Dr. Curry James Cunningham

Curriculum Vitae

Assistant Professor
University of Alaska Fairbanks
College of Fisheries and Ocean Sciences
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Experience

- Developing management strategy evaluations (MSEs) and paired simulation-estimate analyses to investigate Bristol Bay, Alaska commercial sockeye salmon fisheries, Alaskan sablefish apportionment, and Pacific halibut prohibited species catch limits.
- Operation of the University of Washington, Alaska Salmon Program field research camp at Lake Iliamna (2012 – 2016). Duties included logistics, boat and generator maintenance, and oversight of data collection for various long-term and temporary research projects.
- Many years of employment as a commercial fisherman in Bristol Bay, Alaska.
- R package creation. During 2013/2014 as part of a joint UW-NOAA working group, I contributed to an R package *ss3sim*, which enables rapid simulation testing of Stock Synthesis 3. http://cran.r-project.org/web/packages/ss3sim/index.html.

Employment

2017-2019 Research Fisheries Biologist, National Oceanic and Atmospheric Administration, Alaska Fisheries Science Center, Auke Bay Laboratories. Focus on groundfish stock assessment and Management Strategy Evaluation.

Academic Positions

2019-present Assistant Professor, University of Alaska Fairbanks – College of Fisheries and Ocean Sciences.
2019-present Research Assistant Professor, Alaska Pacific University – Fisheries, Aquatic Science, & Technology Laboratory.
2015-2017 Postdoctoral researcher, University of Alaska Fairbanks, College of Fisheries and Ocean Sciences. *Pollock Conservation Cooperative Research Center*: *Using a stage structured population dynamics model to determine key environmental and fishery-related drivers of AYK Chinook salmon survival*. Supervisors: Drs. Peter Westley and Milo Adkison.
2016-2019 Affiliate faculty, Alaska Pacific University, Fisheries, Aquatic Science, & Technology Laboratory.

Education

2010-2015 PhD, University of Washington, School of Aquatic and Fishery Sciences. Advisors: Drs. Ray Hilborn and Thomas Quinn.
2005-2010 BSc in Animal Biology, University of British Columbia, Vancouver.

Peer-reviewed Publications (*Featured on journal cover, ‡Faculty 1000 recommended)

Google Scholar: https://scholar.google.com/citations?user=49EsNzMAAAAJ&hl=en

1. Jones, L., E. Schoen, R. Shaftel, **C. J. Cunningham**, S. Mauger, D. Rinella, and A. St. Savior. *Submitted*. Regional and watershed-scale climate drivers influence Chinook salmon productivity in southcentral Alaska. **Global Change Biology**.
2. Armstrong, J. B., D. E. Schindler, **C. J. Cunningham**, W. Deacy, and P. Walsh. *In Revision*. Watershed complexity increases the capacity of salmon-wildlife interactions in coastal ecosystems. **Conservation Letters**.
3. Litzow, M. A., L. Cianelli, **C. Cunningham**, B. Johnson, and P. Puerta. *Accepted*. Nonstationary effects of ocean temperature on Pacific salmon productivity. **Canadian Journal of fisheries and Aquatic Sciences.**
4. Rosellon-Druker, J. M., M. Szymkowiak, **C. Cunningham**, S. Kasperski, G. Kruse, J. Moss, and E. Yasumiishi. *In Press*. Development of socio-ecological conceptual models as the basis for an IEA framework in Southeast Alaska. **Ecology and Society**.
5. Oke, K. B., **C. J. Cunningham**, T. P. Quinn, and A. P. Hendry. 2019. Independent lineages in a common environment: the roles of determinism and contingency in shaping the migration timing of even- versus odd-year pink salmon over broad spatial and temporal scales. **Ecology Letters**.
6. Manishin, K. A., K. J. Goldman, M. Short, **C. J. Cunningham**, P. A. H. Westley, and A. C. Seitz. 2019. Prey consumption estimates for salmon sharks. **Marine & Freshwater Research**. https://doi.org/10.1071/MF18345.
7. **Cunningham, C. J**., C. Anderson, J. Y. Wang, M. Link, and R. Hilborn. 2019. A management strategy evaluation of the commercial sockeye salmon fishery in Bristol Bay, Alaska. **Canadian Journal of fisheries and Aquatic Sciences** 76(9): 1669–1683. – *Special Issue: Management Strategy Evaluation – 147th AFS.*
8. Wirsing, A. J., T. P. Quinn, **C. J. Cunningham**, J. R. Adams, A. D. Craig, and L. P. Waits. 2018. Alaskan brown bears (*Ursus arctos*) aggregate and display fidelity to foraging neighborhoods while preying on Pacific salmon along small streams. **Ecology and Evolution:** 8:9048-9061.

