

Biography

Dr. Elliott Lee Hazen, Ph.D.

Research Ecologist, NOAA Southwest Fisheries Science Center, Environmental Research Division

Dr. Hazen received his Master's of Science in 2003 from the University of Washington School of Aquatic and Fishery Sciences and his Ph.D. from Duke University in 2008. Currently, he is working at the NOAA-Southwest Fisheries Science Center in Monterey, California. His general research interests fall in the realm of Ecology and Ecological Modeling with an added interest in predator-prey relationships, scale, and oceanographic forcing.

In his research, he has used novel technologies such as fisheries acoustics, bio-logging tags, and oceanographic data paired with spatial statistics to examine predator ecology. His research aims to tease apart ocean, climate, and trophic effects on marine ecosystems. He often combines theoretical and experimental techniques with interdisciplinary collaborators to determine marine species-habitat relationships, predator-prey dynamics, and the effects of climate variability and change on pelagic biodiversity hotspots. He has worked in a variety of systems and a suite of ecological scales around the world often focusing on top predators that need to find dense prey patches to thrive. He has enjoyed working on fine scale foraging ecology of whales, up to basin-scale analyses of habitat characteristics and likely shifts with climate change, and human dimensions of marine ecosystem based management.

A few key examples of his research include:

- **Species ecology, movement, and distribution.** Species distribution models (SDMs) are commonly used as a tool to identify the physical and biological variables that influence how an organism is distributed. He uses a suite of models that can examine linear interactions, threshold effects, and non-linear dynamics to understand how pelagic organisms are distributed relative to oceanographic and bathymetric features.
- **Foraging theory and behavior.** Most recently, he has been examining how foraging effort changes as a function of prey density in North Pacific blue whales to better understand how human impacts may hinder recovery of this sentinel population.
- **Climate variability and change.** Managing our oceans in a changing climate will require a suite of adaptive tools. He is combining models of observed species distribution as a function of sea surface temperature, chlorophyll-a, and bathymetry with global climate models, and estimated changes in species-specific core habitat and basin-scale patterns of biodiversity over the next century.
- **Conservation biology.** He is using habitat modeling and real-time oceanographic data to examine bluefin tuna habitat relative to oil exposure from the Deepwater Horizon spill to quantify potential damage to the population. The ability to use dynamic habitat predictions to improve our management of marine resources is becoming increasingly important with recent extreme climate/ocean events such as “the Blob.”

For more information on Dr. Hazen, visit <https://people.ucsc.edu/~elhazen/hazen/Index.html>.

DR. ELLIOTT LEE HAZEN – *CURRICULUM VITAE*



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EDUCATION

PhD, Ecology, Duke University, Durham, NC and Beaufort, NC, 2008. Advisor: Dr. Larry Crowder.

Dissertation: Linking Prey to Predator: Scale Dependence and Oceanography in Marine Food Webs.

MSc, Fisheries, University of Washington, Seattle, WA, 2003. Advisor: Dr. John Horne.

Thesis: A Comparison of Factors Influencing Backscatter for Walleye Pollock, *Theragra chalcogramma*.

BS, Biology, Cum Laude from Duke University, Durham, NC, 2000.

RELEVANT EXPERIENCE

NOAA NMFS Research Ecologist – Southwest Fisheries Science Center, Environmental Research Division. April 2014 - present. Evaluating the role of climate variability and change in marine ecology and applications to management (Integrated Ecosystem Assessments).

UCSC Assistant Research Biologist and Adjunct Faculty – Housed at the Pacific Fisheries Environmental Lab, NOAA, October 2012 – Present (Adjunct). Modeling and measuring the effects of climate variability and change in marine ecology.

Stanford Center for Ocean Solutions Visiting Fellow – February 2014 – present.

Adjunct Research Professor – Duke University Marine Lab Appointment, Fall 2009 – present.

UH-JIMAR Research Oceanographer – Pacific Fisheries Environmental Lab, NOAA, Fall 2010 – Fall 2012. Evaluating the influence of scale and oceanography in predator-prey ecology.

NRC Postdoctoral Fellow – Pacific Fisheries Environmental Lab, NOAA, Fall 2009 – Fall 2010. Analyzed satellite tagging data relative to oceanographic variables.

Postdoctoral Researcher – Duke University Marine Lab, Spring 2008-Fall 2009. Conducted research on Beaked whale foraging habitat in the Bahamas and Humpback whale foraging behavior in the western Antarctic Peninsula.

Contract Instructor – Duke University Marine Lab, Fall 2007. Green by Design. Co-designed and taught course on environmental sustainability including a concurrent environmental seminar series.

Graduate Research Assistant – Duke University Marine Lab, Fall 2006 – Spring 2007. Performed literature review on offshore fish species and known sensitivities to noise. Helped organize and run a symposium on the effects of mid-frequency sonar on marine fishes. Co-wrote final report for ONR.

