

## Elizabeth Eli Holmes

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## EDUCATION

**Doctor of Philosophy, Zoology**, University of Washington, June 1995

Title: "Spatial models in ecology: explorations into the impact of spatial behavior on population dynamics"

Committee: Peter Kareiva (chair), Robert T. Paine, Joel Kingsolver

**Bachelor of Science, Biology**, Stanford University, June 1988, with honors

**Bachelor of Science, Mechanical Engineering**, Stanford University, June 1988, cum laude

## PROFESSIONAL POSITIONS

**2005-present Affiliate faculty**, School for Fisheries and Aquatic Sciences, Univ. of Washington

**1999-present Research Scientist**, Conservation Biology Division, Northwest Fisheries Science Center, Seattle WA

- Research focuses on population dynamics of endangered and threatened species and development of quantitative methods for risk assessment

**1998-99 National Research Council fellow**, National Marine Mammal Lab., Seattle WA

- Project title: "Metapopulation dynamics of Steller sea lions", supervisors Anne York and Tom Loughlin

**1995-97 National Science Foundation Post-doctoral fellow**, Colorado State Univ., Biology Dept., Fort Collins, CO

- Project title: "An experimental study of the effect of metapopulation structure on parasite-host population dynamics", supervisor Janice Moore

## PUBLICATIONS

**Holmes, E.E.**, S. B.R., N. Kumar, S. Maity, D. Checkley, M. Wells, V. Trainer. 2019. Fishing in a warming ocean: influence of changing temperature and upwelling intensity on Indian oil sardine (*Sardinella longiceps*) landings. In (final) prep.

Pendelton, D., **E.E. Holmes**, J. Zhang. 2019. Out-of-sample hindcast predictions of western Arctic bowhead whale habitat using an Arctic Ocean model to drive species distribution models. *In review*.

**Holmes, E.E.**, M.D. Scheuerell, E.J. Ward. 2019. Applied Time Series Analysis for Fisheries and Environmental Science. Online book for UW course <https://nwfsc-timeseries.github.io/atsa-labs/>

**Holmes, E.E.** 2018. Fish Catch Forecasting with R. Online book for short course. <https://fish-forecast.github.io/Fish-Forecast-Bookdown/>

Ward, E.J., K. Oken, K.A. Rose, S. Sable, K. Watkins, **E.E. Holmes**, and M.D. Scheuerell. 2018. Applying spatiotemporal models to monitoring data to quantify fish responses to the Deepwater Horizon oil spill in the Gulf of Mexico. *Environmental Monitoring and Assessment* 190:530.

Tolimieri, N., **E. E. Holmes**, G. D. Williams, R. Pacunski, and D. Lowry. 2017. Population assessment using multivariate time-series analysis: A case study of rockfishes in Puget