9. **Cunningham, C. J.**, P. A. H. Westley, and M. D. Adkison. 2018. Signals of large scale climate drivers, hatchery enhancement, and marine factors in Yukon River Chinook salmon survival revealed with a novel Bayesian life history model. **Global Change Biology**: 29 (9) 4399-4416.
10. Wang, J. Y., C. M. Anderson, **C. J. Cunningham**, and R. Hilborn. 2018. Does more fish mean more money? Evaluating alternative escapement goals in the Bristol Bay salmon fishery. **Canadian Journal of Fisheries and Aquatic Sciences**: 76(1): 153-167.
11. **Cunningham, C. J.** T. A. Branch, T. H. Dann, M. Smith, J. E. Seeb, L. W. Seeb, and R. Hilborn. 2018. A general model for salmon run reconstruction that accounts for interception and differences in availability to harvest. **Canadian Journal of Fisheries and Aquatic Sciences** 75(3): 439-451.
12. Quinn, T. P., **C. J. Cunningham**, and A. J. Wirsing. 2017. Diverse foraging opportunities drive the functional response of local and landscape-scale bear predation on Pacific salmon. **Oecologia** 183(2): 415-429.
13. Adkison, M. D., and **C. J. Cunningham**. 2015. The effects of salmon abundance and run timing on the performance of management by emergency order. **Canadian Journal of Fisheries and Aquatic Sciences** 72(10): 1518-1526.
14. Hurtado-Ferro, F., C. S. Szuwalski, J. L. Valero, S. C. Anderson, **C. J. Cunningham**, K. F. Johnson, R. Licandeo, C. R. McGilliard, C. C. Monnahan, M. L. Muradian, K. Ono, K. A. Vert-Pre, A. R. Whitten, and A. E. Punt. 2015. Looking in the rear-view mirror: bias and retrospective patterns in integrated, age-structured stock assessment models. **ICES Journal of Marine Science** 72:99-110.
15. Quinn, T. P., A. Wirsing, B. Smith, **C. J. Cunningham**, and J. Ching. 2014. Complementary use of motion-activated cameras and unbaited wire snares for DNA sampling reveals diel and seasonal activity patterns of brown bears foraging on adult sockeye salmon. **Canadian Journal of Zoology**.
16. Carlson, S. M., **C. J. Cunningham**, and P. A. H. Westley. 2014. Evolutionary rescue in a changing world. **Trends in Ecology and Evolution** 29:521-530[*‡]. ***Note: All authors contributed equally.***
17. Quinn, T. P., **C. J. Cunningham**, J. Randall, and R. Hilborn. 2014. Can intense predation by bears exert a depensatory effect on recruitment in a Pacific salmon population? **Oecologia**:1-12.
18. Johnson, K. F., C. C. Monnahan, C. R. McGilliard, K. A. Vert-pre, S. C. Anderson, **C. J. Cunningham**, F. Hurtado-Ferro, R. R. Licandeo, M. L. Muradian, K. Ono, C. S. Szuwalski, J. L. Valero, A. R. Whitten, and A. E. Punt. 2014. Time-varying natural mortality in fisheries stock assessment models: identifying a default approach. **ICES Journal of Marine Science**.
19. Ono, K., R. Licandeo, M. L. Muradian, **C. J. Cunningham**, S. C. Anderson, F. Hurtado-Ferro, K. F. Johnson, C. R. McGilliard, C. C. Monnahan, C. S. Szuwalski, J. L. Valero, K. A. Vert-Pre, A. R. Whitten, and A. E. Punt. 2014. The importance of length and age composition data in statistical age-structured models for marine species. **ICES Journal of Marine Science**.
20. **Cunningham, C. J.**, G. T. Ruggerone, and T. P. Quinn. 2013. Size selectivity of predation by brown bears depends on the density of their sockeye salmon prey. **American Naturalist** 181:663-673.
21. **Cunningham, C. J.**, M. G. Courage, and T. P. Quinn. 2013. Selecting for the phenotypic optimum: size-related trade-offs between mortality risk and reproductive output in female sockeye salmon. **Functional Ecology** 27:1233-1243.
22. Quinn, T. P., A. H. Dittman, H. Barrett, **C. Cunningham**, and M. H. Bond. 2012. Chemosensory responses of juvenile coho salmon, Oncorhynchus kisutch, Dolly Varden, Salvelinus malma, and sculpins (Cottus spp.) to eggs and other tissues from adult Pacific salmon. **Environmental Biology of Fishes** 95:301-307.

