment of a reproducing population of an endangered fish in Grand Canyon, Arizona

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Endangered Humpback Chub *Gila cypha* persist as a self-sustaining population in Grand Canyon, Arizona, despite habitat alterations following the construction of Glen Canyon Dam. This warmwater species has been sustained primarily through reproduction in a single spawning aggregation centered on the Little Colorado River and its inflow reach of the Colorado River, where juvenile growth and survival is limited by unnaturally cold waters combined with the effects of predation and competition by nonnative salmonids. In an attempt to provide for population redundancy and an additional rearing opportunity, the National Park Service, in cooperation with the U.S. Fish and Wildlife Service, and with funding from the U.S. Bureau of Reclamation, initiated a series of translocations of juvenile Humpback Chub from the Little Colorado to Havasu Creek, a Colorado River tributary. Translocations of between 242 and 509 uniquely tagged juvenile fish to Havasu Creek were conducted annually between 2011 and 2016. Abundance, apparent survival, and growth rates of the translocated cohorts were calculated through biannual mark-recapture sampling, while the efficacy of the project in meeting objectives was assessed through a comparative analysis of published vital rates for the source population. Apparent survival and growth rates appeared to be influenced by fish densities and flood occurrence, but met or exceeded the range of published values for juvenile Humpback Chub in the Little Colorado River. Translocated Humpback Chub in spawning condition were observed each year in May, beginning in 2012. Untagged juveniles were captured the following year, and every year thereafter, indicating reproduction had occurred. Recruitment to maturity of non-translocated fish was noted in 2016 and 2017, indicating the potential for the establishment of a self-sustaining population. The Havasu Creek population will continue to be monitored in the future, and augmentation is planned to maintain genetic integrity.

Genomics predict the temporal and spatial distribution of life history diversity for a Western native lamprey (Pacific Lamprey, *Entosphenus tridentatus*)

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Pacific Lamprey *Entosphenus tridentatus* is an anadromous Western native fish that parasitizes marine fishes and mammals. This imperiled species is an important cultural resource and the Columbia River Treaty tribes are leading efforts to restore the species' historical levels of abundance. Biological uncertainties challenge these restoration efforts and more life-history research is needed to understand this mysterious species. Progress in the field of population genomics has enabled characterization of life-history strategies through identification of associations of genes with phenotypic traits. We

determined genomic mapping positions of a large number of genetic markers (3,666 single nucleotide polymorphism, SNP loci). High levels of genetic divergence among Pacific Lamprey throughout the species range appear concentrated in the genome and localize to four different chromosomes (Etr01, Etr02, Etr04, and Etr22). We used 302 SNPs that were developed into a high throughput genetic assay panel to test genotype-by-phenotype trait associations with adult body size, sexual maturity, migration distance and timing, and swimming ability of adult lamprey returns to the Columbia River and larval growth rates in a common garden experiment. Body size traits were strongly associated with SNP loci concentrated on chromosome Etr02 and Etr04. Moderate associations implicate Etr01 with female maturity. Lack of associations with other measured traits helps to characterize the extent of the potential roles of genes under selection. Using genotypes of candidate SNPs for sexual maturity and body size, we extrapolate the spatiotemporal distribution of these traits. This provides a framework for predicting and testing hypotheses about how life history traits are distributed across the range, and understand factors driving regional optimization of these traits. The 302-SNP assay panel elaborates on a previous high throughput panel of 96 SNP markers that was designed for multi-functionality (parentage, adaptive, species identification) and improves its capacity for these applications.

Restoring Hydrologic Connectivity in a Desert Spring System

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Ash Meadows, home to at least 26 endemic species, has endured countless anthropogenic changes due to settlement. Throughout the 1900's, springs in the Upper Carson Slough were altered and their outflows diverted for agricultural and domestic water supply purposes. Because of these alterations, connectivity is limited by the presence of human-caused hydrological barriers. Five Springs is an important habitat for the endangered Ash Meadows Amargosa Pupfish with the highest water temperature and highest elevation of all springs in the Upper Carson Slough; this system provides habitat for three Federally-listed species and three species proposed for listing (all endemic). In 2016, the Five Springs system was restored from abandoned agricultural field back to the historic flowpath in an effort to provide additional habitat within the system and allow for potential gene flow of this population of Ash Meadows Amargosa Pupfish to the Upper Carson Slough.

Evaluating relationships between fish populations and flow regime characteristics in four Arizona streams

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Conserving the natural flow regime of streams is critical to safeguarding the diversity of native fish species throughout river systems. The desert Southwest is home the highest concentration of endangered fish species in the United States, and many of these species have adapted to the variation, magnitude, frequency, timing, and rate of change of flow regimes unique to this ecosystem. Determining the relationship between the characteristics of different flows and fish population dynamics is important for managing southwest rivers for the benefit of native species. The objective of this study is to examine the relationship between fish populations and hydrological data over time using a 30-year fish sampling dataset from the Arizona Game and Fish Department and USGS hydrology data from stream gages in four Arizona streams. Additionally, we used USGS StreamStats to evaluate spatial variation in populations within each stream in relation to

streamflow based on this historical dataset and field data from summer 2017. USGS Streamstats generates estimates of 2-year, 10-year, and 100-year magnitude flooding events using regional regression models, and these metrics were analyzed in relation to spatial variation in fish populations within and across the four study streams. This study can provide critical information to managers on how flow dynamics interact with different fish species in arid-land rivers.

Gene-By-Environment Interactions Underlie Responses to Microbiota Disturbance in Threespine Stickleback Fish

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Disruptions to gut microbiota can have both immediate and long-term consequences on host development, such as increased inflammation and altered behavioral patterns. Much of what is known about host-microbe interactions has been studied using traditional inbred animal models, which limit researchers' abilities to understand the vital role of host genetic background in shaping microbial community composition and its response to disturbance. In our experiments using the genetically variable Threespine Stickleback fish *Gasterosteus aculeatus*, we show that gene-by-environment interactions underlie differences in physiology after short-term tetracycline exposure and germ-free rearing early in development, suggesting population-level variation in developmental instability. We also see evidence for differences in behavior in germ-free versus conventionally reared fish. Future work will focus on the influence of tetracycline exposure on immune system development and microbial community diversity. Results will increase our understanding of how a population's response to microbial disturbance could be indicative of its resilience to environmental perturbations.

The Delta's Smelts – demise and discovery among California's estuarine osmerids

Lewis, Levi Steele*

Willmes, Malte; Hobbs, James

The Delta Smelt *Hypomesus transpacificus* and Longfin Smelt *Spirunchus thaleichthys*, both osmerids native to the San Francisco Bay Estuary (SFE), are two of the most endangered and socio-politically important estuarine fishes in California. While the Delta Smelt has received national attention and both state and federal protection, the Longfin Smelt has received less attention and protection, despite experiencing equal or even greater declines within the SFE. These osmerid smelts live and reproduce directly downstream of the Sacramento-San Joaquin River Delta, where massive demands by California's agriculture industry and 35 million residents place these species in the crossfire between the "coequal" goals of species-habitat conservation and water supply-delivery. Here, we describe similarities and differences between these two endangered estuarine osmerids in terms of their history, status, biology, and threats; as well as recent discoveries, using otolith Sr isotope geochemistry, regarding the diversity of life-history strategies these species use in order to persist within a dynamic and unpredictable environment.

Population Structures of Invasive Alaska Blackfish

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Alaska Blackfish *Dallia pectoralis* is a little studied fish endemic to Alaska. Native populations exist north of the Alaska range were introduced to the Anchorage area in the mid 1950's. Populations in the lower Yukon and Kuskokwim are utilized for subsistence purposes. Anchorage STrEaM academy is conducting research into the basic life histories and population structure of Alaska blackfish. We will report our preliminary findings on this exciting topic, and demonstrate the tremendous power of working with secondary students to answer questions about understudied western species.

June Sucker Recovery Efforts: Response of an Endangered Species to Instream Flows and Captive Rearing

Mills, Michael D. June Sucker Recovery Implementation Program

The June Sucker *Chasmistes liorus* a fish endemic to Utah Lake, has been listed as an endangered species for the past 30 years. Those 30 years have been marked with numerous threats to the species' survival, including the dewatering Utah Lake tributaries, impacts from non-native species, and the destruction of habitat. In the 1990's, the wild population of June Sucker was estimated at less than 1,000 individuals and experts predicted that without extraordinary measures the species would go extinct. The June Sucker Recovery Implementation Program (JSRIP) was formally initiated in 2002 with the dual goals of recovering the June sucker so that it no longer requires protection under the Endangered Species Act and allowing the continued use and development of water within the Utah Lake basin. Today, thousands of adult June sucker migrate up the tributaries of Utah Lake as part of annual spawning runs and produce millions of larval fish. While managers have celebrated the population increase, considerable threats to the species' continued survival remain. Increasing demands for water present challenges in providing adequate water to support spawning fish, the introduction of non-native fish pose new threats on the species, and restoring adequate habitat requires large scale projects within an increasingly urban area. While the species has responded positively to captive rearing and efforts to provide water, the emerging threats will require an adaptive approach and continued investment in recovery actions.

Stream-Specific and Generalized Habitat Suitability Criteria for Three Native Desert Fishes

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Endemic fishes of the arid southwestern United States have rapidly declined due to anthropogenic stressors. Identifying the habitat conditions needed by these species is critical for their successful management. Habitat suitability criteria are commonly used to conserve species of interest. Therefore, developing habitat suitability criteria for native fish species across multiple rivers permits better understanding of how different environments are occupied under various circumstances. We developed stream-specific and generalized criteria for Longfin Dace *Agosia chrysogaster*, Speckled Dace *Rhinichthys osculus*, and Desert Sucker *Pantosteus clarki*, across four central Arizona streams. Over 1,200 sites were sampled using pre-positioned electrofishing devices during the 2017 summer low-flow period to identify relationships among fish presence and habitat variables (depth, velocity, and substrate class). Optimal (central 50% of range used) and suitable (central 95% of range used) ranges within each habitat variable were calculated for each stream, based on the occurrence of each species. In general, Longfin Dace occupied depths of 9.00 – 54.75 cm (14.25 – 27.25 cm) velocities of 0.00 – 0.63

m/sec (0.11 – 0.31 m/sec), and substrate (modified Wentworth scale) of 0.5 – 4.3 (2.1 – 3.3). Speckled Dace occupied depths of 8.25 – 74.00 cm (17.00 – 34.25 cm) velocities of 0.00 – 0.74 m/sec (0.16 – 0.43 m/sec), and substrate of 0.0 – 4.5 (2.2 – 3.6). Desert Sucker occupied depths of 9.00 – 45.00 cm (15.25 – 25.00 cm) velocities of 0.09 – 0.72 m/sec (0.21 – 0.44 m/sec), and substrate of 1.0 – 4.6 (2.5 – 3.7). Generalized habitat suitability criteria for all three species were significantly ($P<0.05$) transferable with the exception of substrate class.

Harnessing Environmental DNA to Monitor the Spatial and Temporal Dynamics of Eulachon *Thaleichthys pacificus* in Northern Southeast Alaska

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Eulachon *Thaleichthys pacificus* are a culturally and biologically important anadromous forage fish with historic range stretching from northern California to Alaska. Today all populations that spawn south of the Nass River in northern British Columbia are severely depleted or extinct, leaving Alaska's populations as a critical stronghold. In southeast Alaska, eulachon remain a key resource for indigenous people and wildlife, but little is known about their population status, trend, or spatiotemporal dynamics. In 2010, the Chilkoot Indian Association in partnership with the Takshanuk Watershed Council began a mark-recapture project to monitor Eulachon in the Chilkoot River near the town of Haines, Alaska. From 2014-2017, Oregon State University paired the use of environmental DNA (eDNA) concentrations from the Chilkoot River as an alternative index of Eulachon abundance. Our results thus far have demonstrated that the concentration of Eulachon eDNA provides a reliable measure of eulachon phenology and abundance. Based on our results from the Chilkoot River, in 2017 we initiated a regional Eulachon monitoring program across 11 rivers in Northern Southeast Alaska. Because Eulachon do not have high site fidelity like salmon, regional monitoring is key to understanding population trends. The goal of our regional Eulachon monitoring program is to (1) determine the spatial and temporal correlation of Eulachon spawning biomass among 11 rivers in northern Southeast Alaska, (2) to test for correlations with environmental parameters that may affect Eulachon run size, timing, and distribution, and ultimately (3) to work with community harvesters and managers in the region to set thresholds for population level changes that would trigger management action.

An Examination of Inconnu Life History Strategies through use of Radiotelemetry, Otolith Microchemistry, and Sonar

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A radiotelemetry study of Inconnu *Stenodus leucichthys* conducted during 2007-2015 in the Kuskokwim River drainage in Alaska has expanded our understanding of life history strategies. Four spawning areas have been identified and examined: Big and Tonzona rivers, and the South and Middle forks, with the Big River as the most populous. Inconnu arrived at their spawning areas during late July through mid-September and spawned during late September through early October. Post-spawning outmigration occurred during 1-1.5 weeks in early to mid-October. Most of the radiotagged Inconnu overwintered in the lower Kuskokwim River and the brackish upper Kuskokwim Bay. After spring ice-out many of these fish swam upriver and spent summers feeding at the mouths of major tributaries. However, some Inconnu spent the entire summer in the lower Kuskokwim River and others spent the entire winter in the middle and upper Kuskokwim River, with year to year variations for individual Inconnu. To further examine anadromy, Strontium:Calcium (Sr:Ca) levels were assessed in thin-

sectioned otoliths, encompassing all annuli over the fish's lifetime. Sr:Ca is positively correlated with salinity, with freshwater environments having lower Sr:Ca values than marine. Various degrees of anadromy were detected that corroborated radiotelemetry data. Some otoliths showed clear evidence of anadromy with others illustrating limited exposure to salt water. Using migration timing determined by the radiotelemetry study, sonar (ARIS) techniques have been used at the mouth of Big River to enumerate post-spawning outmigrating Inconnu. Enumeration efforts will be used to develop a method to index abundance of the spawning population of Inconnu in the Kuskokwim River drainage.

Wild Salmon and the Shift Baseline Syndrome: Application of Archival and Contemporary Redd Counts to Estimate Historical Chinook Salmon Production Potential

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The paradigm whereby new generations accept recent environmental conditions and species abundances as accurately reflecting historical conditions has been termed the "shifting baseline syndrome". This syndrome leads to false impressions of past conditions, acceptance of inaccurate population baselines, and establishment of unrealistically low recovery goals. Consequently, the utility of even the highest-quality and longest-term databases may be compromised without historical abundance estimates. The inherent risks of the shifting baseline syndrome challenge biologists to accurately estimate past abundances and distributions of aquatic and terrestrial fauna. Biologists commonly employ redd counts to monitor trends in Chinook Salmon. In Central Idaho, salmon redd counts began in 1947 and have been consistently completed since the 1950s. Such long-term datasets represent an invaluable baseline against which current population status may be examined. However, because overexploitation of salmon and disruption of habitats occurred decades before initial quantitative assessments, contemporary managers may misjudge actual population potentials. In response to the need for historical accuracy, our goal was to integrate long-term archival (1952-1964) redd counts with contemporary, continuous redd count (1995-2015) and spawn timing (2001-2005) databases to estimate historical (1950s-1960s) spring/summer Chinook Salmon production potential in the Middle Fork Salmon River basin (MFSR). Here we describe our assumptions and analytical approaches for merging the temporal and spatial characteristics of salmon redds with maximum, archival redd counts to estimate historical potential. We also applied historical harvest information to estimate pre-harvest potential in the 1950s-1960s and 1880s. Current salmon populations average 3-5% of 1950s-1960s abundances; which evidence suggests may have been 30% of 1880s populations. Notably, despite high quality MFSR natal habitats, the shifting baseline syndrome has influenced contemporary managers. Summed population goals for MFSR Chinook Salmon equal 10.4%, 17.9%, and 20.4%, of estimated 1950s-1960s salmon production potential for minimum viable abundance, sustainable escapement, and population re-building objectives, respectively.