- Sound. Ecology and Evolution, in press.
- Keith, D.M., H.R. Akcakaya, S.H.M. Butchart, B. Collen, N. K. Dulvy, **E. E. Holmes**, J. A. Hutchings, D. Keinath, M. K. Schwartz, A. O. Shelton, and R. S. Waples. 2015. Temporal correlations in population trends: Conservation implications from time-series analysis of diverse animal taxa. *Biological Conservation* 192:247-257.
- See, K. E. and **E. E. Holmes**. 2015. Reducing bias and improving precision in species extinction forecasts. *Ecological Applications* 25: 1157-1165.
- Ruhí, A., **E. E. Holmes**, J. N. Rinne, and J. L. Sabo. 2015. Anomalous droughts, not invasion, decrease persistence of native fishes in a desert river. *Global Change Biology* 21:1482-1496.
- Holmes, E. E.** Computation of standardized residuals for MARSS models. Technical Report. arXiv:1411.0045 [stat.ME]
- Francis, T. B., E. M. Wolkovich, M. D. Scheuerell, S. L. Katz, **E. E. Holmes**, and S. E. Hampton. 2014. Shifting Regimes and Changing Interactions in the Lake Washington, USA, Plankton Community from 1962-1994." *PlosOne*: e110363.
- Ward, E.J., **E.E. Holmes**, J.T. Thorson, and B. Collen. 2014. Complexity is costly: comparing parametric and non-parametric methods for short-term population forecasting. *Oikos* 123:652-661.
- Hampton, S.E., **E.E. Holmes**, D.E. Pendleton, L.P. Scheef, M.D. Scheuerell, and E.J. Ward. 2013. Quantifying effects of abiotic and biotic drivers on community dynamics with multivariate autoregressive (MAR) models. *Ecology* 94:2663-2669
- Holmes, E. E.** 2013. Derivation of the EM algorithm for constrained and unconstrained multivariate autoregressive state-space (MARSS) models. Technical Report. arXiv:1302.3919 [stat.ME]
- Mongillo, T. M., **E. E. Holmes**, D. P. Noren, G. R. VanBlaricom, A. E. Punt, S. M. O'Neill, G. M. Ylitalo, M. B. Hanson, P. S. Ross. 2012. Predicted polybrominated diphenyl ether (PBDE) and polychlorinated biphenyl (PCB) accumulation in southern resident killer whales. *Marine Ecology Progress Series* 453:263-277.
- Holmes, E. E.**, E. J. Ward and K. Wills. 2012. MARSS: Multivariate autoregressive state-space models for analyzing time-series data. *R Journal* 4: 11-19.
- Scheef, L. P., D. E. Pendleton, S. E. Hampton, S. L. Katz, **E. E. Holmes**, M. D. Scheuerell, and D.G. Johns. 2012. Assessing marine plankton community structure from long-term monitoring data with multivariate autoregressive (MAR) models: a comparison of fixed station vs. spatially distributed sampling data. *Limnology & Oceanography: Methods* 10: 54-64.
- Ward, E., B. Semmens, **E. Holmes**, and K. Balcomb. 2010. Effects of multiple levels of social organization on survival and abundance. *Conservation Biology* 25:350-355.
- Holmes, E. E.** and E. J. Ward. 2010. Analysis of multivariate time series using the MARSS package. (<http://cran.r-project.org/web/packages/MARSS/index.html>)
- Viscido, S. V. and **E. E. Holmes**. 2010. Statistical modeling of communities and ecosystems using the LAMBDA software tool. *Environmental Modeling and Software* 25(12): 1905-1908
- Ward, E. J., Chirakkal, H., González-Suárez, M., Auriolles-Gamboa, D., **Holmes, E. E.** and Gerber, L. 2009. Inferring spatial structure from time-series data: using multivariate state-space models to detect metapopulation structure of California sea lions in the Gulf of California, Mexico. *Journal of Applied Ecology* 47:47-56
- Ward, E., K. Parsons, **E. Holmes**, K. Balcomb, and J. Ford. 2009. The role of menopause and reproductive senescence in a long-lived social mammal. *Frontiers in Zoology* 6:4
- Hinrichsen, R. A. and **E. E. Holmes**. 2009. Using multivariate state-space models to study spatial structure and dynamics. In *Spatial Ecology* (editors Robert Stephen Cantrell, Chris Cosner, Shigui Ruan). CRC/Chapman Hall
- Ward, E. J., **E. E. Holmes**, and K. C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. *Journal of Applied Ecology* 46:632-640

