Curry James Cunningham

Research Fisheries Biologist
NOAA/NMFS, AFSC
17109 Pt. Lena Loop Road
Juneau, AK 99801

Email: cunninghamcurry@gmail.com
Voice: 907.360.4217

Skills

- Programming in R and AD Model Builder software platforms.
- State-space population dynamics modeling in ADMB-RE and JAGS.
- 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 and the LaplacesDemon package in R.
- Visualization of multivariate data and model outputs using R.
- 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.
- Microsoft office software: Excel, Word, PowerPoint, Access.

Experience

- Conducting management strategy evaluations (MSEs) for Bristol Bay, Alaska commercial sockeye salmon fisheries, accounting for uncertainty in both implementation (management) and future production regimes (biology). Findings resulted in changes to management targets for the 2015 season.
- Operation of the U of W, Alaska Salmon Program field research camp at Lake Iliamna (2012 – 2016). Duties include logistics, boat and generator maintenance, and oversight of data collection for various long-term and temporary research projects.
- 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.
- Analyzing spatially-explicit NOAA sea surface temperature and productivity data products.
- Many years of employment in the Bristol Bay, Alaska sockeye salmon commercial fishery.
- Salmonid evolutionary and population dynamics modeling under the supervision of Dr. Ray Hilborn and Dr. Tom Quinn, UW.
- Coursework in decision analysis and numerical estimation methods under Andre Punt, UW.
- Field-based data collection and sampling, as well as lab-based analysis of limnological and biological samples, with the UW, Alaska Salmon Program.
- Coursework in applied ecological modeling of terrestrial and aquatic systems, with a focus on sustainable harvest management, predator-prey interactions, and the use of Ecopath with Ecosim under Dr. Robert Ahrens and Dr. Carl Walters, UBC.

Education

2010-2015 PhD, University of Washington, School of Aquatic and Fishery Sciences. Advisors: Hilborn, Ray and Quinn, Thomas.

2005-2010 BSc in Animal Biology, University of British Columbia, Vancouver.

Recent Research

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

Concern over the sustainability of subsistence and commercial fisheries for Chinook stocks in the Arctic-Yukon-Kuskokwim region of Alaska has driven increased interest in understanding the abiotic and biotic factors influencing survival in both marine and freshwater environments, and quantifying the impacts of bycatch interactions with the BSAI Pollock trawl fishery. I am using stage-structured Bayesian population dynamics models to estimate the influence that a range of potential environmental covariates have on Chinook survival. Bayesian variable selection methods are implemented to account for model structural uncertainty in predictor variables by estimating the inclusion probability for each covariate. This estimation structure is used to identify key drivers of AYK Chinook survival and generate predictions for trends in abundance and recruitment under alternative climate change scenarios. Funding provided by: Pollock Conservation Cooperative Research Center.

Management Strategy Evaluation of the Bristol Bay Commercial Salmon Fishery

Management of the commercial fishery for sockeye salmon in Bristol Bay, Alaska has traditionally operated under a policy of fixed escapement goals and active inseason regulation of fishing effort to achieve these targets. Previous escapement goal analyses have failed to account for both the biological uncertainty in future production regimes and implementation uncertainty in the management process. To address these concerns, we conducted a management strategy evaluation (MSE) of the Bristol Bay fishery to explore: (1) alternative escapement goals, (2) the value of information provided by existing survey and

enumeration projects, (3) the potential for implementation of fixed fishing schedules to avoid costs associated with active inseason management. The MSE framework I built for this project simulates both the future production dynamics of the salmon populations based on time-varying stock-recruitment relationships, and the behavior of district managers during the season to account for the imprecision associated with mixed-stock management. MSE results lead to changes in management targets for Bristol Bay beginning in 2015.