Reports and Technical Memos

1. **Cunningham, C. J.**, P. F. Hulson, C. R. Lunsford, and D. H. Hanselman. 2018. Assessment of the Northern Rockfish stock in the Gulf of Alaska. https://www.fisheries.noaa.gov/resource/data/2018-assessment-northern-rockfish-stock-gulf-alaska
2. Dorn, M. W., **C. J. Cunningham**, M. T. Dalton, B. S. Fadely, B. L. Gerke, A. B. Hollowed, K. K. Holsman, J. H. Moss, O. A. Ormseth, W. A. Palsson, P. A. Ressler, L. A. Rogers, M. A. Sigler, P. J. Stabeno, and M. Szymkowiak. 2018. A climate science regional action plan for the Gulf of Alaska. U.S. Dep. Commer. https://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-376.pdf
3. **Cunningham, C. J.**, A. N. Hendrix, E. Dusek-Jennings, R. Lessard, and R. Hilborn 2015. A multi-stock population dynamics framework for the recovery of Sacramento River Chinook salmon. Delta Science Program, Delta Stewardship Council. http://deltacouncil.ca.gov/sites/default/files/2039%20Final%20Report.pdf
4. **Cunningham, C. J.**, J. Wang, R. Hilborn, C. Anderson, and M. R. Link. 2015. Analysis of escapement goals for Bristol Bay sockeye salmon taking into account biological and economic factors. University of Washington, School of Aquatic and Fisheries Sciences and LGL Alaska Research Associates, Inc. http://www.bbedc.com/wp-content/uploads/2015/03/Evaluation-of-Alternative-Escapement-Goals-in-Bristol-Bay-10-March-2015.pdf
5. **Cunningham, C. J.**, D. E. Schindler, and R. Hilborn. 2015. An evaluation of biological escapement goals for sockeye salmon of Bristol Bay, Alaska. University of Washington. http://www.bbedc.com/wp-content/uploads/2015/03/BB-BEG-Evaluation-V12_Feb-25_2015.pdf
6. **Cunningham, C. J.**, R. Hilborn, J. Seeb, M. Smith, and T. A. Branch. 2012. Reconstruction of Bristol Bay sockeye salmon returns using age and genetic composition of catch. SAFS-UW-1202. https://digital.lib.washington.edu/researchworks/handle/1773/20963

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Curriculum Vitae

Dissertation

Cunningham, C. J. (2015). *Salmonid selection, evolution, and historical abundance patterns.* (PhD), University of Washington, Seattle.

This dissertation focused on: 1) evaluating whether selective predation by brown bears (*Ursus arctos*) depends upon the density of their sockeye salmon (*Oncorhynchus nerka*) prey, 2) quantifying strength and direction of natural and anthropogenic selection forces and life history tradeoffs that shaping optimal phenotypic distributions for populations of sockeye in Bristol Bay, Alaska, 3) development of methods for reconstructing salmon run size by partitioning mixed-stock catches while accounting for differences in availability to harvest within common fishing areas and interception in spatially proximate terminal fishing districts using both age and genetic composition of catch data, 4) simulation testing of a stage-structured statistical life cycle model for evaluating the natural and anthropogenic drivers of Chinook salmon (*O. tshawytscha*), and 5) an application for the statistical life cycle model to seven populations of fall and spring-run Chinook in the Sacramento River watershed of California.