Evaluating the influence of dams and diversions on Burbot movement in the Wind River Drainage, Wyoming using genetic, isotopic, and field data.

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Dams and water diversions fragment habitat, entrain fish, and alter fish movement. Many Burbot *Lota* populations are declining with dams and water diversions thought to be a major threat. Our goal was to assess the effects of dams on Burbot population connectivity, entrainment into an irrigation network, and tributary outmigration within the Wind River Drainage, Wyoming. We used high throughput genomic sequence data to characterize the genetic structure and connectivity of populations within the drainage and assessed natal origins of fish with otolith strontium microchemistry. We also explored outmigration of Burbot from tributary populations with a PIT-tag, mark-recapture study. We found strong genetic differentiation between upper and lower basin populations separated by a diversion dam. We also documented a genetically distinct population within the irrigation network; this in conjunction with the otolith microchemistry results suggests the presence of a self-sustaining population within the irrigation network. The mark-recapture study indicated that outmigration from tributary populations was generally low, but could be influenced by dam releases. We conclude that dams are reducing Burbot population connectivity, but also note that reservoir and irrigation canal construction created novel habitat for Burbot establishment. Using a multi-scale approach increased our inferential abilities and mechanistic understanding of movement patterns between natural and managed systems.

Waste water effluent, estrogenic exposure, and the future of eastern plains native fishes

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Many freshwater streams and rivers are dominated by urban waste water effluent (WWE). For example, flow in the South Platte River downstream of the Denver, Colorado ranges from 69-100% WWE. WWE's typically contain compounds associated with human use and many of these may disrupt vertebrate reproduction. Although Great Plains fishes downstream of WWE's exhibit physiological evidence of reproductive disruption, it is difficult to predict how fish populations are responding. I will summarize three projects undertaken to understand how exogenous estrogens may be influencing Great Plains fish populations. The first two projects were designed to understand if estrogenic compounds influence reproduction and result in measurable population-level effects in two native eastern plains fish, the Red Shiner *Cyrinella lutrensis* and the Fathead Minnow *Pimephales promelas*. The third experiment was designed to identify estrogenic WWE in the South Platte River drainage in Colorado. The first two projects indicate that exposure to environmentally relevant concentrations of estrogen can result in complete reproductive failure and this may have population consequences. Field caging experiments show that fish are being exposed to exogenous estrogens at levels that could indicate risk for reproductive failure but wild populations appear to be behaviorally, physiologically, or evolutionarily coping with exposure.

Spawning migration of Least Cisco in the Chulitna River watershed, southwest Alaska

Young, Dan

Although not considered a species of importance for subsistence users or sport anglers, Least Cisco *Coregonus sardinella*, along with juvenile Sockeye Salmon, play a significant ecological role as forage fish in the Lake Clark system in southwest Alaska. Anecdotal evidence suggests Least Cisco spawn exclusively in the Chulitna River, an area currently being explored for mineral development. This project collected data in 2016 and 2017 to assess the spawning migration of least cisco in the

Chulitna River drainage. Specifically, we 1) operated a DIDSON sonar to identify run timing and strength, 2) captured migrating fish with a beach seine to estimate species apportionment, and 3) collected basic biological data to characterize age and size of migrating fish. Preliminary results estimate approximately 120,000 and 55,000 Least Cisco migrated upstream in 2016 and 2017 respectively. Run duration and timing were similar between years with most fish migrating upriver over a 14-day period from late September to mid-October. Other species captured included Arctic Grayling, Humpback Whitefish, Longnose Suckers, Round Whitefish, and Northern Pike. Age at maturity of Least Cisco ranged from 3-10 years in both years and fork length ranged from 151-274 mm. This project provides the first assessment of Least Cisco spawning migration in southwest Alaska. Understanding the migration patterns and spawning activity by Least Cisco provides managers with further information on the importance of this watershed to the greater Lake Clark system.

Food Webs, Hypoxia, and Stable Isotopes in a Bar-Built Estuary: A Case Study in Rodeo Lagoon, CA

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Estuaries, interfaces between freshwaters and the ocean, are ecologically productive environments that provide crucial habitat for many species, including native fishes. Many estuaries receive high nutrient loads, leading to eutrophic conditions characterized by hypoxic events. These hypoxic events can lead to a general decline in ecosystem quality (e.g., fish kills) and services (e.g., food web disruptions) which can often significantly impact local fish and human populations. Rodeo Lagoon, Golden Gate National Recreation Area, CA, is a small, bar-built estuary located directly north of San Francisco Bay where periodic hypoxic events lead to fish kills which negatively impact Central California Coastal Steelhead *Oncorhynchus mykiss* and Northern Tidewater Goby *Eucyclogobius newberryi*, both species listed under the federal Endangered Species Act. It is unclear whether these hypoxic events are natural, or caused by myriad human activities within the watershed. Using a combination of water quality measurements and stable isotope tools we (1) explore the potential causes of hypoxic events, (2) assess possible effects on food web structure, and (3) look at individual fish responses to localized hypoxia.

Contributed Papers

A new Chinook Salmon genetic baseline for Cook Inlet: opening doors to new analyses

Barclay, Andrew

Gilk-Baumer, Sara; Habicht, Christopher

Chinook Salmon *Oncorhynchus tshawytscha* are important to commercial, sport, and subsistence fisheries in Cook Inlet. Establishing and monitoring escapement goals and identifying fisheries that capture specific stocks is problematic because harvest occurs in mixed-stock fisheries both in salt and freshwater and because the river systems draining into Cook Inlet are large, complex, and often difficult to access. Past work using genetic methods to determine stock composition in mixed-stock commercial and subsistence fisheries in the ocean has provided information on the numbers of fish harvested by stock groups for the first time. However, the resolution of the current genetic baseline is limited to stock groups that often combine stocks that are of interest to managers. A new baseline has just been completed that contains ten times more markers than the original baseline that were specifically selected to distinguish among reporting groups of interest to managers in Cook Inlet. This new baseline promises to provide more distinction among finer-level reporting groups than is currently possible. We anticipate that this baseline will allow for the implementation of genetic mark-recapture applications

within the Susitna and Kenai rivers. We also anticipate distinguishing Yentna River, Susitna River, and Western Cook Inlet population groups in fishery harvests; a major goal of this project. Applications using this new baseline may be more cost effective than traditional methods and may provide opportunities to measure stock-specific fishery harvests for reporting groups that were not previously possible in order to inform stock-recruit relationships. These markers also provide an opportunity to complete parentage analyses where individual offspring can be assigned to their parents, opening the door for assessing variables affecting reproductive success and assigning fish to individual hatchery releases.

Warming up the waters in Arctic lakes: Implications from individuals to ecosystems

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The Arctic is experiencing the highest rates of warming around the globe. However, the ecological consequences associated with warming remain poorly understood. Effects of warming are complex and diverse, with consequences spanning all levels of biological organization, from individuals to ecosystems. Importantly, warming may lead to reductions in suitable habitat for fish driven by warmer surface waters, reduced dissolved oxygen (DO), and changes in whole-lake metabolism. We first quantified the volume of unsuitable habitat for two species of Arctic fishes (Arctic Char *Salvelinus alpinus* and Slimy Sculpin *Cottus cognatus*) using three-dimensional temperature and DO profiles. A combination of increased temperatures, prolonged stratification, and hypoxia lead to substantial reductions in suitable habitat. Consequently, fish will need to locally adapt to changing conditions to avoid negative consequences such as reduced growth and survival. Second, using diel changes in DO (10-min intervals) and maximum likelihood estimation, we calculated daily rates of gross primary production (mediated by light), ecosystem respiration (mediated by temperature), and net ecosystem production. Preliminary estimates indicate relatively low levels of productivity in these systems, reflecting their ultra-oligotrophic state. However, one lake displayed higher levels of productivity, likely due to its morphology, low position in the landscape, and higher levels of organic matter. Additionally, we observed some evidence of increased metabolic rates at warmer temperatures; however, these results will require further assessment and data from multiple seasons to fully address the effects of warming. Nevertheless, warming-induced shifts in ecosystem metabolism will likely result in feedback effects to individual fish (e.g., uptake and production of carbon and oxygen). In future work, we will continue to evaluate and model the relationships between warming and these individual and ecosystem-level impacts. These results will facilitate more effective management of fisheries resources and conservation of aquatic ecosystems within the Arctic under a rapidly warming climate.

Quantifying Drivers of Mercury in Resident Lake Fish from Southwest Alaska Network Parks

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The Southwest Alaska Network (SWAN) is part of the National Park Service's Inventory and Monitoring Program, which was created in 1998 to better understand the status and trends of select indicators. One of the indicators monitored by SWAN is resident lake fish. Monitoring indicates that some of these species have elevated concentrations of mercury, the majority of which is methylmercury, a potent neurotoxin. Compared with resident lake fish sampled from 21 parks in the western United States, mercury concentrations in fish from SWAN are among the highest, although considerable variation exists among lakes. Why do fish from SWAN – which inhabit some of the most remote waters in North America – have such elevated mercury levels? And what accounts for differences in fish mercury levels among lakes? To answer these questions, SWAN partnered with the U.S. Geological Survey in a study of factors controlling fish mercury levels within SWAN lakes. The study focused on a long-lived piscivorous species (Lake Trout) in two park units (Katmai and Lake Clark National Parks and Preserves). Water, sediment, plankton, and fish were collected from 13 lakes with a range of glacier, wetland, and salmon influences. Samples were then analyzed for mercury, methylmercury, and other analytes including stable isotopes of mercury, carbon, and nitrogen. Results indicate that: (1) Lake Trout exhibit a wide range of total mercury levels, both among parks and among lakes; (2) the median value of Lake Trout total mercury is above the State of Alaska's fish consumption threshold in 6 of 13 lakes; (3) by comparison, Sockeye Salmon total mercury levels are consistently low and exhibit little variability; and (4) mercury isotope signatures differ between Lake Trout in the two parks, and between Lake Trout and Sockeye Salmon. Ongoing work involves developing quantitative models to relate mercury in Lake Trout with potential drivers.

Return to Creel of Catchable Size Trout and Factors Influencing Angler Satisfaction and Catch Rates in Arizona Streams

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The Arizona Game and Fish Department operates a stream trout stocking program which costs the state $2.6 million annually and provides numerous put-and-take fisheries. Despite the popularity of this program little is known about return to creel of hatchery trout and angler satisfaction. Our objectives were to investigate return to creel rates of stocked trout, angler success, and to model factors influencing angler satisfaction and angler catch rates in Arizona streams. Creel surveys were conducted on six Arizona streams during the summers of 2013–2016. Multinomial logistic regression was used to model angler satisfaction. Hurdle models were used to model angler catch rates. In total, creel surveys were conducted on 487 days, resulting in 4,984 angler interviews. Total effort varied from 3,618 angler hours to 13,841 angler hours. Total catch of stocked trout varied from 1,918 to 14,288 trout. Total harvest of stocked trout varied from 1,027 to 9,350 trout. Return to creel rates varied from 12.0 to 66.4%. Proportional angling success varied from 14.9 to 56.3%. Results from multinomial logistic regression suggest catch rate, age, and terminal tackle were the most important factors influencing angler satisfaction. Hurdle model results indicate that days post stocking, number of trout stocked per km, and terminal tackle type were the most important factors influencing angler catch rates. Our results suggest that managers should stock to minimize the number of days post stocking for anglers based on their management goals to maximize angler satisfaction.

The road to diploidy and the fate of ohnologs: Partial tetrasomy enables conservation of duplicated genes following whole-genome duplication in Rainbow Trout

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Whole-genome duplications have occurred repeatedly during the evolutionary history of eukaryotes. However, how duplication events modify genome organization and how these events alter patterns of gene expression are mostly unclear. A whole-genome duplication event occurred in the common ancestor of the salmonid fishes approximately 88 million years ago. Since that event, salmonid genomes have reverted partially to diploidy, with ~10% of the genome still exhibiting tetrasomic inheritance. Why certain regions of the salmonid genome still exhibit tetrasomic inheritance remains unknown. To that end, we utilized the most recent Rainbow Trout *Oncorhynchus mykiss* genome assembly and transcriptome data to examine the fate of gene pairs (ohnologs) following the salmonid whole-genome duplication. Sequence identity between ohnologs located within tetrasomic regions is higher than between ohnologs found in disomic regions, suggesting tetrasomic inheritance suppresses mutation and recombination. In addition, tetrasomically inherited ohnologs are more similar in patterns of gene expression than disomically inherited ohnologs, suggesting reduced neofunctionalization in tetrasomic regions. Enrichment testing for Gene Ontology terms identified 16 over-represented terms in tetrasomically inherited ohnologs compared to disomic ohnologs, including terms associated with oxygen binding, utilization of iron, and the cytoskeleton. However, why these genes remain in tetrasomic regions is difficult to answer. It could be that we have identified “dangerous duplicates”, that is genes that cannot take on new roles following whole-genome duplications. Alternatively, there may an adaptive advantage for retaining genes as functional duplicates in tetrasomic regions. Presumably, there is considerable selection pressure maintaining these genes in tetrasomic regions as movement of these genes into disomic regions could affect both their sequence identity (i.e., permit neofunctionalization) and their gene expression patterns.

Thermal experience modifies energy depletion of Sockeye Salmon migrating at the northern edge of their distribution

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The physiological challenge for anadromous fish to migrate upriver to spawn and complete their life cycle is influenced by river temperature. The impacts of river temperatures can be difficult to predict due to an incomplete understanding of how temperature influences migration costs, especially in high latitude ecosystems. To assess temperature influences on migrating Pacific salmon in a Subarctic watershed, we measured an indicator of heat stress (heat shock protein 70), energy density of Sockeye Salmon *Oncorhynchus nerka* throughout their upriver migration, and pre-spawning mortality. We suspected Sockeye Salmon energy levels would be reduced by warmer river temperatures; however, we found no evidence of heat stress, similar rates of energetic decline from river entry to the spawning grounds amongst years, and minimal evidence of pre-spawn mortality. In fact, higher accumulated thermal units (ATU) resulted in higher energy densities in migrating salmon. This is likely due to how the bell-shaped curve of thermal optimal conditions for Sockeye Salmon interacts with the thermal regime of the river. The Pilgrim River is at the northern edge of the Sockeye Salmon distribution and often ranges below the optimal temperature for Sockeye Salmon migration resulting in a positive effect of warmer temperature

pulses on somatic energy. Hindcasting back to 1907, the predicted river temperatures during the spawning migration historically were not substantially different from the measured river temperatures (2013-2016). Air temperature predictions for 2040, 2060, and 2090 indicate an increase in ATU, but not to the level that would suggest negative impacts. ATU levels resulting in negative effects would require a combination of increased air temperature with a dramatically prolonged migration. Understanding interactions between environmental drivers and biological responses will help anticipate future changes and will provide insights to make informed management decisions within the watersheds.

Introgressive Hybridization Between Native and Artificially Propagated Non-native Steelhead *Oncorhynchus mykiss* spp.