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

In order to investigate the influence of anthropogenic and natural environmental factors on the survival of threatened and endangered Chinook salmon stocks in the Sacramento River, CA watershed, I utilized a stage-structured population dynamics model to estimate the impact of a range of environmental factors hypothesized to effect maximum survival and habitat capacity, across freshwater and marine life-stages. Results of this analysis are then used to predict population viability and abundance trends under a range of future climate and water use scenarios. In order to evaluate the efficacy of the estimation model, I also implemented a simulation-testing framework with an operating model that generates abundance trends with known responses to environmental covariates and randomly drawn observation and process errors, to which the estimation model is fit and parameter estimated compared with the "true" values specified to the operating model. Funded by: Delta Science Program, Delta Stewardship Council.

Pre-season and In-season Statistical Forecasting Methods for Bristol Bay, Alaska Sockeye

Accurate forecasts for salmon returns assist management, and inform effort allocation and preseason planning by fishermen and processors. A large component of my current research is focused on improving statistical methods for predicting future returns of sockeye salmon, both prior to and during the commercial fishery. In additional to traditional cohort survival models for preseason forecasting, I'm evaluating the efficacy of environmental predictors of early marine survival, the use of dynamic linear models to evaluate temporal variation in survival relationships and maturation schedules, and benefits of Bayesian model selection methods. To generate predictions for sockeye abundance during the commercial fishery, I've redesigned an integrated inseason assessment model that generates forecasts based upon preseason information, Port Moller test fishery cpue, inshore catch and escapement, as well as age and genetic composition information. Currently, I'm working to integrate the inseason assessment model with predictions for salmon inshore arrival timing based upon spatially explicit winter sea surface temperature trends and spring SST acceleration rates.

A Bayesian Analysis of Alternative Biological Escapement Goals for Bristol Bay, Alaska: Paleolimnological Priors and Shifting Productivity Regimes

Traditional methods for modeling spawner-recruit relationships with Ricker or Beverton-Holt models in order to define MSY-based management goals have traditionally suffered from: 1) an inability to accurately define stock-specific capacity estimates given the relatively small range of spawning abundances observed, and 2) the assumption of temporal stability in relationships across marine and freshwater productivity regimes. Therefore, I have created a Bayesian hidden Markov version of the Ricker model to evaluate changes in river system productivity over time that incorporates prior information on system capacity from paleolimnological data collected by Dr. Daniel Schindler that reconstructs historical salmon abundance based on analysis of Nitrogen isotopes in lake-bottom sediment cores. Using this model we were are able to estimate difference in potential yield and optimal biological escapement goals across productivity regimes as well was the probability of occupying those regimes in the future, and develop management recommendations that are robust to future environmental fluctuations. Funded by: Bristol Bay Economic Development Corporation.

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

1. Cunningham, C. J. T. A. Branch, T. Dann, M. Smith, J. Seeb, and R. Hilborn. *In revision*. A general model for salmon run reconstruction that accounts for interception and differences in availability to harvest. **Canadian Journal of Fisheries and Aquatic Sciences**.
2. Quinn, T. P., C. J. Cunningham, and A. J. Wirsing. 2016. Diverse foraging opportunities drive the functional response of local and landscape-scale bear predation on Pacific salmon. **Oecologia** 183:415-429.
3. 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** 72:1518-1526.
4. 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.
5. Quinn, T. P., A. Wirsing, B. Smith, **C. 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**.
6. 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.*

7. 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.
8. 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**.
9. 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**.
10. **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.
11. **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.
12. 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

1. **Cunningham, C. J.**, A. N. Hendrix, E. Dusek-Jennings, R. Lessard, and R. Hilborn 2015. A multi-stock population dynamics framework for the recover of Sacramento River Chinook salmon. Delta Science Program, Delta Stewardship Council.
2. **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
3. **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
4. **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

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

2011 **Lab instructor and teaching assistant:** for 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.

Honors and Awards

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.

Presentations and Guest Lectures

Feb. 2016 UAF, School of Ocean and Fishery 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 models**"*.

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, entitled "***A management strategy evaluation framework for Bristol Bay sockeye salmon***".

Dec. 2014 Presentation at the UW-NOAA Fisheries Think Tank, entitled "***Methods for forecasting Bristol Bay, Alaska sockeye salmon abundance***".

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

Dec. 2013 Presentation at the SAFS, UW Quantitative Seminar, entitled "***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***".

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