Graduate Teaching Assistant – Duke University, Fall 2003 – Spring 2006. Introductory Ecology, Community Ecology, Marine Ecology, Marine Invertebrate Zoology, Marine Policy, and Marine Fisheries Ecology. Created lab syllabus, organized and led field experiments, graded assignments and review papers.

PUBLICATIONS (54)

- K. Scales, **E.L. Hazen**, M. Jacox, C. Edwards, A. Boustany, M. Oliver, S.J. Bograd, 2016. Scales of inference: On the sensitivity of habitat models for wide-ranging marine predators to the resolution of environmental data, *Ecography*, doi: 10.1111/ecog.02272
- G.C. Hays, L.C. Ferreira, A.M.M. Sequeira, M.G. Meekan, C.M. Duarte, H. Bailey, F. Bailleul, W.D. Bowen, M. J. Caley, D.P. Costa, V.M. Eguíluz, S. Fossette, A.S. Friedlaender, N. Gales, A.C. Gleiss, J. Gunn, R. Harcourt, **E.L. Hazen**, M.R. Heithaus, M. Heupel, K. Holland, M. Horning, I. Jonsen, G.L. Kooyman, C.G. Lowe, P.T. Madsen, H. Marsh, R.A. Phillips, D. Righton, Y. Ropert-Coudert, K. Sato, S.A. Shaffer, C.A. Simpfendorfer, D.W. Sims, G. Skomal, A. Takahashi, P.N. Trathan, M. Wikelski, J.N. Womble, M. Thums, 2016. Key Questions in Marine Megafauna Movement Ecology. *Trends in Ecology & Evolution*, Doi: 10.1016/j.tree.2016.02.015
- A.S. Friedlaender, **E.L. Hazen**, J.A. Goldbogen, A.K. Stimpert, J. Calambokidis, B.L. Southall, 2016. Prey-mediated behavioral responses of feeding blue whales in controlled sound exposure experiments. *Ecological Applications*, doi: 10.1002/15-0783
- S.J. Bograd, **E.L. Hazen**, S. Maxwell, A.W. Leising, H. Bailey, 2016. “Offshore Ecosystems”, in *Ecosystems of California – A Source Book*, H. Mooney and E. Zavaleta, eds., University of California Press, Oakland, CA, 287-303.
- S.J. Bograd, A.W. Leising, and **E.L. Hazen**, 2016. “Oceanographic Drivers”, in *Ecosystems of California – A Source Book*, H. Mooney and E. Zavaleta, eds., University of California Press, Oakland, CA, 95-101.
- E.L. Hazen**, A.S. Friedlaender, J.A. Goldbogen, 2015. Blue whales (*Balaenoptera musculus*) optimize foraging efficiency by balancing oxygen use and energy gain as a function of prey density. *Science Advances*, 1:9, DOI: 10.1126/sciadv.1500469.
- Whitlock, R.E., **E.L. Hazen**, A. Walli, C. Farwell, S.J. Bograd, D.G. Foley, M. Castleton, B.A. Block. 2015. Direct quantification of energy intake in an apex marine predator suggests physiology is a key driver of migrations. *Science Advances*, 1:e. doi:0.1126/sciadv.1400270.
- Scales, K.L., P.I. Miller, S.N. Ingram, **E.L. Hazen**, S.J. Bograd & R.A. Phillips. 2015. Identifying predictable foraging habitats for a wide-ranging marine predator using ensemble ecological niche models. *Diversity & Distributions* 22(2): 212-224. doi:10.1111/ddi.12389
- M.G. Connors, **E.L. Hazen**, S.A. Shaffer, 2015. Shadowed by Scale: Subtle Behavioral Niche Partitioning Revealed at the Individual and Species Level in Two Sympatric, Tropical, Chick-Brooding Albatross Species. *Movement Ecology*, 3:28. DOI 10.1186/s40462-015-0060-7
- L.H. Thorne, **E.L. Hazen**, S.J. Bograd, D.G. Foley, M.G. Connors, M.A. Kappes, H.M. Kim, Y. Tremblay, D.P. Costa, and S.A. Shaffer, 2015. Sympatric North Pacific albatross species show contrasting responses to climate variability. *Movement Ecology*, 3:27 DOI: 10.1186/s40462-015-0050-9
- T.M. Thys, J.P. Ryan, H. Dewar, C.R. Perle, K. Lyons, J. O'Sullivan, C. Farwell, M.J. Howard, K.C. Weng, B.E. Lavaniegos, G. Gaxiola-Castro, L.E.M. Bojorquez, **E.L. Hazen**, S.J. Bograd, 2015. Ecology of the Ocean Sunfish, *Mola mola*, in the southern California Current System. *Journal of Experimental Marine Biology and Ecology*. 471: 64-76.
- T. Yamamoto, Y. Watanuki, **E.L. Hazen**, B. Nishizawa, H. Sasaki, A. Takahashi, 2015. Statistical integration of tracking and vessel survey data to incorporate life history differences in habitat models. *Ecological Applications*. doi:10.1890/15-0142.1