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The artificial-propagation and release of non-native species is a widespread practice that can threaten native biodiversity. When non-native species create fertile hybrids with the native species, the non-native species causes direct demographic and genetic impacts. We examined introgressive hybridization in two subspecies of Steelhead anadromous *Oncorhynchus mykiss* in the Willamette Basin, Oregon. The native, Coastal Steelhead *O. m. irideus* is listed as threatened under the Endangered Species Act. A hatchery population primarily originating from Interior Steelhead *O. m. gairdneri* is released annually into the basin as mitigation for the impact of numerous dams. Other potential genetic populations include legacy hatchery-origin winter run Steelhead and native resident *O. mykiss* populations. Sixteen microsatellite loci were used to detect introgression in natural-origin adult Steelhead sampled early in the adult spawning migration during 2012-2013 and 2013-2014 run years. Bayesian clustering analysis (STRUCTURE) was used to identify the level of admixture in the population and assign individuals to clusters. The most likely clustering analysis indicated two populations were sampled: native, Coastal Steelhead and hatchery-origin Interior Steelhead. Introgressive hybridization was detected in 27.4% of the natural-origin adult Steelhead. First generation hybrids were about 7.1% of the natural-origin adult Steelhead. Hybrids backcrossed to the native Coastal Steelhead were three times more numerous than backcrosses to the Interior Steelhead. Hybrids were more similar to Coastal Steelhead than Interior Steelhead based on Fst values. All populations (Coastal, Interior and hybrids) had significantly different migration timing and analyses assuming three populations also indicated hybridization between winter and summer lineages. Low numbers of natural-origin, Interior Steelhead and back-cross hybrids to the non-native, Interior Steelhead were identified in the natural-origin population, consistent with the effects of outbreeding depression. High propagule pressure from hatchery releases, combined with apparent reduced fitness, likely depresses the population growth rate of the endemic population of Steelhead.

Monitoring the status of salmon populations and their habitats in British Columbia using the Pacific Salmon Explorer

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Salmon play an important role in the economies, ecology and cultures of the west coast of North America. However, the lack of centralized, standardized, and easily accessible data on the state of salmon populations, and threats to them, impedes efforts to make informed, transparent, and evidenced-based management and conservation decisions. In an effort to provide broader public understanding of salmon data in British Columbia (BC), the Pacific Salmon Foundation (PSF) has embarked on a major initiative to synthesize, and make openly available, the best available information on salmon populations and their freshwater habitats in BC. Drawing upon these experiences, we illustrate how government datasets can be used to monitor and assess the state of salmon populations and their habitats. We provide open, standardized, and reproducible information on a suite of indicators of salmon population condition including estimates of freshwater production, spawner abundance, harvest, trends in abundance, run-timing, population productivity, and assessments of biological status. This biological information is coupled with remote-sensed data that is used to quantify cumulative pressures on freshwater salmon habitats. All of this information is made available to the public through the Pacific Salmon Explorer (www.salmonexplorer.ca), an online data visualization tool that allows users to explore salmon-related information through a series of interactive maps and figures, as well as download source datasets. While initially developed for northern and central BC, the PSF is now scaling the Pacific Salmon Explorer up to all salmon-bearing watersheds in BC. Our novel and scalable approach provides a synoptic overview of the status of salmon populations and their habitats in BC, and highlights areas where data gaps exist and where more research is needed.

Recent Efforts to Reintroduce Endangered Sacramento River Winter-run Chinook Salmon to Historic Habitat In Battle Creek, CA.

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Currently, Sacramento River winter-run Chinook Salmon *Oncorhynchus tshawytscha* exist as a single population, which is restricted to spawn in the Sacramento River downstream of Shasta Dam - an area completely outside of the geographical range of historic spawning. As a result, the persistence of winter-run Chinook Salmon is precariously dependent on the release of cold water from Shasta Dam and the population remains extremely vulnerable to catastrophic events and climate change. National Marine Fisheries Service (NMFS) has determined that lack of spatial diversity is a primary threat to the continued existence of the federally- and state-listed, endangered winter-run Chinook Salmon. The historic distribution for winter-run Chinook Salmon included Battle Creek, the only historic habitat downstream of Shasta Dam. Battle Creek is a unique watershed mainly because of its cold water springs and high year round baseflows. These features have made it an ideal stream for the recovery of Central Valley salmonids, specifically for winter-run Chinook Salmon. Agency agreement for restoration was solidified with the signing of a Memorandum of Understanding in 1999 and currently construction for the Battle Creek Salmon and Steelhead Restoration Project is underway. Battle Creek is a key component of the NMFS Recovery Plan for winter-run Chinook Salmon, which will require reintroduction of this run into the watershed. In preparation for the completion of the Restoration Project, resource agencies along with Pacific Gas and Electric and ICF, developed a Winter-run Reintroduction Plan to guide the implementation of the Reintroduction Project once the Restoration Project is completed. However, following the drought, winter-run Chinook Salmon populations continue to decline and in summer 2017, resources agencies decided to jumpstart the Reintroduction Project. This presentation will highlight the considerations and technical aspects that were included in the Battle Creek Winter-run Reintroduction Plan, and will provide an update on the current status of the Jumpstart Project.

An overview of FLOW 2018: Managing Rivers, Reservoirs, and Lakes in the face of drought

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This presentation will provide an overview of the FLOW 2018 workshop held at the Hilton Hotel in Fort Collins, Colorado April 24 to 26, 2018. FLOW 2018 was the 4th international instream flow and water level uses workshop hosted by the Instream Flow Council (IFC) and coincided with its 20th anniversary. Approximately 200 water stakeholders participated. The workshop focused on problem solving and proven practices used from around the globe to mitigate negative impacts of drought to instream flow regimes and water levels required to sustain fish, wildlife, and habitat. Four, half-day sessions in plenary format featured selected speakers who focused sharply on outcome-based elements that have been shown to work for dealing with drought-induced challenges to water management including 1) legal strategies 2) institutional capacity (effective agency and administrative actions), 3) scientific principles (spanning hydrology, biology, geomorphology, connectivity, and water quality), and 4) incorporating public involvement. Facilitated discussions were held with presenters and attendees after each plenary session to explore and capture additional insights, strategies, and tools.
As with previous IFC conferences, the workshop format and emphasis on interdisciplinary problem-solving created networking opportunities designed to further benefit the effectiveness of participants to mitigate drought and other types of hydro-illogic cycles long after the end of the workshop. Similar to FLOW 2015 https://www.instreamflowcouncil.org/conferences-flow-2015-workshop-materials/ , FLOW 2018 workshop products are slated to be available for download from the IFC web site <instreamflowcouncil.org> no later than October 2018.
The IFC seeks to help state, provincial, and territorial fish and wildlife agencies better fulfill their public trust responsibility to protect aquatic resources, so that they can be used and enjoyed by current and future generations.

Emerging genetic baseline for Coho Salmon in Alaska: Capitalizing on small(er) scale challenges to create large scale solutions

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Barclay, Andrew. Gene Conservation Laboratory, Alaska Department of Fish and Game; Rogers Olive, Serena. Gene Conservation Laboratory, Alaska Department of Fish and Game; Habicht, Chris. Gene Conservation Laboratory, Alaska Department of Fish and Game

Genetic methods provide powerful tools for answering management questions where the exploitation and productivity of individuals stocks are not well known. These tools work particularly well with salmon because they return to their home stream to spawn, which results in genetic variation among populations. Genetic information can be used to better understand stock structure, to estimate stock composition in mixed fisheries, estimate escapement with genetic mark-recapture, or understand migratory pathways on the high seas. Paramount to using this tool, a baseline of genetic data must first be developed that contains adequate representation from stocks of interest. Expenses for developing these baselines increase as the potential contributing populations increase. As a result, these genetic baselines are initially developed only to answer localized management questions and are expanded as our understanding of stock structure improves and management questions widen. Here we discuss a case study in the development of an emerging baseline: Coho Salmon *Oncorhynchus kisutch* in Alaska. Localized single-nucleotide polymorphism baselines have been developed for management questions in Cook Inlet and Southeast Alaska. In the process of developing these focused baselines, the population structure of Coho Salmon within each of these areas has provided a better understanding of how genetic variation is structured. We found adequately deep structure within areas for mixed-stock analyses (MSA), but relationships

among collections are not always correlated by distance. As a result, Coho Salmon baselines require more representation of locations than species of salmon, such as Pink Salmon, Chum Salmon, and Chinook Salmon, to conduct unbiased MSA. We look at how these baselines are connecting across the State and at the potential for adding existing baseline samples from other areas, both within and outside the state. Finally, we discuss potential large scale applications of this expanding baseline for this important salmon species.

Implementation of high throughput genotyping in the world's highest volume fish genetics lab

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Gilk-Baumer, Sara. Gene Conservation Laboratory, Alaska Department of Fish and Game; Habicht, Chris. Gene Conservation Laboratory, Alaska Department of Fish and Game

The Gene Conservation Laboratory (GCL) at the Alaska Department of Fish and Game is responsible for protecting the genetic integrity of wild populations of fish, wildlife, and aquatic plants and for using genetic information to help manage these resources in a sustainable manner. The GCL currently processes more than 85,000 genetic samples per year, and houses an archive of more than 4 million samples from Alaska and around the world. New advances in genetic technology are providing novel methods to assess genetic variation and to implement cost-effective management tools. The GCL has recently implemented advanced genotyping-in-thousands by sequencing (GTSeq) methods as another tool to efficiently produce high quality data necessary to manage valuable fisheries throughout Alaska. Recent projects have been completed in about half the time required under previous methods. A description of the methodology will be provided, along with a comparison to previous methodologies and a case study of Chinook Salmon from Cook Inlet, Alaska.

Integrating fish use of headwaters, backwaters, and big rivers: a Fish Use Habitat Index (FUHI).

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Shelly, Alice. R2 Resource Consultants; George, Gerald. R2 Resource Consultants; Steimle, Kai. R2 Resource Consultants*

As conservation planning and impact assessment strive to include larger scale perspectives, it can be challenging to collect and analyze data across complex riverscapes. We present a Fish Use Habitat Index (FUHI) that incorporates both the overall relative abundance of fish and fish species/life stage richness to characterize and compare the relative importance of diverse habitat types. The FUHI was developed for a large-scale sampling effort conducted on the Susitna River in 2013 incorporating data from 46,804 fish captured in over 4,000 gear events and included 22 fish species and life stages. An initial comparison revealed little correlation between measures of fish abundance and species richness at either the macrohabitat or mesohabitat scale, so both measures were integrated into the FUHI to describe the seasonal use of habitats by fishes. Our results provide an effective, simple, and customizable method for summarizing patterns of habitat usage by fishes across complex landscapes.

Understanding the genetic basis of ecotypic variation in Sockeye Salmon from across Alaska

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The genetic mechanisms that facilitate adaptive radiation remain poorly understood, especially in non-model organisms. Here, we genotyped neutral SNPs, SNPs in islands of divergence identified in a previous study, and a region of the major histocompatibility complex in 32 populations of Sockeye Salmon to investigate signatures of selection across Alaska. Populations from multiple ecotypes were sampled from seven drainages spanning a range of 2,000 km, facilitating investigation of adaptive radiation in systems with differing habitats and colonization histories. We found strong signatures of parallel selection across drainages, suggesting that the same loci undergo divergent selection during adaptive radiation. However, patterns of differentiation at loci that were putatively under selection were not associated with ecotypes and were not correlated among drainages, suggesting that these loci are responding differently to a mosaic of selective pressures. Our study provides some of the first evidence that conserved genomic islands may be involved in adaptive divergence of salmon populations. Additionally, our data provide further support for the hypothesis that Sockeye Salmon inhabiting rivers that are not connected to lakes are the ancestral form and that these populations have repeatedly recolonized lake systems as they have become available after glacial recession. Finally, our results highlight the value and importance of validating outlier loci by screening additional populations and regions, a practice that will hopefully become more common in the future.

Younger smolts may explain Kvichak Sockeye Salmon decline

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The Kvichak Sockeye Salmon population has been in decline since the early 1990's. One hypothesis for this decline is that warmer water temperatures over this time period have increased growth, such that juveniles smolt at an earlier age, but at a smaller size. Larger smolts generally have higher survival, so a decrease in smolt size could cause a decline in the number of returning adults. To investigate this hypothesis, we examined early growth, smolt size, and age using otoliths (n = 2600) of returning adult Sockeye Salmon captured in at tributary to Lake Iliamna, the Newhalen River, from 1966 to 2012. We found that first-year growth has increased over this time period and smolt age has declined, from predominantly age-2 to age-1. Smolt size did not decrease over this time period, as hypothesized. This suggests that there is a length threshold for smolt survival, and that low smolt survival may be one reason for the Kvichak population decline.

Mad First Impressions: invertebrate communities in three Northern California estuaries

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The majority of Northern California estuaries are small, flooded, river valleys that are largely unstudied due to their small sizes and remote locations. Yet these estuaries serve as important nursery areas for many marine fish and are vital to anadromous species. These highly productive ecosystems provide abundant prey for salmonid smolts, juvenile rockfish and flounder, and a diversity of marine fishes that enter estuaries seasonally to feed. I sampled the summer and winter benthic prey communities of the Mad River Estuary and two Northern California estuaries designated as Marine Protected Areas (MPAs), the Big and Ten Mile river estuaries. Benthic invertebrates were collected via cores, June 2014 – June 2016. Additional sampling was conducted June 2015 – June 2016 in the Mad River Estuary, alongside a diet study of two benthic

fishes: Pacific Staghorn Sculpin *Leptocottus armatus* and English Sole *Parophrys vetulus*. Invertebrate diversity varied more by estuary than by season (i.e. summer, winter). The Big River Estuary had the strongest ocean connection and the most marine invertebrate fauna. The Mad River Estuary invertebrate community was most similar to the Ten Mile River Estuary, which had the least ocean connectivity and species diversity. Additional sampling in the Mad River Estuary showed that invertebrate communities were diverse from spring through fall, and that invertebrate communities within an estuary differed more by upstream distance than by season. Staghorn Sculpin diet in the Mad River Estuary varied by location of capture, but not by season.

Is bigger always better? Size-selective early marine survival in an Alaskan Sockeye Salmon population

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Understanding the factors that influence body size and the consequences for survival is a long-standing challenge of evolutionary ecology. This talk provides emerging insights into a study of size-selective mortality of out-migrating Sockeye Salmon from a small watershed on Kodiak Island, Alaska. Generally speaking, Sockeye Salmon *Oncorhynchus nerka* are thought to experience high mortality during a brief period after juvenile fish (i.e., smolts) enter the ocean. There is evidence that early marine mortality may be size-selective, where larger smolts of the same cohort have a higher probability of survival than their smaller counterparts. Individual smolt size of the same brood year is highly variable, where length is determined largely by the number of years spent in freshwater (i.e. age at outmigration) and other abiotic and biotic factors such as temperature and intraspecific competition. There is potential for long-term changes in climate to cause shifts in freshwater growth for juvenile Sockeye Salmon and have consequences for both freshwater age structure, as well as early marine survival. However, the linkages between growth in freshwater and survival in the marine environment are complex, dynamic, and often context or site-dependent. By exploring the potential linkages between freshwater growth and marine survival of Sockeye Salmon, we hope to better understand how salmon populations will respond to a changing freshwater environment and varying escapement scenarios.

Haunted rivers: application of mobile RFID-GPS systems to evaluate the prevalence of ghost PIT tags

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The use of mobile radio-frequency identification (RFID) systems to detect passive integrated transponder (PIT) tags has increased in support of fish research and management. We describe the development and application of a mobile RFID system that incorporates Global Positioning System (GPS) to detect PIT-tags in streams. Georeferenced, PIT-tagged rocks were used to evaluate detection probability and GPS accuracy. Results indicate that detection probability was negatively influenced by stream width, distance from stream center, and water depth, but increased with number of passes. GPS error between detected and surveyed positions averaged 4.5 m, with greater error observed in longitude than latitude. The RFID-GPS system was then field deployed to estimate abundance of PIT-tagged trout and evaluate habitat utilization. Initial results from field deployment suggested that abundance estimation of PIT-tagged fish was possible and relatively precise due to high capture and recapture probabilities. Although the majority of trout were detected in pools, the detection field

covered more cross-sectional area in pools than riffles, which could have biased analysis of habitat utilization. After repeated deployment of the system, it became apparent that some detections might be associated with ghost tags rather than PIT-tagged fish. To address this issue, we developed and applied a protocol for ghost tag identification upon completion of a companion fish-movement study. Additional backpack RFID systems were deployed with the RFID-GPS system to identify ghost tags, quantify tag loss, and determine the location in which tags were expelled and/or had settled. Ghost-tag surveys indicate that at least 33% of the trout had either died or expelled their tags 2-3 years after tagging. Although the flexibility of the RFID-GPS system makes it useful for a variety of studies related to habitat utilization, fish migration, and population trends, failure to account for ghost tags may lead to incorrect interpretations regarding fish location and fate.