Teaching Experience

2019 **Instructor**: 3-day workshop for the Alaska Native Tribal Health Consortium: *Introduction to Data Analysis and Statistical Inference in R.*

2018 **Co-instructor** with Dr. Jim Thorson for a short course on spatio-temporal models for survey index standardization at the NOAA Alaska Fisheries Science Center.

2017 ***Substitute*** **lecturer and lab instructor** for Dr. Franz Mueter. *Modern Applied Statistics in Fisheries* (FISH 604), UAF College of Fisheries and Ocean Sciences.

2017 ***Substitute*** **lecturer and lab instructor** for Dr. Milo Adkison. *Fisheries Population Dynamics* (FISH 421), UAF College of Fisheries and Ocean Sciences.

2017 **Instructor**: Workshop on the use of Git/Github for version control and collaborative project design for the American Fisheries Society, University of Alaska Fairbanks student subunit.

2017 **Instructor**: Workshop on the use of Git/Github for version control and collaborative project design for the NOAA Auke Bay Laboratories.

2011 **Lab instructor and teaching assistant:** Modeling and Estimation in Conservation and Resource Management (FISH 458), University of Washington. Duties as instructor for computer labs included lessons in excel and R focusing on: maximum likelihood approaches for fitting models to data, predatory-prey dynamics, evaluation of alternative management policies, information-theoretic approaches to model selection, population viability analysis, and parameter estimation using size and age-structured population dynamics models.

2010 **Teaching assistant**: Aquatic Ecological Research in Alaska (FISH 491), University of Washington. AERA is a 6-week undergraduate field course held at the U of W research camps in Alaska, focusing on limnology, geomorphology, and the population dynamics and evolutionary ecology of salmon. Duties included preparation of field experiments and sampling equipment, as well as aiding students in development and implementation of individualized research projects.

Graduate Committees

Kelly Cates	Doctoral student at University of Alaska Fairbanks: College of Fisheries and Ocean Sciences.
Kari Fenske	Doctoral student at University of Alaska Fairbanks: College of Fisheries and Ocean Sciences.
Holly Smith	Masters student at Alaska Pacific University: Fisheries, Aquatic Science, & Technology Laboratory.
Kaitlyn Manishin	Masters student at University of Alaska Fairbanks: College of Fisheries and Ocean Sciences. Successfully defended September, 2018.

Funding

2018 Shelton, O., J. Watson, C. Cunningham, E. Ward, A. Gray, M. Ford, and K. Sommers. *NOAA/NMFS National Protected Species toolbox (NPST) Initiative*: **Integrating Chinook catches from directed fisheries and trawl bycatch to improve distribution information for bycatch avoidance and impacts on predators in a changing environment.** Award amount: $158,000.

2017 Litzow, M., E. Ward, B. Burke, C. Harvey, S. Zador, C. J. Cunningham, N. Bond. *NOAA Fisheries and the Environment (FATE) Program:* **Measuring the strength of ocean-atmosphere coupling to predict climate forcing of northeast Pacific ecosystems.** Award amount: $200,000

2017 Rooper, C., R. Wilborn, S. Lowe, P. Spencer, D. Hanselman, C. Cunningham. *NOAA Habitat Assessment Improvement Plan (HAIP)*: **Accounting for habitat variables to improve abundance indices in Alaska trawl surveys with an emphasis on results from averaging multiple modeling methodologies**. Award amount: $130,161

2015 Westley, P, M. D. Adkison, and C. J. Cunningham. *Pollock Conservation Cooperative Research Center* funding award for postdoctoral research at the University of Alaska Fairbanks, College of Fisheries and Ocean Sciences. $207,171. *Ghost wrote* proposal in collaboration with Drs. Westley and Adkison (UAF, CFOS).

Honors and Awards

2014 *University of Washington, Graduate School Fund for Excellence and Innovation (GSFEI)* international travel award to present at Canadian Society of Ecology and Evolution conference in Montreal, Quebec.
2012-2013 Faculty Merit Award, University of Washington, School of Aquatic and Fishery Sciences.
2012 National Science Foundation, Graduate Research Fellowship Program, honorable mention in the field of evolutionary biology.
2011 National Science Foundation, Graduate Research Fellowship Program, honorable mention in the field of population and community ecology.