- Ellner, S. P. and **E. E. Holmes**. 2008. Resolving the debate on when extinction risk is predictable. *Ecology Letters* 11: E1–E5
- Hauser, D. D. W., M. G. Logsdon, **E. E. Holmes**, G. R. VanBlaricom, R. W. Osborne. 2007. Summer distribution patterns of Southern Resident killer whales (*Orcinus orca*): core areas and spatial segregation of social groups. *Marine Ecology Progress Series* 351: 301-310.
- Holmes, E. E.**, J. Sabo, S. V. Viscido, and W. F. Fagan. 2007. A statistical approach to quasi-extinction forecasting. *Ecology Letters* 10:1182–1198.
- Holmes, E.E.**, L. W. Fritz, A. E. York and K. Sweeney. 2007. Age-structured modeling reveals long-term declines in the natality of western Steller sea lions. *Ecological Applications* 17: 2214–2232.
- Hauser, D. D. W., M. G. Logsdon, **E. E. Holmes**, G. R. VanBlaricom, R. W. Osborne. 2007. Summer distribution patterns of Southern Resident killer whales (*Orcinus orca*): core areas and spatial segregation of social groups. *Marine Ecology Progress Series* 351: 301-310.
- Hauser, D., G. VanBlaricom, **E. Holmes**, R. Osbourne. 2006. Evaluating the use of whalewatch data in determining killer whale (*Orcinus orca*) distribution patterns. *Journal of Cetacean Research and Management* 8: 273-281.
- Levin, P., **E. E. Holmes**, K. Piner and C. Harvey. 2006. Shifts in a Pacific Ocean fish assemblage: the potential influence of exploitation. *Conservation Biology* 20: 1181-1190.
- Fagan, W. F and **E. E. Holmes**. 2006. Quantifying the extinction vortex. *Ecology Letters* 9: 51-60.
- Holmes, E. E.**, W. F. Fagan, J.J. Rango, A. Folarin, J.A., Sorensen, J.E. Lippe, and N.E. McIntyre. 2005. Cross validation of quasi-extinction risks from real time series: an examination of diffusion approximation methods. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-67, 37 p.
- Holmes, E. E.** 2004. Beyond theory to application and evaluation: diffusion approximations for population viability analysis. *Ecological Applications* 14: 1272-1293.
- Holmes, E. E.** and B. Semmens. 2004. Population viability analysis for metapopulations: a diffusion approximation approach. Pp. 565-598 in *Ecology, Genetics, and Evolution of Metapopulations*, editors Ilkka Hanski and Oscar E. Gaggiotti. Elsevier Press.
- Sabo, J. L., **E. E. Holmes**, and P. Kareiva. 2004. The efficacy of simple viability models in ecological risk assessment: Does density dependence matter? *Ecology* 85: 328-341.
- Holmes, E. E.** and A. E. York. 2003. Using age structure to detect impacts on threatened populations: a case study using Steller Sea Lions. *Conservation Biology* 17:1794-1806.
- McClure, M. M., **E. E. Holmes**, B. L. Sanderson, and C. E. Jordan. 2003. A large-scale, multi-species risk assessment: anadromous salmonids in the Columbia River Basin. *Ecological Applications* 13(4):964-989.
- Holmes, E. E.** and W. F. Fagan. 2002. Validating population viability analysis for corrupted data sets. *Ecology* 83: 2379-2386.
- Holmes, E. E.** 2002. Compute and Conserve, Book review of "Quantitative methods for Conservation Biology" *Conservation Biology* 16(1): 275-276.
- Holmes, E. E.** 2001. Estimating risks in declining populations with poor data. *Proceedings of the National Academy of Science* 98: 5072-5077.
- Holmes, E. E.** and P. M. Kareiva. 2000. Using single-species measurements to anticipate community level effects of environmental contaminants. In *Environmental Contaminants and Terrestrial Vertebrates: Effects on Populations, Communities, and Ecosystems*, P.H. Albers, G.H. Heinz, and H.M. Ohlendorf, editors. Published by the Society of Environmental Toxicology and Chemistry (SETAC), 315 pp.
- Holmes, E. E.** 1999. Book review of "Quantitative Analysis of Movement" *Bulletin of Mathematical Biology*
- Holmes, E. E.** and H. B. Wilson. 1998. Running from trouble: long distance dispersal and the competitive coexistence of inferior species. *American Naturalist* 151: 578-586.

- Holmes, E. E.** 1997. Basic epidemiological concepts in a spatial context. In *Spatial Ecology* (editors, D. Tilman and P. Kareiva). Princeton University Press.
- Holmes, E. E.** 1995. *Spatial models in ecology: explorations into the impact of spatial behavior on population dynamics*. Dissertation. University of Washington.
- Holmes, E. E., M. A. Lewis, J. Banks, and R. Veit.** 1994. Partial differential equation models in ecology. *Ecology* 75: 17-29.
- Holmes, E. E.** 1993. Is diffusion too simple? Comparisons with a telegraph model of dispersal. *American Naturalist* 142: 779-796.