Growth Rate Variation Among Juvenile Chinook Salmon Cohorts and Rearing Conditions

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The San Joaquin River (SJR) in California's Central Valley represents the historical southern-most range of Chinook Salmon *Oncorhynchus tshawytscha*. However, the construction of the Friant Dam and its water diversion canals in 1942 caused degradation of extended portions of the SJR and extirpated one of the largest Chinook Salmon runs in the United States. In 2006, the San Joaquin River Restoration Program (SJRRP) was created to mitigate the negative effects of the Friant Dam on river function and integrity, and to restore a self-sustaining Chinook Salmon population below Friant Dam. The artificially changing river levels and flows of the SJR affect thermal dynamics of the rearing habitat in the restoration reaches. Temperature plays a significant role in juvenile salmonid survival, through effects on growth, metabolism, development and early life history phenology. As fish are reintroduced into the SJR, it is crucial to know the optimum thermal conditions for fish growth to facilitate a sustainable population. JCS growth rates were calculated using otolith analysis techniques. We can use juvenile growth rate data from hatchery conditions to provide a baseline reference for water temperature-growth relationships. On a larger scale across Chinook Salmon populations in North America, we can study these relationships with bioenergetic model simulations to examine population-specific temperature regulation of manifested and potential growth. These patterns can help inform both water management and salmon conservation, especially in California where river water temperatures are highly regulated by water agencies and conflicting water demands and uses.

Future of Salmon in the Face of Change: Lessons from One of the World's Remaining Productive Salmon Regions

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Pacific salmon *Oncorhynchus* spp. face serious challenges from climate and landscape change, particularly in the southern portion of their native range. Conversely, climate warming appears to be allowing salmon to expand northwards into the Arctic. Between these geographic extremes, in the Gulf of Alaska region, salmon are at historically high abundances but face an uncertain future due to rapid environmental change. We examined changes in climate, hydrology, land cover, salmon populations, and fisheries over the past 30-70 years in this region. We focused on the Kenai River, which supports world-famous fisheries but where Chinook Salmon *O. tshawytscha* populations have declined, raising concerns about their future resilience. The region is warming and experiencing drier summers and wetter autumns. The landscape is also changing, with melting glaciers, wetland loss, wildfires, and human development. This environmental transformation will likely harm some salmon populations while benefiting others. Lowland salmon streams are especially vulnerable, but retreating glaciers may allow production gains in other streams. Some fishing communities harvest a diverse portfolio of fluctuating resources, whereas others have specialized over time, potentially limiting their resilience. Maintaining diverse habitats and salmon runs may allow ecosystems and fisheries to continue to thrive amidst these changes.

Combining runoff modeling and fuzzy streamflow classification to identify transitional flow regimes in Southeast Alaska

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Humans have a natural desire to organize objects in a logical way, and freshwater ecologists are no exception. Hydrologic classification is a widely applied practice with numerous analytical approaches, but its fundamental goal is to arrange streams into a logical set of categories based on their flow characteristics. This arrangement can support many activities, including the exploration of ecological patterns across stream categories, prioritization of conservation actions, or monitoring program design. In Southeast Alaska, a region with thousands of streams but relatively few stream gages, recent advances in freshwater runoff modeling now allow ecologists to conduct broad-scale classification analyses, even in rivers with no empirical flow data. In this talk I will present a “fuzzy” streamflow classification method that uses Bayesian mixture modeling and unbiased hydrologic descriptors such as mean and skewness to describe flow time series. The primary advantage of this fuzzy approach is that each stream is assigned a probability of inclusion in a given streamflow category (e.g., snowmelt) versus one or more other categories (e.g., winter rain). In a region of receding glaciers, diminishing snowpack, and warming air temperature, we will demonstrate that this flexible approach to streamflow classification can directly identify transitional watersheds most likely to shift streamflow categories in the future. Since flow drives physical, chemical, and biological patterns in streams, the population dynamics of aquatic organisms residing in transitional watersheds will likely be in flux over the coming years. Identification of these transitional watersheds across the landscape will provide key information for adaptive fishery and watershed conservation planning.

DNA mixtures for ecology

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Mixtures of DNA from multiple contributors present a novel opportunity to count specimens to inform fisheries and aquatic ecology. We apply a likelihood based framework to estimate the number of contributors to a DNA mixture for ecological applications. We assessed the performance of DNA mixture estimation through a combination of simulation analyses, laboratory testing, and a field trial to estimate fish predation rates from stomach content analysis. Simulations indicated reasonably sized genetic marker panels could estimate the number of contributors to mixtures comprised of up to 10 individuals, with potential to resolve larger mixtures. Mixture estimates demonstrated robustness to common genotyping errors associated with fish and wildlife genetics applications. Laboratory trials demonstrated genotypes from amalgamations of Yellow Perch *Perca flavescens* DNA could be generated with a 14-loci microsatellite panel and led to successful estimation for up to 5-contributor mixtures. Stomach content analysis with DNA mixtures indicated a 5-fold increase in predation rates of yellow perch by Largemouth Bass *Micropterus salmoides* relative to conventional visual assessment of diet contents which can miss partially digested prey items. DNA mixtures have potential to expand applications of count-based ecological analyses. Technical challenges in generating genotypes from DNA mixtures may initially limit their use, however, advances in next generation genotyping platforms are anticipated to surmount these obstacles. Chiefly, we envision opportunity for DNA mixtures to advance eDNA analysis beyond presence/absence based inference to local enumeration of specimens.

Species index of relative abundance for combining CPUE across multiple gear types for fish-habitat associations in the Susitna River, Alaska

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Studies designed to identify the habitats used by multiple species and lifestages of fish in large diverse river systems require the use of multiple gear types. But gear types differ in catch efficiencies for different sizes and species of fish. Not all gears can be used, or used effectively, in all habitats. Also, measures of effort are not comparable across gears. These issues result in complex data sets that require careful interpretation. We developed an index method for interpreting relative abundance of individual species or groups of similar species across habitat types and geomorphic reaches in the Susitna River, Alaska, based on a large-scale sampling effort conducted in 2013. We call our index the species index of relative abundance (SIRA), and compare it to alternative methods using Susitna River data for five species with different habitat usage and total catch patterns. We also compare the index methods using a computer simulation of known total catch distributions, with gear usage patterns and relative catch distributions including gear types not used in all habitats, and skewed catch distributions with a high proportion of zeros. Our results provide an effective, simple but not simplistic method to understand patterns fish-habitat associations across complex landscapes for individual species or groups of species.

Can we improve upon vital rate estimation and reduce handling stress of endangered fishes using passive floating PIT tag detectors and post hoc statistical classification of live versus dead tags?

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Accurate estimates of an organism's vital rates are essential for tracking and understanding the successful recovery of endangered species such as razorback sucker and Colorado Pikeminnow. Mobile PIT tag antenna systems (e.g., on a floating raft) have recently been developed to increase resight rates. Although promising, passive (PITPASS) mobile systems present new challenges to estimation techniques. Tags, not fish, are detected, thus increasing the chance that shed tags or dead fish with tags are included as live fishes, which can lead to biases in survival and abundance estimates. Thus classification of tags as live or dead is essential and, in part, motivated this portion of this study. Our goal was to develop a mathematical method for classifying detected PIT tags as live or dead/shed. We conducted our 2 year study on 273 kilometers of designated critical habitat in the San Juan River. We seeded PIT tags into the river to quantify dead/shed tag movement (900 resights); live fish (302 resights) movements were identified by matching tag detections with live capture data. In our best model, the most important explanatory variables for correct classification of tags were total distance moved, distance moved upstream, flood effect, and meters moved per day. This model had a total error rate of 6.3% incorrectly classified tags, with a low rate for dead/shed tags (1.8% incorrectly classified as live tags) and higher error for live tags (19.5% incorrectly classified as dead/shed tags). With this method, we can classify detections as live or dead/shed tags, and this new source of data can increase our resight rate, potentially improve estimates of vital rates, which could help identify influential management actions, and explore habitat associations. Further, this technique requires no additional handling after initial tagging, reducing stress on imperiled and protected native fish when compared with repeat electrofishing events.

An Evaluation of Recycling Summer Steelhead on the Cowlitz River

Gibson, Scott R. *

Sandstrom, Phillip

The Cowlitz River is located in southwest Washington and is a tributary of the Columbia River. There are three major hydroelectric dams within in the Cowlitz basin (Mayfield Dam, Mossyrock Dam, and Cowlitz Falls Dam). As a result, construction of the Cowlitz Trout Hatchery was completed in 1968 to provide fish for angling opportunities and conservation measures. Non-endemic summer-run Steelhead have been reared at the hatchery since 1968 with the intent of mitigating for hydro development by maximizing sport harvest while eliminating direct harvest of wild Steelhead populations. Current production goals for summer-run Steelhead are 650,000 smolts with a harvest goal of 10,000 to 20,000 adults in the lower Cowlitz River. Adult fish return to the river May-October and typically spawn December-January. To increase angling opportunity Tacoma Power recycles (moves fish collected at the fish separator back downstream) up to 3,300 summer-run Steelhead per year. To address concerns related to straying of recycled fish, multiple mark-recapture studies using floy tags and radio telemetry have been conducted to assess the fate of recycled fish. These studies were meant to evaluate 1) the number of recycled fish that returned back to the collection facility; 2) number of recycled fish removed by anglers; 3) and in the case of the telemetry study, if the Steelhead that were not removed from the river interacted with wild fish. We synthesized the results of these studies and ongoing monitoring results to examine trends over time and determine how many fish could be recycled while maintaining the desired pHOS rate (<5%) based on current results. Similar results of fish fate were found for all studies with 41% (range: 32-55%) returning to the collection facility; 17% (range: 15-20%) being removed by anglers; 42% (range: 30-49%) unknown fate.

The Pebble Mine and Safeguarding Bristol Bay

Williams, Nelli. Trout Unlimited

Local community leader; Local community leader; Bristol Bay fisheries science expert

For well over a decade the proposed Pebble Mine in southwestern Alaska, has been a source of concern for local residents, many Alaska Native tribes and corporations, commercial fishermen, recreational fishing business owners and fishery scientists. In December of 2017, Northern Dynasty Minerals submitted a permit application and mine plan with the Army Corps of Engineers launching a permit review process, providing details about the mine and its associated infrastructure and outlining several opportunities for the public to weigh in. During this session local residents, business owners and fisheries experts will provide an update on the proposed mine and highlight new and ongoing concerns about the risks the mine would bring to local communities, jobs and Bristol Bay's thriving fisheries. Speakers will also discuss the importance of community involvement in fisheries habitat decisions.

A Quick History of National Forest Stream Restoration in Depositional Areas of the Pacific Northwest

Hogavorst, Johan. USFS

Helstab, Matt. USFS*

On National Forest lands in Oregon, as in much of the rest of the Pacific Northwest, a wide range of disturbances over the last century have affected streams including riparian harvest, overgrazing, and floodplain modifications (i.e. road infrastructure). In depositional reaches, the primary effect has been the conversion from low energy floodplain-connected environments to incised and efficient transport channels, leading to the elimination natural processes and functions found in historic floodplains. Early attempts at restoration of these streams largely focused on form based "stable" designs aimed at providing apparent habitat needs for salmonids. More recently, a group of Forest Service restoration practitioners have developed a new paradigm for stream restoration in depositional environments. While this new paradigm was largely constructed through trial and error over years of implementing projects in degraded streams of the Pacific Northwest, it was recently informed by Cluer and Thorne (2013) as Stage 0 of the Stream Evolution Model (SEM). Stage 0 projects aggrade channel elevations to reconnect floodplains in disturbed, historically depositional areas that have been converted to transport reaches. As part of project design, elevations of historic flow paths are derived from both LiDAR and field reconnaissance to mathematically define the valley profile (Geomorphic Grade Line, Powers et al., In Prep.). Key to the Stage 0 approach is the concept of stream power per unit width and how this parameter becomes exaggerated in incised channels, creating a firehose effect. Stage 0 restoration projects result in an anastomosing networks with an increase in habitat complexity across the valley floor. The newly formed template allows reestablishment of key processes such as flood storage, sediment retention, sorting of substrates, channel movement and critical cover for stream biota at all flows.

Poster Session

The Center for Salmon and Society

Adkison, Milo D.

Wild Pacific salmon are profoundly important because they connect ecosystems, economies, cultures and traditions around the Pacific Rim. Sustainability hinges on the health of the relationship between wild salmon and people. However, salmon can also divide people, especially in times of scarcity or when economic development is pitted against salmon. The salmon community, which includes all people who care about salmon, is currently embroiled in acrimony in many parts of Alaska, signaling a threat to salmon sustainability and connections between salmon and society. No single entity exists that provides a trusted voice for the use of science to inform salmon policy, nor is there a forum on common neutral ground for the gathering of the salmon community to shape, together, the future of Alaskan salmon. The vision of the CSS is to provide an objective forum for the co-creation and targeted dissemination of the best available science to policy-makers to support informed decision-making. CSS will bring together the Alaska salmon community in an objective forum to collectively identify and address knowledge gaps, synthesize information to make informed societal choices, and communicate results and recommendations widely. The CSS will connect UA faculty and collaborators across state, federal, tribal, and non-governmental organizations, using existing infrastructure and support mechanisms to collaborate in knowledge generation and to garner support through external grants. The mission of the CSS is to make a meaningful and lasting contribution to long-term conservation of wild Pacific salmon, salmon-dependent communities and cultures, and to the state's economy.

Fish Surveys and Culvert Assessments on Adak Island

Alas, Jeanette, ADF&G, Division of Habitat*; Eisenman, Mark, ADF&G, Division of Sport Fish

Streams and culverts along the road system on Adak Island, Alaska were sampled as a joint project between ADF&G's Fish Passage Assessment Project and the Division of Habitat to conduct reconnaissance level assessments of stream crossings and conduct fish surveys to correct and add information to the Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes and its associated Atlas (AWC). Fish sampling included 30 minnow trap events, 19 backpack electrofishing events with a SmithRoot LR 24, and on the ground visual observations. Seventy-six stream crossings were assessed, which included documenting the culvert type or crossing structure; measuring the culvert inlet or outlet and any perched culverts; documenting any potential velocity or other barriers to fish passage; and photo documentation of the inlet and outlet, inside the culvert, and habitat upstream and downstream of the culvert. A Garmin 64 handheld GPS was used to record the position of all fish sampling events, culvert locations, and to mark currently cataloged stream mouths and upstream extents of anadromy ending with a natural or man-made barrier. AWC nominations have been submitted for 19 additions, 18 corrections, and 14 backup or supporting information. Culvert assessment data has been used to update the Fish Passage Inventory Database. Resident and anadromous fish data has been submitted to the Alaska Freshwater Fish Inventory Database. All database updates will include the online Fish Resource Monitor. A prioritized list of recommended culvert improvements will be developed to maximize the benefit of increased habitat for salmonids.

Microplastics in Oregon coast Pacific Oysters and Pacific Razor Clams

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The presence of microplastics is increasingly being recognized as an ecological stressor with potential implications for marine food webs. This study aims to determine the concentrations, types, and spatial distribution of microplastic

contaminants in Oregon's estuarine Pacific Oysters from six sites along the Oregon coast, and open coast Pacific Razor Clams from nine sites along the Oregon coast. Data on spatial, temporal, and species variability of microplastic concentrations in these commercially and recreationally- important bivalves was collected. Organic matter for each individual specimen was digested using a potassium hydroxide solution, and plastics persisted through the digestion process. The resulting liquid was then analyzed under a stereomicroscope for size, type, and concentration of microplastics per gram of organism tissue. While results are preliminary and razor clam samples have not yet been analyzed, the findings of this study suggest Oregon Pacific Oysters do contain microplastics at all six collection sites. This baseline study will enhance Oregon's capacity to understand whether there are microplastic "hotspots" along the coast, and will help shape future work to minimize plastic transmission pathways to the environment.