Working Group Membership

2018 NOAA Fisheries and the Environment (FATE) program working group: *Measuring the strength of ocean-atmosphere coupling to predict climate forcing of northeast Pacific ecosystems*.
2017 National Center for Ecological Synthesis and Analysis (NCEAS), State of Alaska Salmon and People (SASAP) project: *Consistency, Causes, and Consequences of Declining Size and Age of Alaskan Salmon.*

Presentations and Guest Lectures

Oct. 2019 Invited speaker at the national American Fisheries Society Meeting (Reno, NV): ***Origins and evidence of overcompensation in salmon***.
May 2018 Presentation at Western Division American Fisheries Society Meeting (Anchorage, AK): ***Life cycle modeling of Yukon River Chinook salmon reveals signals of large scale climate drivers, hatchery enhancement, and density-dependent juvenile survival***.
May 2018 Presentation at Western Division American Fisheries Society Meeting (Anchorage, AK): ***Use of Port Moller test fishery CPUE and genetic composition of catch data to improve in-season Bristol Bay run size forecasts***.
May 2018 Presentation at Western Division American Fisheries Society Meeting (Anchorage, AK): ***What is causing changes in the size of Alaskan salmon?***
April 2018 Guest Lecture for Dr. Megan McPhee at UAF, CFOS: ***Salmon fishery management in Alaska.***
April 2018 Presentation to NOAA-AFSC Alaska Integrated Ecosystem Assessment Meeting: ***Management strategy evaluation in the context of IEA***.
Nov. 2017 Guest Lecture for Dr. Peter Westley at UAF, CFOS: ***Conflict, compromise, and Chinook: Balancing multiple ecosystem objectives in California's Central Valley***.
Sep. 2017 Presentation to North Pacific Fishery Management Council, BSAI and GOA Groundfish Plan Teams: ***Evaluation of VAST spatial Delta-GLMM for GOA and AI bottom trawl survey data***.
Aug. 2017 Presentation at the national American Fisheries Society meeting (Tampa, FL): ***Bristol Bay, Alaska commercial salmon fishery MSE: Accounting for variable production regimes and the importance of industry and harvester participation***.
May 2017 NOAA/NMFS Quantitative Ecology and Socioeconomics Training (QUEST) webinar: ***Management Strategy Evaluation: Ideas and Application***.
Jan. 2017 Presentation to Pollock Conservation Cooperative Research Center board: ***Using stage structured population dynamics to determine drivers of AYK Chinook salmon survival***.
Oct. 2016 UAF, College of Fisheries and Ocean Sciences guest lecture (Fairbanks, AK): ***Bristol Bay salmon fishery: History, abundance, and forecasting methods.***
Feb. 2016 UAF, College of Fisheries and Ocean Sciences departmental seminar (Fairbanks, AK): ***Salmonid selection, evolution, and historical abundance patterns***.
Jan. 2016 Presentation at the Alaska Marine Science Symposium (Anchorage, AK): ***Evaluating the freshwater and marine drivers of Yukon River Chinook salmon survival with stage-structured life cycle model***".
Nov. 2015 Presentation at the American Fisheries Society, Alaska Chapter Meeting (Homer, AK): ***New methods in estimating stock-recruitment relationships for anadromous species***.
Nov. 2015 Invited speaker for UAF, Juneau Fisheries Seminar (Juneau, AK): ***A management strategy evaluation for Bristol Bay sockeye salmon***.
March 2015 Invited speaker at the 2015 California Interagency Ecological Program meeting (Folsom, CA): ***Sacramento River Chinook: A statistical model for evaluating the influence of environmental variability and competition on survival***.
Feb. 2015 Presentation at the SAFS, UW Quantitative Seminar: ***A management strategy evaluation framework for Bristol Bay sockeye salmon***.
Dec. 2014 Presentation at the UW-NOAA Fisheries Think Tank: ***Methods for forecasting Bristol Bay, Alaska sockeye salmon abundance***.
Dec. 2013 Presentation at the SAFS, UW Quantitative Seminar: ***Sacramento River Chinook: A statistical model for evaluating the environmental drivers of survival and competition among populations***.
Jan. 2013 Guest lecture for University of Washington, Wildlife Science Seminar (ESRM 455 & SEFS 554): ***Boats, bears, and bravery: Interactions between natural and anthropogenic selection on sockeye salmon***.
Nov. 2012 Presentation to the Wild Salmon Center (Portland, OR), ***Sacramento River Chinook: Modeling the influence of environmental variability on survival***. This presentation to a group of scientists and policy experts described

simulation testing of a Fall-run Sacramento River Chinook model and results from a Winter-run Chinook model.