## R PACKAGES

- Holmes, E., Ward, E., and Wills, K. 2013. MARSS: Multivariate Autoregressive State-Space Modeling. R package version 3.5. Currently one of the top 10% of downloaded R packages. <http://cran.r-project.org/web/packages/MARSS>
- Holmes, E., 2013. fbRanks: Association Football (Soccer) Ranking via Poisson Regression. R package version 2.0. <http://cran.r-project.org/web/packages/fbRanks/>
- Many more on my GitHub repositories. Largely having to do with time-series analysis and risk-assessment for federally managed populations <https://github.com/eeholmes>

## REPORTS

- Holmes, E. E.** 2003. "Review of methods, progress and cross-validation studies pertaining to population trend and risk assessment for Columbia River salmonids" in Final Report on the Technical Workshop on Population Trends and Extinction Metrics Workshop held December 5, 2003, NWFSC, Seattle, WA.
- Richard G. Gustafson, Jonathan Drake, Michael J. Ford, James M. Myers, **Elizabeth E. Holmes**, and Robin S. Waples. Status Review of Cherry Point Pacific Herring (*Clupea pallasii*) and Update of the Status Review of the Georgia Basin Distinct Population Segment of Pacific Herring Under the U.S. Endangered Species Act. June 2005 Draft
- Drake, J., E. A. Berntson, J. M. Cope, R. G. Gustafson, E. E. Holmes, P. S. Levin, N. Tolimieri, R. S. Waples, S. Sogard, G. D. Williams. 2010. Status review of five rockfish species in Puget Sound, Washington: Bocaccio (*Sebastes paucispinis*), canary rockfish (*S. pinniger*), yelloweye rockfish (*S. ruberrimus*), greenstriped rockfish (*S. elongatus*), and redstripe rockfish (*S. proriger*). U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-108.
- Ford, M. J., K. Barnas, T. Cooney, L. G. Crozier, M. Diaz, J. J. Hard, **E. E. Holmes**, D. M. Holzer, R. G. Kope, P. W. Lawson, M. Liermann, J. M. Myers, M. Rowse, D. J. Teel, D. M. Van Doornik, T. C. Wainwright, L. A. Weitkamp, M. Williams. 2015. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Pacific Northwest. National Marine Fisheries Service, Northwest Fisheries Science Center.

## TEACHING

### Graduate and Post-Graduate

- 2020** Upcoming: Modeling impacts of ocean change on species distributions in the Bay of Bengal and Indian Ocean using Species Distribution Modeling. 3-week short course at the Indian National Centre for Ocean Information Services, Hyderabad, India. Part of my NOAA International Fellowship for 2020.
- 2018** Fish catch forecasting with R. Week-long short course at the Indian National Centre for Ocean Information Services, Hyderabad, India.
- 2013, 2015, 2017, 2019** Fish 507, Time-series analysis for environmental and fisheries data at the University of Washington with Eric Ward and Mark Scheuerell.
- 2015** Multivariate linear modeling for fisheries data. Weeklong workshop the Earth System Science Organization, Indian National Center for Ocean Information Services (ESSO INCOIS), Hyderabad, India.
- 2014** Multivariate Time-Analysis with MARSS. Weeklong workshop at Stockholm University,

Sweden.

- 2010, 2011, 2012** 1-day workshops on multivariate time series analysis, Ecological Society Meetings. Online versions available on my website.
- 2009** 1-day workshop on analysis of population monitoring data, Biennial Conference of the Marine Mammal Society, Quebec City, Quebec.
- 2008** 1-day workshop on multi-variate state-space models for analyzing ecological data. Ecological Society Meetings, Milwaukee, WI, August 2008 (short version repeated at University of Chicago, Oct 2008).
- 2007** 1-day workshop on multi-variate autoregressive models for analysis of community time series data. Ecological Society Meetings, San Jose, CA, August 2007. (repeated at the National Center for Ecological Synthesis and Analysis, Sept 2007).
- 2005** 1-day workshop on state-space modeling for Population Viability Analysis at the Ecological Society Meetings, Montreal, Canada, August 2005.
- 2001/2002** Graduate course on ecosystem management, Zoology Dept., Univ. of Wash.
- Review of the concept of ecosystem management versus its application in actual Ecosystem Management plans and projects
  - Co-organized and co-lectured with D. Boersma, M. McClure, P. Kareiva
- 2000** Spatial Ecology, graduate course, Zoology Dept, University of Washington
- Course on the effect of spatial structure on population and community dynamics
  - Lecture style course based on a course reader that I developed
- 1998** 10 wk graduate seminar on Metapopulation models, University of Washington
- Course on the population, community and genetic consequences of metapopulation structure
- 1996** 6 wk graduate seminar on Cellular Automata models, Imperial College, UK,