Classification of habitat suitability for Finescale Dace in the Belle Fourche - Cheyenne and Niobrara Drainages.

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Finescale Dace *Chrosomus neogaeus* are a species of greatest conservation need in Wyoming and adjacent states on the Great Plains, where they occur as glacial relicts. Despite historic efforts to transplant populations, their range at present time is severely restricted. Current populations are found primarily in isolated habitats within the Belle Fourche - Cheyenne and Niobrara Drainages. Non-native predatory fish, stream fragmentation, and specific habitat requirements of the species all increase the risk of decline or extirpation of populations in this region. Presence / absence of Finescale Dace and a piscivorous fish guild were determined from historic fish survey data provided by state agencies in Wyoming, South Dakota, and Nebraska. Data in landscape metric categories including hydrology, geomorphology, landcover, and climate were retrieved from federal agency sources. A random forests modeling approach identified mean annual discharge and soil classification as the most important variables in explanation of the Finescale Dace presence / absence response variable. Potentially suitable habitat was ascertained by predicting model output back to study area watersheds. These results will aid in evaluation of candidate field sites for fish and habitat sampling and provide insight into important landscape scale factors that influence the distribution of a rare minnow in high plains aquatic systems.

Using BLM’s National Aquatic Monitoring Framework to collect scalable data to address current and future management challenges

Brady, Colin; Varner, Matthew; Post, Jason; Miller, Scott; Cappuccio, Nicole

The Bureau of Land Management (BLM) manages over 118,000 miles of perennial stream and lotic riparian habitat, as well as almost 3 million acres of lakes throughout the State of Alaska. Overall, Alaska aquatic systems make-up more than 87% of the Bureau’s riverine resources. The large majority of BLM Alaska’s aquatic resources are believed to exist in a relatively unaltered state; however, little monitoring data is available to objectively characterize current conditions or to detect change in response to development or shifting climatic and meteorological conditions. Section 201 of the Federal Land Policy and Management Act of 1976 (FLPMA) requires the BLM to prepare and maintain a current inventory of public land resources.

The need for knowing the condition and trend of aquatic systems is underscored by increased resource uses (e.g., mining, energy development, and recreation) and landscape level change. In order to quantitatively monitor and assess the condition of aquatic systems on BLM-administered public lands, the AIM NAMF was developed. The AIM-NAMF strategy seeks to integrate both local- and regional-scale monitoring activities to inform condition assessments by establishing core indicators, standardizing field methodologies, using statistically valid sample designs, and developing electronic data capture and storage technologies. This information serves as the foundation for decision-making and is critical to achieving the Bureau's multiple use mission of "sustaining the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations."

Abundance trends of wild Chinook Salmon in Bear Valley Creek, Middle Fork Salmon River, Idaho, USA.

Cazier, Scott S. Shoshone Bannock Tribes*; Blackadar, Ryan J. Shoshone Bannock Tribes; Evans, Melissa L. Shoshone Bannock Tribes; Tardy, Kurt A. Shoshone Bannock Tribes

Bear Valley Creek is a critical spawning and rearing stream for Chinook Salmon *Oncorhynchus tshawytscha* in the Middle Fork Salmon River and an important traditional use area for members of the Shoshone-Bannock Tribes of the Fort Hall Reservation. Past counts of Chinook Salmon redds indicate that Bear Valley Creek was the primary spawning stream in the Salmon River, if not in the entire Columbia River basin. However, all naturally produced Chinook Salmon in the Salmon River basin, including Bear Valley Creek Chinook Salmon, have been listed as "threatened" under the U.S. Endangered Species Act due to declining population abundances. The Tribes developed the Bear Valley Chinook Salmon Abundance Monitoring Project to conduct viable salmonid population monitoring to guide and improve management decisions in the watershed. Beginning in 2010, the Tribes have annually operated a passive, non-invasive adult fish counting station and conducted multiple-pass spawning ground surveys. In 2012, the Tribes added a rotary screw trap to annual operations to monitor juvenile emigration. During 2010 - 2017, mean adult escapement for spring/summer Chinook Salmon into Bear Valley Creek was 1,178 (range 136 – 2,189) and redd counts averaged 396 (range 92 – 589), annually. Juvenile outmigrant estimates have varied widely (range 240,692 – 790,442) but the 5-year mean is 451,329. Current production estimates indicate that over 1,500 surviving juveniles are necessary to return a single adult. Overall, population estimates of both adult and juvenile Chinook Salmon in Bear Valley Creek have declined over the last eight years. Habitat quality in Bear Valley Creek is excellent, therefore, out-of-basin effects (hydropower system, ocean conditions, harvest, etc.), are the likely drivers of observed declines. Management actions are needed now more than ever to enable the long-term persistence of this important natural production stronghold for Columbia River Basin Chinook Salmon.

Defining genetic population management units of kelps in Alaska

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Alaska has a diverse flora of seaweeds along its coast that can potentially support a substantial seaweed farming industry. Worldwide, seaweeds represent a more than $10 billion dollar industry that is expected to double by 2024. Kelps (brown seaweeds: Phaeophyta), in particular, are used in numerous products, ranging from food (including the foam on beer) to paper, textiles, and biofuels, and have been used in wastewater management and efforts to mitigate the effects of climate change on marine ecosystems. The Alaska Mariculture Initiative has stimulated numerous pilot projects to test the feasibility of farming seaweeds. Permitting of these farming activities by the State of Alaska is designed to prevent the loss of genetic diversity and to avoid introductions of mal-adaptive genes into wild populations. The goal of this project is to describe the genetic population structure of two species of interest to the seaweed industry: Sugar Kelp (*Saccharina latissima*) and the Winged Kelp (*Alaria marginata*), which inhabit lower intertidal and subtidal zones of rocky and gravel shores. We are using nuclear and organellar DNA markers to define the genetic population structures of these kelps along Alaska's shoreline. The results will help to develop permitting practices that will lead to maintenance of wild populations while allowing for development of Alaska's seaweed resources.

Determining the stable isotope signature range of juvenile hatchery salmon from Hidden Falls Hatchery in Chatham Strait

Cook, Aaron T. University of Alaska Southeast Sitka*; Kosma, Madison M. University of Alaska Fairbanks; Straley, Janice M. University of Alaska Southeast Sitka

Salmon are one of the most valuable fisheries managed by the state of Alaska, supplying commercial, sport, and subsistence user groups. Humpback Whales have been observed feeding on juvenile salmon at hatchery release sites in Southeast Alaska. Humpback Whales are suspected to have played a role in hatchery Chum Salmon run failures in past years. Since the end of commercial whaling, North Pacific humpback whale numbers have increased. These predators are of increasing concern to fishermen and managers of aquaculture operations because depredation upon the released salmon. The overarching goal of this study was to determine the stable isotope signature range of juvenile salmon from Hidden Falls Hatchery, in Chatham Strait. Our hypothesis is that the signature range will be narrow because the fish are fed similar diets when reared in the hatchery. Hatchery species included: Chum, Coho, and Chinook Salmon. Potential relationships of isotopic signatures by prey species, length, and weight may exist and, if very different, may complicate future analysis of predator-prey stable isotope analysis. Our preliminary data show that hatchery salmon have a different isotope signature compared with wild diet items and this signal should be detectable in whales feeding upon hatchery salmon. This study represents the first step and the foundation to understanding the stable isotope signatures and diets of predators that feed on juvenile salmon, such as Humpback Whales. More broadly, the results from this work will be used to improve concurrent work using stable isotopes to determine the proportional contribution of hatchery salmon to the diet of Humpback Whales and help hatchery managers to better understand the impact of Humpback Whales.

Digital Hydrography for Alaska's Rivers

Daniel Miller; Lee Benda*

Alaska's rivers and streams are essential to the state's economy and cultural identity. Management of these resources requires knowledge of the types, locations, and abundance of the habitats these river systems provide. Digital hydrography derived from remotely sensed data can provide characterizations of these natural systems to help guide research and

management efforts, but to do so, these digital products must also characterize the physical processes that create and modify riverine habitats. Newly available IfSAR and LiDAR data offer fantastic opportunities for driving these analyses, but also pose significant challenges in translating potentially noisy and incomplete data to estimates of channel geometry, valley floor and hillslope landforms, and ultimately to maps of where certain habitat types exist and of how fish might use them. Here we describe our efforts to meet these challenges, showing how disparate data sets can be seamlessly combined, landforms delineated, and geomorphic processes inferred. We use examples with IfSAR, LiDAR, and NED elevation data across Alaska, combined with digital image analyses and ground-based surveys. We provide examples of delineation and classification of channel networks, of floodplain landforms, of hillslope sediment and woody debris sources, and show how these can be combined to provide estimates of habitat type, location, and abundance in terms of habitat intrinsic potential models for different salmon species.

Stock-specific travel times improve utility of the Port Moller Test Fishery

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The large size and temporally compressed nature of the annual return of Sockeye Salmon to Bristol Bay are challenges for fishery managers. Managers must weigh the cost of overharvesting weak stocks versus foregoing harvest opportunities on an hourly basis. These decisions must be made early in the season as the run is building with little information. The hundreds of populations of Sockeye Salmon in the area are managed at the drainage level: Ugashik, Egegik, Naknek, Alagnak, Kvichak, Nushagak, Wood, Igushik and Togiak. An offshore test fishery approximately 100-300 km from the area's fishing districts is used to characterize the magnitude, timing, age- and stock-compositions of the return to these nine drainages. Stock composition estimates from the test fishery provide a valuable in-season forecasting tool, but the relationship between catches in the test fishery (CPUE) and inshore run (catch and escapement) termed "return-per-index" and stock-specific travel times (days of travel between test fishery and fishing districts) are poorly characterized. Furthermore, return-per-index and travel times are confounded. Here we synthesize 11 years of observations to resolve the confounded nature of these parameters and estimate stock-specific travel times to improve the utility of in-season estimates.

An Inventory and Database for Southeast Idaho Fish Screens

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Fish screens are increasingly being used in inland fisheries to prevent fish entrainment into irrigation canals. This has been the case in Southeast Idaho where numerous fish screens have been installed by several organizations during about the past 20 years. However, there were no efforts to inventory, summarize, and disseminate information about these projects. In 2017, we began the development of a database and inventory methodology. General information to populate the database was gathered by reviewing data files for fish screen projects and contacting personnel from organizations that had coordinated the installation of fish screens. Detailed information was collected with the development of a fish screen inventory and initial site visits that were completed in summer and autumn 2017. There are 84 fish screens located in the project area. Most of these screens are drum types (n=62) on small canals (less than 5 cfs) that have been installed during about the past 10 years. Other types of screens including vertical (n=14), horizontal (n=6), and cone (n=2). Fish screens on

five canals exceed 50 cfs design capacity. Several screens are the second or third generation of fish screens on canals. The Bear River Watershed has the greatest number of fish screens (n=48), followed by the Henrys Fork Snake River (n=19), South Fork Snake River (n=8), Blackfoot (n=6), Salt River (n=2), and Portneuf (n=1) watersheds. We continue to gather and compile these data to facilitate information sharing and the improvement of fish screening efforts in Southeast Idaho and beyond.

Control and Eradication of Invasive Northern Pike in Southcentral Alaska

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Northern Pike are an invasive species in Southcentral Alaska. Illegal introductions of Northern Pike began in the Upper Susitna drainage in the late 1950s. Subsequent expansion coupled with continued illegal introductions have resulted in the widespread distribution of Northern Pike from the Matanuska-Susitna Valley to the Kenai Peninsula. Northern Pike are highly piscivorous and reduce ecologically and economically valuable salmonid populations throughout Southcentral Alaska. The Alaska Department of Fish and Game (ADF&G) has taken an adaptive management approach with Northern Pike control. Protocols chosen for control activities in a water body are dependent on its unique conditions. Northern Pike control efforts have included liberalized harvest, outreach, fish passage barriers, gillnetting, and piscicide applications. Piscicide applications are conducted to eradicate Northern Pike populations, restore fisheries, and prevent Northern Pike from spreading. A large-scale gillnetting project is run by ADF&G annually to control Northern Pike in Alexander Creek, a tributary to the Susitna River, where some of the worst fishery losses have occurred. ADF&G and partners conduct research on Northern Pike movement patterns, diet and bioenergetics, effective control methods, and detection methods such as eDNA. Invasive Northern Pike control, eradication, and research projects are directed by an Invasive Northern Pike Management Plan and prioritized through a strategic planning process.

Effects of biotic and abiotic factors on the specific growth rates of Rio Grande Cutthroat Trout, *Oncorhynchus clarkii virginalis*

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Native Cutthroat Trout *Oncorhynchus clarkii* spp. populations in the western U.S. continue to decline from non-native trout invasions, but mechanisms to explain replacement vary widely by subspecies and geography. Brown Trout *Salmo trutta* are the most widespread nonnative trout in New Mexico, and threaten Rio Grande Cutthroat Trout (RGCT) population persistence. Past in situ manipulations suggest that sympatry with non-native Brown Trout retards growth in two cutthroat trout subspecies, but these experiments lacked representative temperatures and trout densities for headwaters of New

Mexico. Our goal was to investigate the potential interactions among temperature, invasion, and trout density on RGCT mass specific growth rates in wild populations. We used mark-recapture data from four sympatric and four allopatric RGCT populations in northern New Mexico (August-October 2017) to test the effects of Brown Trout presence, mean daily temperature (ºC), and total trout biomass per area (g/m^2) on mass specific growth rates (g·g-1d-1) of juvenile (<150mm, n= 216) and adult (>150mm, n=146) RGCT with mixed-effects regression modeling. Model selection indicated that the three individual variable models scored the highest in each model set, with zero weight allocated to additive or interactive models. Sympatry with Brown Trout explained the majority of variation in adult RGCT mass specific growth rates (AIC weight= 0.43) while trout biomass per area explained the majority of variation in juvenile growth rates (AIC weight= 0.49). Interestingly, juvenile RGCT grew slightly faster while ladult RGCT grew slower in the presence of Brown Trout. This unexpected result might be explained with niche partitioning, but further investigation is needed.

Sea Lion predation impacts on salmon and Steelhead in the lower Columbia River, a growing problem

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Marine mammal predation on Columbia River salmonids is a new and growing impact to salmonids. In 2017, approximately 5,384 (4.7% of the ladder count) salmonids were predated by sea lions within ¼ mile of Bonneville Dam. Additional sea lion predation occurs beyond the monitoring program. We implemented a project to estimate abundance of sea lions in the lower Columbia River, estimate salmon predation outside the Bonneville Dam observation area, and conduct non-lethal hazing of sea lions in the Bonneville Dam tailrace. Eleven weekly tandem boat surveys resulted in sea lion abundance estimates ranging from less than 40 to 319 sea lions located between Bonneville Dam and Astoria, OR (RM 15), which is an 8 times decrease over last year. In an effort to eventually estimate sea lion specific predation, we attached accelerometer tags to 6 different sea lions to assess predation signals. This technique is showing great promise to remotely quantify the number of salmon consumed each year by sea lions. CRITFC hazed sea lions for a total of 29 days from 3/06/2017 to 5/17/2017 in the tailrace of Bonneville Dam. Hazing resulted in 222 hazing events on 311 and 592 California Sea Lions *Zalophus californianus* and Steller Sea Lions *Eumetopias jubatus*, respectively.