Oct. 2012 Presentation at the 7th Biennial Bay-Delta Science Conference (Sacramento, CA): ***Sacramento River Chinook: Modeling the influence of environmental variability***, and summarized simulation testing of a Fall-run Chinook population dynamics model with generated data, and panel member for discussion of population dynamics modeling efforts in the Sacramento and San Joaquin watersheds.

May 2012 Presentation at the SAFS, UW Quantitative Seminar: ***Sacramento River winter-run Chinook: Evaluating the environmental drivers of survival***.

Sep. 2011 Presentation at the national American Fisheries Society meeting (Seattle, WA): ***Evaluating the interaction between natural and anthropogenic selection with predictive individual-based modeling***.

Posters

Jan. 2015 Poster at the Alaska Marine Science Symposium (Anchorage, AK): ***Evaluating the impact of bycatch, changing demography, and environmental factors on Yukon River Chinook salmon production***.

Oct. 2014 Poster at the Biennial Bay-Delta Science Conference (Sacramento, CA): ***Sacramento River Chinook: Modeling the influence of environmental variability***.

April 2012 Poster at the Interagency Ecological Program 2012 Annual Workshop (Folsom, CA): ***Sacramento River Chinook: Evaluating the natural and anthropogenic drivers of survival***.

Skills

- Programming in R, AD Model Builder (ADMB) and Template Mode Builder (TMB) software platforms.
- State-space population dynamics modeling with ADMB-RE and JAGS.
- Git/Github.
- Expertise in frequentist statistical theory, as well as maximum likelihood and Bayesian estimation methods.
- Stock Synthesis 3, integrated stock assessment software.
- Programming Bayesian models using JAGS, STAN, and the LaplacesDemon package in R.
- Visualization of multivariate data and model outputs using R (base and ggplot graphics).
- Creation of multivariate autoregressive state-space models, including dynamic linear models.
- Advanced mathematics including but not limited to: single and multiple variable integral and differential calculus.
- Applied mathematics and probability theory.
- Decision analysis and management strategy evaluation procedures.
- Analyzing spatially explicit NOAA sea surface temperature and oceanographic data products.

Service

- *Ad hoc* proposal reviewer for the *North Pacific Research Board* competitive research grant program.
- *Ad hoc* proposal reviewer for the *NOAA Saltonstall-Kennedy* grant program.
- *Ad hoc* manuscript reviewer for: *Nature Climate Change*, *Fisheries Research, PeerJ, Natural Resource Modeling, PLoS One*, *Canadian Journal of Fisheries and Aquatic Sciences, Journal of Wildlife Management.*

Recent Research

Management Strategy Evaluation of Harvest Apportionment Alternatives for the Sablefish Stock in the North Pacific

The acceptable biological catch (ABC) for sablefish (*Anoplopoma fimbria*) in Alaskan waters is apportioned among NMFS management areas in each year. Traditionally, ABC was apportioned based on the distribution of sablefish observed in fishery-independent surveys following an exponentially-weighted moving average. However, since 2014 apportionment has been fixed at the 2013 proportions due to concerns regarding the variability in the traditional approach. To address concerns from both stake holders and recommendations from the NPFMC SSC we have initiated a MSE to evaluate the potential outcome of a range of apportionment alternatives developed in collaboration with the stakeholder community. A spatially-explicit operating model (OM) is being developed based on demographic parameters from the 2017 sablefish stock assessment and movement rates informed by the NOAA-NMFS Sablefish Tagging Program. The OM will be paired with the existing sablefish stock assessment model, with representative observation and implementation uncertainty, and used to evaluate the biological and harvest outcomes for the range of proposed apportionment alternatives. **Collaborators:** Dr. Dana Hanselman and Ms. Kari Fenske (AFSC).