## **SUPERVISION**

### **Post-docs**

Dr. John Sabo, Professor Arizona State University  
Dr. Steven Viscido, Associate professor at Winston-Salem University (NC State)  
Dr. Kim Parsons, researcher for North Gulf Oceanic Society  
Dr. Brice Semmens, Director CalCOFI, Associate professor at UCSD  
Dr. Eric Ward, Federal research scientist at NWFSC  
Dr. Yasmin Lucero, independent statistical contractor  
Dr. Dan Pendelton, senior research scientist at New England Aquarium  
Dr. James Thorson, Federal research scientist at AFSC  
Dr. Guillaume Bal, research scientist at Marine Institute, Ireland.

### **Graduate students**

Co-chair for Donna Hauser, graduated, M.S. student, School of Aquatic & Fisheries Sciences, Univ. of Wash., Seattle, WA. "Summer habitat use by Southern Resident Killer Whales"  
Co-chair for Teresa Mongillo, graduated, M.S. student, School of Aquatic & Fisheries Sciences, Univ. of Wash., Seattle, WA. "Effects of contaminants on Southern Resident Killer Whale Population Dynamics"  
Co-chair for Kevin See, Ph.D. student, School of Aquatic & Fisheries Sciences, Univ. of Wash., Seattle, WA. "Multivariate autoregressive modeling of spatial community data"

## **SCIENCE ADVISORY WORK (a subset of it)**

**1999-2005** Development of trend estimation methods for noisy salmonid data in support of the Biological Recovery Teams for listed salmonids in the Columbia River basin. See section on Methods in Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-66, 598 p.

- 2005** Cherry Point Pacific Herring Biological Recovery Team, team member, analyst on the risk assessment for 2005 status review
- 2005-2007** Steller Sea Lion Biological Recovery Team, advisor
- 2005-2007** Southern Resident Killer Whale Biological Recovery Team, advisor, mainly in reviewer capacity
- 2007** Marine Stewardship Council certification of the Alaska pollock fisheries, marine mammal assessment scientist, advisor
- 2007** Review panel member, 5-year laboratory peer review for the Atlantic Division NHERL laboratory, Environmental Protection Agency
- 2008-2009** Puget Sound Rockfish Biological Review Team, team member
- 2008-2012** NWFSC Internal Grants Program, proposal review panel member
- 2009-2012** Science Advisory Board for the National Center for Ecological Analysis and Synthesis (NCEAS), Santa Barbara, CA
- 2009** CAMEO-NSF proposal review panel member
- 2009-2011** Secretary, statistical ecology section of the Ecological Society of America
- 2011-2015** 4-year NASA funded grant on 'Forecasting Changes in Habitat Use by Bowhead Whales in Response to Arctic Climate Change: Integration of Physical-Biological Models with Satellite, Biological Survey and Oceanographic Data' PIs: E. E. Holmes and D. Pendleton. This is a collaborative project with M. Ferguson (National Marine Mammal Lab) and J. Zhang (Applied Physics Lab, UW).
- 2012-present** Subject editor, Ecological Applications, Ecological Monographs
- 2012-present** Co-lead for the Population Assessment group in the NOAA-wide Protected Species Toolbox project. This is a \$600,000 per year, 3 year, project to develop quantitative tools for protected species.
- 2014-2015** 5-year Status Review of listed Pacific NW Salmonids, advisor/trend analysis
- 2014-2019** Development of Predictive Capabilities on Marine Fisheries and Harmful Algal Blooms in Indian Seas, MoES (India)-NOAA Technical Cooperation. Joint workshops with US and Indian fisheries biologists and oceanographers in Cochi and Hyderabad, India.
- 2015** Statistical contributor for the 2015 IUCN Red List assessment for polar bears.  
<http://www.iucnredlist.org/details/22823/0>
- 2016-2017** Working group member Sacramento River Winter-Run Chinook control evaluation.
- 2019-2020** NOAA International fellowship with Ministry of Earth Sciences (India). Working with Indian fisheries biologists and oceanographers in Cochi and Hyderabad, India on effects of ocean climate change in the Indian Ocean.
- 2019-present** Another 5-year Status Review of listed Pacific NW Salmonids, advisor/trend analysis.