Viability of using RADseq to resolve polychaete phylogeny- A pilot study

Hoover, Alyx N. UAF*; Neeley, Deidra M. UAF*; Gastaldi, Angela. UAF

Polychaete taxonomy and systematics have long been in a state of confusion, but molecular biology techniques have made it possible to use genetics to understand evolutionary relationships between groups and species of polychaetes. Restriction site-associated DNA sequencing (RADseq), a form of next-generation sequencing, has recently become one of the most widely used and cost-effective methods of next-generation sequencing. RADseq has great potential as a useful tool to aid in resolving polychaete taxonomy and systematics, but few studies have been published using RADseq in polychaetes. In this pilot study, we are testing the viability of using RADseq on polychaete worms. We will be using RADseq techniques to investigate the phylogenetic relationships among the cryptic species complex *Harmothoe imbricata*, which previous studies have shown consists of five divergent lineages.

Global Warming of Salmon and Trout Rivers in the Northwestern U.S.: Road to Ruin or Path Through Purgatory?

Isaak, Dan. US Forest Service; Luce, Charles. US Forest Service; Horan, Dona. US Forest Service; Chandler, Gwynne. US Forest Service; Wollrab, Sherry. US Forest Service; Nagel, Dave. US Forest Service

Large rivers constitute small portions of drainage networks but provide important migratory habitats and fisheries for salmon and trout when and where temperatures are sufficiently cold. Management and conservation of cold-water fishes during a period of rapid climate change require knowing which rivers will continue supporting populations. However, estimates of warming rates have been lacking due to a dearth of long-term river temperature monitoring, so here we mine a new comprehensive interagency database to extract multi-decadal temperature records and estimate trends at 391 sites in the 56,500 km river network of the northwestern U.S. River warming trends were regionally prevalent during summer and early fall months in recent 20- and 40-year periods (0.18–0.35 °C/decade during 1996–2015 and 0.14–0.27 °C/decade during 1976–2015), paralleled air temperature trends, and were mediated by regional or local discharge trends. Summer cooling trends downstream of large dams with cold hypolimnetic water releases indicate that managers are being forced to release larger amounts of cold water to ameliorate thermal stress in temperature sensitive salmon rivers like the Yakima River in Washington, the Klamath River in California, and the Clearwater River in Idaho among others. Effects of regional warming patterns on population persistence and associated fisheries will be context dependent and strategic habitat restoration or adaptation strategies could ameliorate some biological impairments but effectiveness will be tempered by the size of rivers, pervasiveness of impacts, and high economic costs. Most salmon and trout rivers will continue to provide suitable habitats for the foreseeable future but it also appears inevitable that some reaches will gradually become too warm to provide traditional habitats and transitions to other fish communities may occur as global warming proceeds.

Diet profiling Alaskan octopuses: Applying stable isotope analysis to Alaskan populations of the giant Pacific Octopus, *Enteroctopus dofleini*.

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The Giant Pacific Octopus *Enteroctopus dofleini* (GPO), dominates octopus bycatch in Alaskan fisheries. Management of GPO stocks in Alaska is hindered by the data-poor status of the species. Limited information exists on important elements of GPO life history and ecology, such as diet. Much of what is currently known about GPO diets has been determined using midden analysis in inter- and sub-tidal zones. While a valuable source of information, little is known about the effects of tide and current on midden retention, and the representation of soft bodied prey in middens. Furthermore, significant logistical challenges hamper the use of midden analysis to investigate the diet composition of GPO inhabiting offshore benthic habitats. Carbon and nitrogen stable isotope analysis (delta13C and delta15N) offers an alternative approach to study diet of individual GPOs. In addition, stable isotope analysis can provide temporally-linked, individual-specific diet information. We will use delta13C and delta15N analysis to investigate GPO diets in Alaska by: a) conducting a controlled diet-switch experiment to determine incorporation rates and diet-to-tissue discrimination values for delta13C and delta15N in GPO muscle, dermis, and beak tissues; b) collecting samples of the three tissues from free-living individual GPOs caught incidentally in commercial, recreational, and subsistence fisheries; and c) compiling a library of the delta13C and delta15N

values of potential prey items collected during survey trawls and intertidal surveys. Diet composition of individual free-living GPOs will be estimated using MixSIAR, a Bayesian implementation of a stable isotope mixing model using discrimination values derived from our captive experiments. Diet profiling in this way will provide essential information on a widely-encountered octopus species in commercial fisheries, and will provide management with foundational life-history information on octopus predator-prey interactions.

Status of stream temperature monitoring and synthesis of a statewide database for Alaska

Jones, Leslie. University of Alaska Anchorage; Clark, Jeanette. National Center of Ecological Analysis and Synthesis; Mauger, Sue. Cook Inletkeeper; Geist, Marcus. University of Alaska Anchorage

Stream temperature is a vital component of ecosystem function, influencing physical, chemical and biological properties of river systems. It has both economic and ecological significance and is one of the primary parameters in stream ecology that determines the overall health of aquatic ecosystems. It has tremendous significance for freshwater organisms; influencing aquatic metabolism, and the physiology, survival, abundance, distribution, and phenology of aquatic species. In Alaska, both natural and anthropogenic induced change are causing increased variation in thermal regimes and baseline monitoring is essential to understanding ecosystem response and potential impacts to aquatic species distributions and life-history diversity. The State of Alaska Salmon and People (SASAP) project has identified stream temperature as an important data gap for monitoring the health of our aquatic ecosystems. As part of the SASAP project the National Center for Ecological Analysis and Synthesis has teamed up with University of Alaska Anchorage and Cook Inletkeeper to develop the first comprehensive stream temperature database for Alaska. Development of a statewide database will support research projects across a multitude of academic disciplines, strengthening conservation and management of Alaska's freshwater resources. We will report on the progress of these efforts and status of baseline stream temperature monitoring and assessment in Alaska.

Habitat-based assessment of fisheries dependent and independent sampling of Pacific Cod *Gadus macrocephalus* in the Aleutian Islands.

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Pacific Cod *Gadus macrocephalus* is a commercially targeted, demersal groundfish. In the Aleutian Islands (AI), off the southwest coast of Alaska, Pacific Cod biomass is estimated using data collected by a biennial government multi-species trawl survey. The AI cod fishery is primarily prosecuted during the winter months, and deploys multiple gear types (principally trawl, longline, and pot gear) in a wide range of depths, and habitat types (e.g. smooth flat to steep rocky seabed). The trawl survey is conducted in the summertime with gear that can only be deployed on "trawlable" ground (smooth flat seabed). The degree to which the survey data are representative of actual cod abundance and size composition is unknown, but the sampling limitations of the trawl survey have been recently highlighted as an area of concern (e.g. the 2016 Center for Independent Experts review). To better understand the overlaps and mismatches between the cod spatiotemporal distributions and the times and locations sampled by the survey and those fished by the fishery, we quantified the underlying differences between some key environmental variables know to influence cod

distributions (e.g. depth, slope and sediment). Preliminary results indicate that areas sampled by trawl, pot, and longline gear are shallower compared to predicted Pacific Cod EFH. Relative to EFH area by depth, the survey “under-samples” shallow waters (<100m) and “over-samples” in depths from 150 to 300m. Temporally, differences exist between gear types and the survey, with pot and trawl fishing occurring mostly in the winter months (January – April) and longlining occurring throughout the year. The fishery-independent survey is conducted during an 8-week period between June and August. This project aims to improve the state of understanding about some underlying biases that may result from the current sampling methodology, and suggest alternative approaches shown to be effective in other fisheries.

Biosurfactant Producing Microbes - A Possible Treatment for Organisms Exposed to Crude Oil

Kelly Ireland*; Emily Lescak; Lucas Kirschman; Kat Milligan-Myhre

Crude oil has many harmful effects on organisms, both acute and chronic. Oil has been linked to cancer, cardiovascular disease, immune system suppression, reduced health of embryos, genetic mutation, and more. Crude oil is made up of polycyclic aromatic hydrocarbons and other compounds. Certain microbes are actually capable of breaking these components down with the use of biosurfactants. It may be possible that these microbes are capable of reducing the detrimental effects of crude oil on human health. I aim to use the Threespine Stickleback *Gasterosteus aculeatus* as a model organism to study the effects of crude oil on the immune system to determine whether the gut microbiota can ameliorate the effects of crude oil on the host. I will compare the immune gene expression of Threespine Stickleback that have no gut microbiota (germ free), have the conventional diverse gut microbiota, and have only biosurfactant-producing gut microbiota. Half of each of the individuals in the three gut microbiota groups will be either be exposed to crude oil or control conditions. I hypothesize that when Threespine Stickleback are exposed to crude oil, their immune genes will be suppressed. I also hypothesize that the immune response will be restored when the Threespine Stickleback possess biosurfactant-producing gut microbiota when compared to germ free or conventional gut microbiota treatments because many biosurfactant-producing microbes are capable of mineralizing oil, thus lessening the effects of crude oil.

Innovative Design Solutions for Steep Fish Passage Structures

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Barriers to fish passage come in different forms--one of which is drastic elevation change. Even Flying Fish cannot actually fly, so accommodating fish through steep (or even vertical) barriers requires innovation. PND Engineers, Inc. has experience developing innovative solutions to vertical barriers, including fish ladders and a “fish elevator” at the Seward Sealife Center. PND also recently designed over 10 excessively steep (greater than 6% grade) stream simulation fish passages on Prince of Wales Island in Southeast Alaska. These stream simulation culverts were constructed in cascading bedrock streams, home to Dolly Varden and Pink Salmon. Within the structures, PND was able to match the grade of the reference reaches within 1%, meeting USFS stream simulation guidelines, and utilized welded baffles to replicate existing natural stream pools and retain streambed material. PND is known for its innovative designs and cost-effective solutions.

eDNA Mapping of Juvenile Chinook Salmon Overwintering Distributions

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Yukon Chinook Salmon *Oncorhynchus tshawytscha* returns since 2014 have been declining, which has led to strong regulations on both commercial and subsistence harvests. There is a large information gap on the overwintering habitat and behavior of Chinook Salmon. Assessing overwintering habitat of juveniles is important in helping to manage potential impacts to this species. To determine Chinook overwintering habitat in Clear Creek on the Tanana Flats near Fairbanks Alaska, we used environmental DNA (eDNA) assays with the goal of checking the viability of eDNA as an approach to measure the overwintering distribution of juvenile Chinook, and using eDNA to identify areas where Chinook overwinter within the Tanana Flats region. Our results indicate that eDNA is a useful tool for detecting low density fish species and that juvenile Chinook Salmon are detectable in the Tanana Flats.

Exploring the use of mucus to assess stress hormones in Pacific Halibut *Hippoglossus stenolepis*

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The endocrine responses of non-target fishes captured by commercial fishing gear can provide insight into their post-release survival. During the capture process, a suite of physical and sensory interactions between the gear, the environment, and the fish can result in increased levels of the stress hormone cortisol. Currently, the probability of a non-retained fish surviving after handling is determined by visual assessments. While efficient, this approach may lack in its ability to detect and assess internal damage and physiological disturbances resulting from the capture process or the potential effects of prior experiences on the potential for post-release survival. This research aims to use cortisol measurements to investigate the stress response in Pacific Halibut with the eventual goal of developing tools to augment the visual assessments used to estimate post-release survival. Previous work employing cortisol analysis in fish has predominantly used plasma as a sampling tissue. Given the logistical challenges associated with sampling and storing blood plasma onboard marine vessels, as well as the potential increases in circulating cortisol caused by the blood sampling procedure itself, we will investigate the use of a relatively novel sampling tissue—mucus. Unlike blood plasma, external mucus can be sampled in a relatively non-invasive fashion and does not require centrifugation. Initial objectives focus on external mucus sampling methods and include determining the most effective tools and protocols for sample collection and storage and investigating sampling locations on the halibut body to minimize potential sample contamination from contact with other fishes during capture or holding. These sampling methods will then be employed in a controlled experiment to determine the magnitude and rate of cortisol absorption and elimination in blood plasma and external mucus by stimulating cortisol release in captive Pacific Halibut using adrenocorticotrophic hormone (ACTH) injections. Preliminary results from live and postmortem sampling efforts indicate that standard glass microscope slides inserted into centrifuge tubes may provide an effective and efficient solution for external mucus sampling.

Beyond the noise: the challenge of using “active” and “passive” hydroacoustic techniques for fisheries management

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Noise, as defined by Webster's dictionary, is irrelevant or meaningless data or output occurring along with desired information. But as they say, "one person's trash is another person's treasure" or put another way "one person's noise is another person's data". In underwater sound transmission, sound waves travel in multiple directions. However, for "passive" acoustics and acoustic telemetry specifically, the most important desired information is conveyed by the direct signal path. The non-direct or reflected signals are irrelevant and often misleading. For other hydroacoustic applications, specifically "active" acoustics using scientific echo sounders the reflected signals (echoes) are the important desired information. Often extracting information from these signals can be difficult and subject to misinterpretation. In this poster, we highlight fisheries acoustic techniques that reveal the most important information. Ultimately, this information is applied to sound fisheries management decisions.

Examination of Catch Accounting for Trawl-Caught Red King Crab in the Bering Sea

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United States fisheries policy requires managers to account for mortality of all fished species, including target catch, bycatch and prohibited species catch (PSC). Bycatch and PSC rates (e.g. PSC/ton of target species) are estimated by sub-sampling catch from individual fishing events. These rates are aggregated to produce sector-level bycatch or PSC estimates within a fishery. The degree to which current sub-sampling practices represent the actual population of incidentally-caught individuals in a fishing event is poorly understood, particularly for PSC species that are rare relative to the target species or exhibit patchy distributions. In groundfish trawl fisheries in the North Pacific, reaching or exceeding PSC limits can result in closures to specific areas or the entire fishery sector. Haul-level data on PSC are needed to understand how to mitigate risks from increasing PSC species encounter rates and/ or decreasing PSC limits. To better understand current PSC estimation methods and performance, we will examine sampling extrapolation by conducting a census of trawl-caught red king crab PSC post observer sampling. Red King Crab PSC catch rates (number of crab caught per metric ton of groundfish), sex, size, maturity, and shell condition will be assessed. In addition, haul-level data on bottom temperature, depth, target species catch, tow duration, and haul speed will be collected. The impacts of these covariates on the relationship between Red King Crab subsample-based PSC estimates and actual Red King Crab catch will be explored with the goal of understanding the relationships between the spatial ecology of PSC species, extrapolation uncertainty, and PSC estimates.

Planning Infrastructure Improvements at Coleman National Fish Hatchery (CNFH) to Aid in Restoration Efforts of Natural Salmonid Runs in Battle Creek.

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Battle Creek, a tributary to the upper Sacramento River, is important for the recovery of ESA-listed salmonids in California's Central Valley. Ongoing restoration efforts in Battle Creek to restore access to 48 additional stream miles of prime salmonid habitat are nearing completion. Plans to re-introduce endangered Winter-r Chinook Salmon (CS) *Oncorhynchus tshawytscha* are also underway. The Coleman NFH and adjacent Coleman fish barrier-weir are located downstream of the restoration area on lower Battle Creek. The barrier-weir blocks upstream migration of fish and directs them into a fish ladder. The fish ladder remains closed while the hatchery collects returning salmonids for broodstock and all fish are directed into holding ponds for processing. This operation delays natural migrating fish stocks and increases the risk of fish injury. To reduce hatchery impacts on natural salmonids and native fish, and to facilitate fish population monitoring, an automated sorting and trapping facility is being planned at CNFH. The facility is being designed to support multiple purposes, including CNFH operation, Winter-run CS reintroduction, and implementation of adaptive management plans for BC Steelhead and Salmon Restoration Program and CNFH. The facility will be controlled by an SCADA system and equipped with CWT and PIT readers, overrides, switch-gates, and traps to enable automatic fish sorting, monitoring, and trapping as well as volitional passage of migrating natural salmonids. We present the goals, objectives and biological requirements for the new facility, describe the system components and conceptual functioning, and report on the progress to date and next steps.