Management Strategy Evaluation of the Bristol Bay Commercial Fishery

Management of the Bristol Bay commercial sockeye salmon fishery has traditionally operated under a fixed escapement policy, with active in-season regulation of fishing effort to achieve these targets. However, previous escapement goal analyses did not account for: 1) biological uncertainty in future production regimes, 2) implementation uncertainty in the management process, and 3) the economic costs of high catch variability to the processing and harvesting sectors. To address these concerns and assess management alternatives, we conducted a MSE for this fishery in collaboration with stakeholder representatives from the harvesting and processing sectors, fisheries economists, and the Alaska Department of Fish and Game. As part of this MSE, I developed a simulation framework that uses time-varying stock-recruitment

relationships to simulate variation in future production dynamics, and approximates the in-season behavior of fishery managers to account for the imprecision associated with mixed-stock management and delays in information. This MSE process was successful in developing consensus among stakeholders and resulted in changes to the management targets for Bristol Bay beginning in 2015. **Collaborators**: Drs. Ray Hilborn and Chris Anderson (SAFS, UW), Michael Link (Bristol Bay Science and Research Institute).

Evaluation of Prohibited Species Catch Limit Alternatives for Pacific Halibut

To limit bycatch of Pacific halibut in Alaskan groundfish fisheries, the North Pacific Fisheries Management Council (NPFMC) sets Prohibited Species Catch (PSC) limits for Pacific halibut in Alaskan waters. However, these limits are fixed for long periods of time and therefore functionally independent of halibut abundance. In contrast, directed commercial halibut fishery catch limits are set by the International Pacific Halibut Commission (IPHC) on an annual basis as informed by stock assessment. This current management structure has resulted in concern that as halibut abundance declines the PSC impact rate on the halibut stock functionally increases; placing the burden of halibut conservation on directed fishery participants. To evaluate alternative methods for setting halibut PSC limits that are responsive to changes in halibut stock status, I have the privilege of collaborating on two projects that are concurrently developing MSE frameworks intended to quantify the ecological and economic impacts of PSC limit alternatives on directed and non-directed (PSC) fisheries. **Collaborators:** *Saltonstall-Kennedy funded effort:* Dr. Courtney Carothers (CFOS, UAF) and Dr. Matt Reimer (ISER). *NMFS-IPHC collaboration:* Drs. Carey McGilliard, Jim Ianelli, and Dana Hanselman (AFSC), and Dr. Allan Hicks (IPHC).

AYK Chinook: Bayesian Lifecycle Models for Evaluating Marine and Freshwater Drivers of Survival

In the Arctic-Yukon-Kuskokwim region, concern regarding the sustainability of Chinook salmon stocks has fostered increased interest in understanding the abiotic and biotic factors influencing survival in both marine and freshwater environments, including quantifying the age-specific impacts of bycatch in Bering Sea trawl fisheries. As part of my postdoctoral research at CFOS funded by the *Pollock Conservation Cooperative Research Center (PCCRC)*, I developed a stage-structured Bayesian population dynamics model to estimate how Chinook salmon survival responds to a range of candidate environmental and ecosystem factors. I implemented Bayesian variable selection methods to account for model structural uncertainty by estimating the inclusion probability for each predictor variable. When applied to the Chena and Salcha Chinook salmon populations of the Yukon River, the date of freshwater ice-out, wintertime marine temperatures, and competition with foreign hatchery-reared salmonids were identified as key predictors of survival. In addition, evidence for density-dependent capacity limitation in freshwater habitats was found. **Collaborators**: Drs. Milo Adkison and Peter Westley (CFOS, UAF).