Abiotic Factors Influencing Salmonid Hybridization

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There are many reproductive barriers to salmonid hybridization, and few studies have considered which environmental factors may be most influential. Differences in temporal and spatial use of spawning habitat represent a reproductive barrier, and can be influenced by habitat characteristics such as water temperature, flow, and streambed composition. Higher incidence of hybridization in salmonids in the wild is found when at least one of the involved species is outside its natural range. Anthropogenic impacts on disturbance regimes, changing environmental conditions, and land use practices may influence the risk of hybridization by altering abiotic factors. The goal of this study is to identify which factors are most important to hybridization risk in salmonids and will focus on specific populations in the Pacific Northwest. The initial model looks at changes in species distribution and possible changes in response to climate change, while incorporating covariates such as stream characteristics.

Prioritizing Land for Ecological Value in Western Cook Inlet Watersheds

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Prioritizing land for ecological value addresses the existing ecological conditions that support biodiversity in addition to the ecosystem services that support the communities. Land use and conservation planning is nuanced given complex land status, diversity of habitats, and the priorities of the stakeholders, so land prioritization for conservation must be strategic. In an ideal world the high functioning ecosystems ought to be conserved regardless of administrative boundaries because the movements of birds, mammals, and fish, are not dictated by man-made administrative boundaries. Conserving the highest value ecosystems must take into account the parcel and administrative boundaries in order to be strategic, practical, and cost effective. A GIS prioritization of land takes into account the high value ecosystems using the best available data and methods to locate the best available lands to conserve biodiversity and ecosystem services given land status, conservation

planning goals, and community priorities. This project identifies ecologically valuable lands within the watersheds of Western Cook Inlet, within the Redoubt-Trading Bays subbasin. It uses an additive method that scores biodiversity and ecosystem services indicators on a scale of 0 to 1, allowing for weighting if focused conservation planning is needed, such as prioritizing high value salmon habitat. More than a dozen criteria were scored in the resulting prioritization. It provides a planning tool to help make informed land use decisions that conserve the region's important natural resources for the long-term sustainability of the communities and ecosystems in the watershed. The results of this prioritization tool will be best used by conservation practitioners, local communities, Village and Regional Native corporations, land managers, and natural resource development personnel to make strategic decisions about land across a large geographic area.

Alluvial Valley Reset: Stage 0 Restoration at Deer Creek, Oregon

Meyer, Kate M. U.S. Forest Service

Deer Creek exemplifies the classic story of degradation of Western Cascades mid-order streams. Historic riparian logging and stream "clean-out" of wood combined with berm construction channelized the stream creating a single-thread, incised, transport channel through a once depositional alluvial valley. Based on modern theories supported by Cluer and Thorne (2013) – that prior to human modification most alluvial valleys had streams that were anastomosing and overflowed onto their floodplains several times a year (e.g. Stage 0 in the updated Stream Evolution Model) – the goal for Deer Creek was to restore dynamic fluvial processes and improve ecological function by "re-setting" channel and floodplain elevations (back to Stage 0) for full valley-bottom connectivity. Building upon this modern restoration paradigm, we utilized similar design and construction standards from recently implemented Stage 0 projects across Oregon to implement a valley-scale restoration project at Deer Creek in 2016 and 2017. The Geomorphic Gradeline method (Powers et al., In Prep) was used to determine desired elevations. Berms and artificial surfaces were cut to the desired elevations and that material was used to fill the incised mainstem channel, effectively "re-setting" the valley bottom. We then placed large wood accumulations throughout the valley bottom to create hydraulic complexity, dissipate energy wherever channels may migrate, and encourage sediment deposition and grain size sorting. This approach does not dictate channel form or construct channels. Rather, it allows natural processes to create dynamic channels, islands, bars, wetlands, and exceedingly complex habitat. Preliminary monitoring has shown a dramatic shift in the form and function of Deer Creek. It is now an anastomosing system with retention of diverse sediment sizes, nutrients, and organic matter and greater habitat complexity. The expectation is that over time these physical changes will set the stage for more diverse and productive aquatic and riparian communities.

Determining the reproductive maturation of Pacific Herring in Sitka Sound Alaska using scale measurements

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Pacific Herring *Clupea pallasii* maturity at age is commonly estimated using age-structured assessment (ASA) models. However, model estimates of maturity, natural mortality, and recruitment are often confounded, so corroborating these with field studies is critical for evaluating the accuracy of model forecasts and providing for sustainable management. Although field studies are necessary, estimating the true proportions of mature fish at each age with a sampling program is problematic, because the spatio-temporal distributions of immature and mature herring throughout the year are not well known. Therefore, it is not possible to ensure the mature and immature portions of the population have been sampled in

proportion to their abundance. Failure to adequately represent maturity at age in the model could lead to either an overestimation of reproductive potential and possible overharvest or an underestimation of reproductive potential and lost harvest opportunity. Research on Atlantic Herring *Clupea harengus* has indicated that maturity at age can be estimated from scales through growth ring analysis. If, by examining scales of spawning fish, the age at maturity can be determined from growth patterns, then the proportion mature at each age can be determined without sampling when the population distribution is uncertain, and thus remove a significant source of likely bias. The research proposed here will corroborate and expand existing studies using scale growth increments as an age-at-maturity estimation method in herring. If annual scale growth increments can be used to accurately infer age at maturity across cohorts, retrospective analysis of Alaska Department of Fish and Game's scale archives can describe long-term variability in maturity of Sitka Sound Pacific Herring and strengthen the ASA model. In addition, scales could be used to estimate empirical maturity at age for other herring populations thereby improving assessments and management of herring populations throughout Alaska and internationally.

Estimating fishing effects in three dimensions as a tool to evaluate fishing gear modifications

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Fisheries management has evolved from focusing on individual stocks of fish to managing a stock's entire ecosystem (e.g. ecosystem-based management), emphasizing the mandate in U.S. federal fisheries to evaluate fishing effects on habitat. This has led to a generation of mathematical models to estimate habitat effects. In all of these models, fishing gear is characterized two-dimensionally, such that when the fishing gear is not in direct contact with the seabed it has no effect on habitat. However, based on the heights of some vertical epifauna (e.g. Sea Whips *Halipteris willemoesi* can reach >2 meters tall) gear-benthos interactions can occur during near-bottom fishing. We adapted the Fishing Effects model - the tool currently employed to quantify fishing effects in the North Pacific - to account for habitat effects that may occur on and above the seafloor. We re-characterized the fishing gear by delineating each gear component into one of four seabed clearance height bins - 0-10 cm, 10-20 cm, 20-30 cm, and greater than 30 cm- and establishing three plausible susceptibility gradients to characterize the expected changes in impact susceptibility in each subsequent height bin. To explore the performance of this 3 dimensional framework, we used the 2010 implementation of elevated sweeps for flatfish trawl fisheries in the Bering Sea fisheries as a case study. All scenarios were run assuming uniform sediment and fishing effort to focus on the effects of gear modifications. Lifting components (e.g., disks, bobbins) on trawl groundgear (footropes and sweeps) raise the wider spans between these components above the seafloor. The scenarios presented here include using larger lifting components to increase the clearance of the sweeps from the 10-20 cm bin to the 20-30 cm bin and adding components to raise the footrope to the original sweep elevation (gear partially in contact with the seabed raised to the 10-20 cm bin). This adapted model provides a more realistic characterization of fishing gear - benthos interactions and, while it will likely be some time before the information gap on clearance-specific susceptibility values is filled, scenario testing provides useful information for analyzing the relative effects of fishing gear modifications on benthic habitat features.

Assimilation of Old Carbon by Stream Fish in Arctic Alaska

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Permafrost thaw in the arctic and subarctic region is mobilizing old carbon (C) from perennially frozen soils, driving the release of old C to the atmosphere and aquatic ecosystems. Little is known, however, about the role of old C as a source to aquatic food webs in watersheds underlain by thawing permafrost. To quantify the contributions of old C to Arctic stream food webs, we measured radiocarbon (14C) and stable isotopes (δ13C, δ15N) of periphyton, macroinvertebrates, and fish (Arctic Grayling *Thymallus arcticus* and Dolly Varden *Salvelinus malma*). We also characterized the isotopic composition of possible C sources to the food web, including dissolved organic C and dissolved inorganic C in streams. Samples were collected across 10 streams in Alaska, draining watersheds underlain by varying parent material and ground-ice content. 14C ages (YBP, year before present) for fish ranged from 3195 YBP to modern across streams, and closely tracked spatial variation in 14C content of periphyton. Parent material and ground-ice content appear to govern the age and form of dissolved C sources to stream biota through controls on subsurface hydrology. Ice-poor watersheds reflect contributions of DOC from groundwater and DIC from carbonate weathering; whereas, ice-rich watersheds reflect leaching of DOC from saturated, peaty soils of the active layer. Using mixing models, we show that C from deep peat and permafrost was an important source to fish, comprising 65% and 44% of diet in ice-poor and ice-rich terrain, respectively. Further, the contribution of this relatively old C to diet was positively correlated with energy density, reflecting a possible subsidy to fish productivity. These findings highlight permafrost characteristics as a control on subsurface hydrology and the delivery of aged C to surface waters and we hypothesize that older C may become a more important contribution to stream biota under conditions that promote thaw.

Genetic data reveal broad-scale population structure in the Alaska Inconnu

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We used genetic data to address two objectives with respect to Inconnu in Alaska: 1) describe and evaluate genetic diversity and population structure, 2) evaluate a genetic baseline for estimating stock composition in a mixed population sample. The genetic data represents variation at 20 microsatellite loci in 10 Inconnu collections from Kotzebue Sound and the Yukon and Kuskokwim rivers. These data revealed that the population structure in Alaskan Inconnu is explained by four broad geographic groups (Kotzebue Sound, middle Yukon River, lower Yukon River, and Kuskokwim River). We found no evidence of population structure within Kotzebue Sound or the Kuskokwim River. Genetic diversity as measured by heterozygosity and allelic richness was largest in the Kotzebue Sound collections and similar among Yukon and Kuskokwim River collections. Simulation results indicated that the genetic data may be used as a baseline for genetic mixed-stock analysis on a relatively broad spatial scale to identify stocks at the drainage level and the lower and middle Yukon River.

A model-based approach to identifying fishing and vulnerable habitat overlaps: An Aleutian Islands case study.

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Understanding the effects of fishing on vulnerable habitat features is fundamental to long-term ecosystem monitoring and fisheries management. Currently available data streams allow for quantitative assessment of the benthic impacts of commercial fishing at regional scales. However, data information gaps on both the locations of vulnerable habitat features and the locations where fishing gear interacts with these features at sub-regional scales limits our ability to a) assess the localized benthic impacts of commercial fishing on vulnerable habitat features and b) evaluate how larger-scale impacts are driven by targeted management policies. The purpose of this project is to fill these information gaps by better understanding where and to what extent fishing gear interacts with vulnerable habitat features, specifically corals and sponges. We will be focusing our efforts in the Aleutian Islands using high resolution fishing locations from VMS data and recent habitat distribution models. We will consider environmental and physical covariates such as depth, sediment, and slope in our analyses using a model-based approach to identify where fishing overlaps with vulnerable habitat features, and what type of gear is being used in these areas. Additionally, large spatial closures in the Aleutian Islands will provide a natural “experimental control” to address a challenge common to these types of analyses: are vulnerable habitat features found in lower abundance in fished areas because they are heavily impacted by fishing or is fishing activity inherently limited to areas outside the habitat of vulnerable features? We anticipate these analyses will help span the gap between regional-scale assessments and localized gear-habitat interactions to provide a more complete picture of the dynamics at play in the management of habitat impacts.

Genetic variation in the 2016 Arctic Lamprey Yukon River spawning migration

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The Arctic Lamprey *Lethenteron camtschaticum* is an anadromous species broadly distributed across sub-Arctic and Arctic regions in Asia and North America. In the Yukon River, Arctic Lamprey migrate in the fall and winter to reach an unknown number of spawning locations across the drainage. The spawning migration is targeted by subsistence and limited test commercial fisheries in the lower and middle reaches of the river, where it presumably comprises individuals that will eventually spawn at distinct locations. Here we present a student led effort to understand whether the Arctic Lamprey that make up the spawning migration on the Yukon River is composed of members from a common and widely distributed gene pool, or if it is a mixture of fish belonging to populations with distinct genetic characteristics. We are characterizing population genetic from Arctic Lamprey samples that were caught in the Yukon River as part of fishery monitoring operations. We discuss the strategy for data collection and analyses we are implementing in this study, report initial results, and describe potential applications of our findings in the context of the biology and harvest of Arctic Lamprey in Alaska.

Stage Zero Restoration Design at Whychus Creek, Oregon

Press, Cari A. U.S. Forest Service

Restoration that seeks to emulate historic ecological and hydrologic processes and function has become an underlying principle in restoration work on Whychus Creek, a tributary to the Deschutes River, OR. The desired future condition can be described as the Stage 0 designation in the Cluer and Thorne Stream Evolution Model (Cluer and Thorne, 2013). Stream restoration that attempts to restore valley-scale processes associated with depositional valley types began on Whychus Creek at Camp Polk Meadow Preserve near Sisters, Oregon, in 2009, and has continued in two subsequent projects in 2014 and 2016. Monitoring and evaluation of the evolution of the Camp Polk project has helped inform Stage 0 restoration design that is being applied on many unconfined meadows and valleys in Region 6 of the U.S. Forest Service, and is based on the determination of the Geomorphic Gradeline and valley departures from this line (Powers et al., In Prep). As a result of lessons learned from the Camp Polk Meadow project, recent restoration projects in Whychus Creek on a moderately sloped alluvial fan (2%) in 2014, and in a low-slope meadow (0.9%) in 2016, were designed to accelerate recovery to a Stage 0 condition. Benefits of this restoration approach include maintaining a high year-round alluvial aquifer, rapidly establishing diverse riparian plant communities, providing floodplain connection and high water refugia, increasing pool and instream wood densities, and increasing fish densities. Preliminary monitoring shows an increase in channel habitat complexity and fish density within 1 to 4 years post-restoration. Continued monitoring and development of additional metrics that fully capture the diversity and complexity present in the anastomosing channels found in Stage 0 restoration will further help quantify the benefits or shortcomings of this restoration approach.

Using reach-scale electrofish and snorkel surveys to assess single pass capture (electro) and observer (snorkel) efficiencies and generate Mark-Recapture population estimates in central Idaho stream habitats.

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Electrofishing and snorkeling are common methods used to characterize the abundance, distribution, and size class of fish populations in small streams. Sampling techniques to develop fish population estimates have limitations that are inherent in the assumptions for each method; therefore, it is important to understand the relative capture efficiencies between sampling methods and habitat types. We conducted single-pass, closed-system electrofish and snorkel surveys and developed mark-recapture and mark-resight population estimates and associated capture/observer efficiencies in multiple reaches within the Yankee Fork Salmon River watershed, Idaho. We found electrofish capture efficiencies to be higher than snorkel observer efficiencies, a common and not unanticipated finding. We observed relatively consistent electrofishing capture efficiencies and comparatively lower and more variable snorkel observer efficiencies. Our evaluation will help managers use appropriate tools and methods to more accurately estimate the true abundance of salmonid populations and achieve a better understanding of fish and fish habitat relationships in the Salmon River basin.

Spatiotemporal assessment of Pacific Halibut *Hippoglossus stenolepis* growth in Southcentral Alaska

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Observed declines in average size-at-age of Pacific Halibut in Southcentral Alaska have resulted in decreases in the harvest levels of target and non-target halibut fisheries and have potentially serious implications to the total yield available for harvest and the female spawning biomass within the area. While mechanisms driving these declines are the subject of current research, efforts are hampered by our limited understanding of the spatiotemporal nature of the declines. Currently the declines are frequently described via summary of large areas which may not actually provide an accurate depiction of any spatial trends occurring within the area. This work seeks to explore spatial and temporal patterns in growth and size-at-age of Pacific Halibut in the Gulf of Alaska by 1) describing the spatiotemporal distribution of halibut size-at-age and modelling the spatial structure of halibut growth performance, 2) determining the presence/absence and locations of persistent spatiotemporal anomalies in growth performance, and 3) exploring potential relationships between Pacific Halibut size-at-age and diet using δ13C δ15N analysis of spatially-explicit samples collected during the International Pacific Halibut Commission setline surveys. Preliminary results indicate that decreases in size-at-age are not randomly distributed in space, with defined differences in size-at-age between the Eastern and Western Gulf of Alaska. Work to investigate these is ongoing.

Seasonal variation in the detection of Northern Pike eDNA in a southcentral Alaska lake

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Environmental DNA (eDNA) is organismal DNA found in an environmental sample (e.g., water). Molecular genetic methods for detecting eDNA are increasingly being used to detect organisms at low density because a physical sample or direct observation is not required. One of the applications of eDNA analysis is in detecting aquatic invasive species like Northern Pike in southcentral Alaska. Because site access in remote Alaska varies seasonally and may favor one method versus another (e.g., float plane versus snow machine) it is important to know if and how eDNA detection varies seasonally. In this study we evaluate seasonal variation in detection of a quantitative polymerase chain reaction (qPCR) assay (EluCOI) routinely used to detect Northern Pike. We collected 1-liter water samples from 17 locations in a lake with Northern Pike (Fire Lake) northeast of Anchorage and repeated this protocol three times: spring 2017, fall 2017, winter 2018. The eDNA results were analyzed using a multiscale occupancy model to determine how detection rates may vary seasonally. This information can inform future season-specific sampling protocols employed in lakes with unknown Northern Pike presence.

Communicating Complex Climate Science to the Public with an Infographic: Changes Facing Salmon Ecosystems in Alaska

Schoen, Erik R.; Wipfli, Mark S.; Trammell, E. Jamie; Rinella, Daniel J.; Meyer, Benjamin E.*; 11 Others

Climate science is complex, yet it is crucial for researchers to communicate their findings beyond professional meetings and the peer-reviewed literature to reach policymakers and the general public. In a paper we recently published in Fisheries, we examined changes in climate, hydrology, land cover, salmon populations, and fisheries over the past 30–70 years in the Gulf of Alaska region, with a focus on the Kenai River. Rivers entering the Gulf of Alaska produce one-third of the world's wild salmon, and salmon production in the region is currently near historic highs. However, salmon face risks and uncertainties from a rapidly changing climate, landscape change, ocean acidification, and other environmental drivers. More

extreme floods and droughts, warmer and drier summers, insect outbreaks, forest fires, glacial loss, and invasive species are some of the most serious threats to salmon and fisheries, but some salmon populations may also benefit from warming temperatures and glacial retreat under some circumstances. Maintaining a diverse portfolio of aquatic habitats across the landscape may allow salmon populations and fisheries to continue to thrive in the face of these changes. To communicate these findings more broadly to non-technical audiences, we designed an infographic highlighting the changes facing salmon ecosystems in Alaska, which we present here as a large-format poster. This infographic was distributed to project stakeholders as posters and is also available online as a free download at http://www.alaska.edu/files/epscor/pdfs/Salmon-Ecosystems.pdf. We invite discussion and constructive criticism of this approach to communicate the complexities of climate science to the public.

A proposed set of metrics to describe thermal regimes of Wyoming streams

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Water temperature data are routinely collected with remote data loggers, and the ease of these collections has resulted in the proliferation of large datasets across the western United States. In Wyoming, regional aquatic habitat biologists are developing long-term water temperature records for multiple sites to provide baseline information and track potential changes in lotic systems. However, a set of reporting metrics has not been standardized across the state. Here, we propose a suite of 12 metrics to describe stream thermal regimes in Wyoming in terms of magnitude, frequency, duration and timing of events. These include metrics used routinely in other assessments across the West, but we have also designed some to articulate thermal regimes of importance specific to Wyoming. By using multiple descriptors, we hope to measure several biologically meaningful characteristics of stream ecosystems, and be able to monitor dynamics of these river systems. Our proposed metrics include: August mean, annual 7-day average maximum and minimum, cumulative degree days (CDD), frequency of days >21°C and <0.5°C, annual maximum daily range, annual maximum duration of days >20° and <7°, and the timing of the 25th, 50th, and 75th percentiles of CDD for the calendar year. We invite feedback on the appropriateness of these proposed metrics, and hope to generate interest in these efforts outside of Wyoming.

A Software and Hardware System for the Collection, Editing, and Reporting of Salmon Age, Sex, and Length Data: The Fisheries Database Management System (FDMS)

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Each year the Alaska Department of Fish and Game (ADF&G) collects salmon age, sex, length (ASL), stock of origin, and biological samples from the commercial salmon fishery in Bristol Bay, Alaska. This data is used to assess in-season run strength, and postseason is used to build brood tables to establish and evaluate spawning escapement goals, forecast future returns, examine river productivity, analyze salmon growth, and address other important fisheries management objectives. To replace a discontinued data collection tool ADF&G Bristol Bay research staff worked with a local vendor, Alaska Metrology & Calibration Services Inc., to build a practical and cost effective salmon measuring board to collect individual salmon sex and length data using Bluetooth technology. These measurements are then recorded in the Fisheries Database Management System (FDMS) mobile software which is loaded on a Trimble Yuma 2 rugged tablet computer that is designed for ASL data collection in the field. In 2014 ADF&G Bristol Bay research staff developed FDMS software to

consist of two separate components 1) a mobile application and 2) a web application. The FDMS mobile application is designed to be used on portable devices by dock samplers but really is a desktop application built for Windows 7 devices. A data text file is generated which samplers save on a USB flash drive and deliver to the ADF&G King Salmon office with the biological samples to be error checked and uploaded. Once the sex and length data is uploaded into the FDMS web application and verified ADF&G personnel are immediately able to enter salmon ages with the corresponding fish data. Paired together the Bluetooth salmon measuring board and FDMS software system have created an affordable and efficient system to provide managers with enhanced harvest age composition estimates which are necessary for effective salmon management.

Juvenile Salmon Diets in the Yukon Delta

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The Yukon River delta is an important migrating and rearing habitat for juvenile salmon during June and early July. Juvenile growth prior to ocean entry can be an important predictor of adult fitness and survival. There is limited information on how the Yukon delta supports juvenile salmon growth under such heterogeneous habitat conditions: stream temperatures increase rapidly over the month of June, there are strong vertical and horizontal salinity gradients across the estuary, and the Yukon has high suspended sediment loads. The goal of this study was to describe patterns in juvenile Coho and Chinook Salmon diets across the delta during the summer of 2016. Stomach contents were removed from 194 Chinook and 110 Coho juveniles captured between May 21 and July 27 in the lower Yukon. Invertebrates were examined separately from fish prey items. Invertebrate prey items were identified to the lowest practical taxonomic level, often family. Two diet metrics were calculated for all prey taxa (n = 69) for each site and species (n = 18). Both species relied on several aquatic and terrestrial invertebrate families as important food sources and there were no differences in diet between the two species. Non-biting midges (Chironomidae) were the most common across all sites and had the highest relative abundances across all prey taxon (~20 - 80% depending on the site). Other important taxa that occurred in more than 10% of the total stomachs by species included biting midges (Ceratopogonidae), mayflies (Ephemerellidae), stoneflies (Perlodidae), caddisflies (Polycentropus), two families of beetles (Scirtidae and Staphylinidae), and crane flies (Tipulidae). These results show that juvenile salmon diets include invertebrate taxa from a diversity of insect families and orders in the Yukon River delta. This diversity may provide important resiliency as warming temperatures shift the timing and abundance of food resources in the future.

Creatively Communicating Salmon Fisheries Management in the Alaskan Context

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Fisheries management bridges the divide between the science of stock assessment and the day to day realities of harvest on the fishing grounds. However, managers often struggle to strike the right balance between scientific accuracy and public accessibility in a complex discipline rife with technical terminology. For many harvesters, fisheries science can be a foreign language, and much may be lost in translation. Interpreting key fisheries management concepts into a more universal visual language helps to make these ideas more accessible for a much broader audience and lowers the barriers for harvesters' understanding and participation in deeper discussions of resource management issues and trade-offs. Moreover, visual

messages are quick to absorb, easy to share, and cut through the noise of a communications channel often crowded with bulletins, technical reports, peer-reviewed papers, and other dense texts for resource users, managers, and researchers alike. This poster shows examples of infographics created for the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative to visually communicate three key types of trade-offs in salmon fisheries management: (1) harvest-diversity trade-offs, (2) harvest-escapement quality trade-offs, and (3) harvest timing trade-offs.

Detecting early invasions by Lake Trout in Sawtooth Valley lakes, Idaho, using environmental DNA

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Lake Trout *Salvelinus namaycush* is a freshwater char native to Canada, Alaska, and northeastern portions of the United States. The species is prized as a popular game fish, and as such, has been introduced extensively outside of its native range. Lake Trout are an aquatic apex predator and thus, may have a significant impact on native freshwater biodiversity and conservation. Stanley Lake, one of five nursery lakes for the endangered Snake River Sockeye Salmon *Oncorhynchus tshawytsch*a, was historically stocked with Lake Trout and currently supports a self-sustaining population. The outlet of Stanley Lake is impounded by an artificial barrier, but Lake Trout colonization of other nursery lakes within the Sawtooth Valley, is considered a major risk to Snake River Sockeye Salmon recovery. Understanding Lake Trout distribution and detecting early invasions is therefore critical to sockeye recovery planning and management. Environmental DNA (eDNA), collected from an environmental sample, such as water, can detect target species when present in low abundance and possibly at the onset of an invasion. Here, we will discuss the development and efficacy of protocols and methods used to collect eDNA and detect Lake Trout in Sawtooth Valley lakes and their outlet creeks.

Merging scientific and traditional ecological knowledge: Sockeye Salmon *Oncorhynchus nerka* management in the English Bay Lakes System, Alaska

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The Alaska Native Village of Nanwalek, located on English Bay near the southern tip of the Kenai Peninsula, relies on local commercial and subsistence Sockeye Salmon *Oncorhynchus nerka* fishing supported by the English Bay Lakes system. The community has witnessed a large-scale decline in their salmon run over the past 20 years, the causes of which remain largely unclear. This study aims to explore the use of a geospatial framework to combine information from both traditional knowledge and scientific data sources for use in the design and implementation of fisheries management decisions. Aerial images of the English Bay Lakes system will be captured by small unmanned aerial systems (sUAS), orthorectified, and stitched into large map formats. The maps will be provided to the community as a basis for conversation surrounding traditional salmon spawning locations, ecological information, important historical events, and changes in land-use practices and landscape. These locations and the temporal information in which they are associated, will then be used to inform targeted data collection using current scientific data collection methods, such as aerial salmon surveys, water temperature and quality assessments and environmental DNA (eDNA) analysis. This project will result in data products that support both

tribal entities and agency officials in managing the English Bay Lakes Sockeye Salmon fishery, provide recommendations on processes for building and sustaining collaborative partnerships with Alaska Native communities, and substantiate the value of Indigenous knowledge through tribal representation in fishery management.

Environmental impacts of drilling at a mining prospect

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While the impacts on mines – as well as mitigations that reduce impacts – are well documented, the impacts from exploration are generally less clear. In August 2016, the United Tribes of Bristol Bay, a consortium of tribes in Southwest Alaska, asked the Center for Science in Public Participation (CSP2) to investigate whether exploration activities at the proposed Pebble Mine drilling site had caused any damage to the landscape or posed a risk to fish habitat. All drilling at the site ceased in 2012, and for four years only reclamation work had been conducted. CSP2 determined that there were problems caused by drill waste disposal and by inadequate drill hole reclamation. About half of the 101 sites inspected were reclaimed in good condition and none had free-flowing acid drainage. However there were large and small areas of drill cutting disposal on the land surface, which now represent an acidic, high copper layer on the soil. There were several uncontrolled artesian drill holes venting water with high metal concentrations. Lastly, a drill waste pit appeared to be leaching into a groundwater spring. The potential for pit leaching should be examined more extensively, and connections between contaminants and fish-bearing waters should be the focus of further work. Based on the 2016 results, CSP2 strongly encourages Alaska Department of Natural Resources to develop sampling plans and to work with Alaska Department of Fish and Game and Alaska Department of Environmental Conservation when conducting reclamation inspections and determining impacts.

Coexistence of top aquatic predators in headwater streams: intraguild competition and implications of shrinking habitat ranges.

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Cutthroat Trout *Oncorhynchus clarkii* and the Coastal Giant Salamander *Dicamptodon tenebrosus* are the dominant aquatic predators in headwater streams of the Pacific Northwest. In most of these streams, the habitat and prey preferences of trout and salamander overlap, making intraguild competition a common occurrence. However, in the upper part of the headwaters, salamander presence extends further upstream than trout. Studies indicate that as headwater streams warm as climate change persists, optimal habitat for trout will shrink, leaving salamanders to be the sole dominant predator in these habitats. The goal of this study is to monitor variation in food sources available to these predators in sites where both fish and salamanders coexist and in sites where only salamanders are present. In addition, surveys to estimate predator abundances will be conducted via backpack electrofishing. From a subset of individuals, gastric lavage will be employed to identify variations in summer diet composition between upstream and downstream sites. The study will take place at the HJ Andrews Experimental Forest, a long-term ecological research site where several decades of stream temperature recordings and fish monitoring data will provide the spatiotemporal context of our study. We will conduct an additional experiment using enclosures and cameras to track the fine-scale movement and habitat use of salamander and trout when

in close proximity. This experiment will shine light on the poorly understood concept of how intraguild competition, if present, may play a role in habitat use of Cutthroat Trout in headwater streams. Collectively, this research will help to answer the questions forming about how headwater streams and their biota are organized and how this ecosystem will be affected as climate change progresses and sensitive predators experience habitat shifts.

Maintenance of genetic variation in a population of resident Dolly Varden located above a barrier

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Waterfalls forming barriers to migration are a primary cause of genetic divergence among fish populations in rivers. Resident Dolly Varden occur in the Shungnak River, a tributary of the upper Kobuk River in northwestern Alaska blocked to upstream migration by a waterfall. The Shungnak River is also the site of mineral deposits under exploration for mining development. Genetic variation was assayed in Dolly Varden collected Subarctic Creek, a tributary of Shungnak River in conjunction with an aquatic biomonitoring project in 2016-2017. Our objective was to estimate genetic variability in these resident fish, and compare it to anadromous Dolly Varden in the lower Kobuk River. Subarctic Creek Dolly Varden showed reduced genetic variation and increased genetic divergence relative to lower Kobuk River tributaries. Expected heterozygosity in Subarctic Creek was 0.55, compared to 0.63 in Salmon and Tutuksuk rivers, a reduction of 13%. Allelic richness ranged from 6.15 in Subarctic Creek to 9.26 in Tutuksuk River, a reduction of 36%. Pairwise FST was greater between Subarctic Creek and lower river tributaries (~0.06) than between Salmon and Tutuksuk rivers (~0.01). Without a priori population definition, two genetic clusters were detected, corresponding to above- and below waterfall localities. The average proportion of the above-barrier group genome assigned to Subarctic Creek samples was 96%, while the average proportion of the below-barrier genome assigned to Salmon and Tutuksuk River samples was 86%, suggesting greater downstream than upstream gene. Two individuals with migrant ancestry were detected among Tutuksuk River samples, but none in Subarctic Creek. Further sampling of Dolly Varden in Shungnak River would allow an assessment of the mechanisms maintaining genetic variation in Subarctic Creek (habitat size, population subdivision). Further sampling of Dolly Varden in tributaries of the Kobuk River would allow assessment of factors leading to genetic divergence (distance between populations versus barriers to migration).