Sacramento River Chinook: A Statistical Lifecycle Model for Evaluating the Environmental Drivers of Survival

Chinook salmon in the Central Valley of California are subject to a broad suite of anthropogenic stressors stemming primarily from extensive habitat alteration and water management, including water exports from the Sacramento-San Joaquin Delta for agricultural and urban use. To investigate the influence of anthropogenic and natural processes on the survival of threatened and endangered Chinook salmon stocks in the Sacramento River watershed, I developed a stage-structured population dynamics model that estimated the impact of the environmental factors hypothesized to affect maximum survival and habitat capacity, across freshwater and marine life stages. Results indicated nearshore marine upwelling and oceanographic conditions, water exports, and juvenile rearing temperature to be major drivers of Chinook survival variation. These estimates were then used to predict population viability and abundance trends under a range of future climate and water management scenarios for the Central Valley. **Funded by:** *Delta Science Program, Delta Stewardship Council*. **Collaborators:** Dr. Ray Hilborn (SAFS, UW), Dr. Noble Hendrix (QEDA Consulting), Dr. Robert Lessard (Columbia River Intertribal Fish Commission).

NCEAS working group: Consistency, Causes, and Consequences of Declining Size and Age of Alaskan Salmon

Scientists, commercial fishers, and subsistence users alike have long noted declines in the size and age of Alaskan salmon, which could result from fisheries-induced evolution, climate change, inter or intra-specific competition at sea, or increased marine predation, among other hypotheses. As part of a working group funded by the *State of Alaska Salmon and People (SASAP)* initiative at the *National Center for Ecological Synthesis and Analysis (NCEAS)*, I am collaborating with researchers from academic institutions, state and federal agencies, and tribal organizations in Alaska, California, New York, and Canada, to analyze patterns in the magnitude and consistency of changes in size and age of salmon and test alternative hypotheses about the processes driving these observed changes. Ultimately, our goal is to quantify the impact of these changes on commercial fisheries value, subsistence opportunity, and ecosystem productivity and stability. My role in this working group has been to collaborate in leading statistical analyses of trends in, and drivers of, changes in salmon size and age at return. **Funding**: *The Moore Foundation, through NCEAS.* **Lead collaborators**: Dr. Eric Palkovacs (University of California Santa Cruz), Dr. Peter Westley (UAF), Dr. Bert Lewis (ADFG).

Alternative Methods to Define Biological Escapement Goals for Bristol Bay, Alaska: Paleolimnological Priors and Shifting Production Regimes

Traditional methods for defining MSY-based escapement goals for Bristol Bay sockeye salmon have suffered from an inability to accurately estimate density-dependent parameters given the relatively small range of spawning abundances observed historically, and the assumption of time-invariant production dynamics. To address the problem of true system capacity and allow for non-stationary production, I collaborated with Dr. Daniel Schindler (SAFS, UW) to incorporate paleolimological reconstructions of historical salmon abundance from marine-derived nitrogen concentrations in lake sediment cores into a hidden Markov version of the traditional Ricker model. Using this novel approach, we were able to provide important baseline data, estimate differences in potential yield and optimal biological escapement goals across production regimes, quantify the probability of occupying those regimes in the future, and develop management recommendations that are more robust to future environmental variation. **Funded by**: Bristol Bay Economic Development Corporation. **Collaborators**: Drs. Daniel Schindler and Ray Hilborn (SAFS, UW).

Evaluation of Geostatistical Delta-GLMMs for NOAA Bottom Trawl Survey Index Standardization

A large component of my recent research has focused on evaluating the use of spatio-temporal methods for standardizing survey data for commercially important marine species harvested in the Alaska region. NOAA-NMFS Alaska bottom trawl surveys provide valuable fishery-independent biomass indices for stock assessment. While a simple design-based estimator has been used in the past to generate indices from these survey data, several advances in methodology have fostered interest in exploring alternative model-based methods for index standardization. These advances include delta-models that separately quantify the encounter probability and catch rate for a species, and geostatistical methods that account for the spatial and spatio-temporal correlation in observed species presence and biomass. I am collaborating with a working group focused on evaluating the use of these spatio-temporal delta generalized linear mixed models (delta-GLMMs) for generating model-based indices from Gulf of Alaska and Aleutian Island bottom trawl survey data. The purpose is to identify whether geostatistical methods provide greater precision and whether uncertainty in these indices is more robust to possible future reductions in survey effort. **Collaborators**: Dr. Jim Thorson (NOAA, NWFSC), Dr. Jim Ianelli (NOAA, AFSC), Dr. Dana Hanselman (NOAA, AFSC).