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- S.M. Maxwell, **E.L. Hazen**, R. Lewison, D. Dunn, H. Bailey, S.J. Bograd, A.J. Hobday, M. Bennett, S. Benson, D.K. Briscoe, M. Caldwell, D.P. Costa, H. Dewar, T. Eguchi, S. Fossette, L. Hazen, S. Kohin, T. Sippel, L.B. Crowder, 2015. Dynamic ocean management: Defining and conceptualizing real-time management of the ocean. *Marine Policy*. 58: 42-50. doi:10.1016/j.marpol.2015.03.014
- A.B. Carlisle, S.Y. Litvin, **E.L. Hazen**, D.J. Madigan, K.J. Goldman, R. N. Lea, B. A. Block, 2015. Stable isotope analysis and strandings reveal habitat use of juvenile Salmon Sharks, *Lamna ditropis*, in the California Current. *Marine Ecology Progress Series*. 525: 217-228. doi:10.3354/meps11183
- R. Lewison, A.J. Hobday, S. Maxwell, **E.L. Hazen**, J.R. Hartog, D.C. Dunn, D. Briscoe, S. Fossette, C. E. O’Keefe, M. Barnes-Mauthe, M. Abecassi, S. J. Bograd, N. D. Bethoney, H. Bailey, D. Wiley, S. Andrews, E. Howell, L.J. Hazen, L.B. Crowder, 2015. Dynamic Ocean Management: 21st century approaches for marine resource management and conservation. *BioScience* doi:10.1093/biosci/biv018
- J. Goldbogen, **E.L. Hazen**, A. Friedlaender, J. Calambokidis, S. DeRuiter, A. Stimpert, B. Southall, 2015. Prey density and distribution drive the three-dimensional foraging kinematics of the largest filter feeder. *Functional Ecology*, 29: 951–961. doi: 10.1111/1365-2435.12395
- E. Willis-Norton, **E.L. Hazen**, S. Fossette, G. Shillinger, R. Rykaczewski, D.G. Foley, J. Dunne, S.J. Bograd. 2015. Climate change impacts on leatherback turtle pelagic habitat in the southeast Pacific. *Deep-Sea Research II*, 2014. doi:10.1016/j.dsr2.2013.12.019
- S.J. Bograd, **E.L. Hazen**, E.A. Howell, and A.B. Hollowed. 2014. The Fate of Fisheries Oceanography: Introduction to the Special Issue. *Oceanography* 27(4):21–25.
- I.M. Belkin, G.L. Hunt, **E.L. Hazen**, J.E. Zamon, R. Schick, R. Prieto, J. Brodziak et al. 2014. Fronts, Fish, and Predators. *Deep Sea Research Part II: Topical Studies in Oceanography*.
- J.W. Young, B. Hunt, T. Cook, J. Llopiz, **E.L. Hazen**, H. Pethybridge, D. Ceccarelli, A. Lorrain, R.J. Olson, V. Allain, C. Menkes, T. Patterson, S. Nicol, P. Lehodey, R. Kloser, H. Arrizabalaga, M. Gasalla. 2014. The trophodynamics of top marine predators: advances and challenges. *Deep Sea Research II*, in press. <http://dx.doi.org/10.1016/j.dsr2.2014.05.015>
- I.D. Schroeder, J.A. Santora, A.M. Moore, C.E. Edwards, J. Fiechter, **E.L. Hazen**, S.J. Bograd, J.C. Field, B.K. Wells. 2014. Application of a data-assimilative regional ocean modeling system for assessing California Current System ocean conditions, krill, and juvenile rockfish interannual variability, *Geophysical Research Letters*, in press. DOI: 10.1002/2014GL061045.
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- J. Stewart, **E.L. Hazen**, S.J. Bograd, A. Byrnes, D. Foley, W. Gilly, B. Robison, J. Field. 2014. Combined climate- and prey-mediated range expansion of Humboldt squid (*Dosidicus gigas*),

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- C. Ware, D. Wiley, A. Friedlaender, M. Weinrich, **E.L. Hazen**, A. Bocconcelli, S. Parks, A. Stimpert, M. Thompson, K. Abernathy. 2014. Bottom Side-Roll Feeding by Humpback Whales (*Megaptera Novaeangliae*) in the Southern Gulf of Maine, USA. *Marine Mammal Science*. doi: 10.1111/mms.12053
- S.M. Maxwell, **E.L. Hazen**, S.J. Bograd, B.S. Halpern, B. Nickel, G.A. Breed, N.M. Teutschel, L. B. Crowder, S. Benson, P.H. Dutton, H. Bailey, M.A. Kappes, C.E. Kuhn, M.J. Weise, B. Mate, S.A. Shaffer, J.L. Hassrick, R.W. Henry, L. Irvine, B.I. McDonald, P.W. Robinson, S. Simmons, B.A. Block, D.P. Costa. 2013. Pelagic predator distributions and anthropogenic impacts: implications for effective spatial management in the California Current. *Nature Communications*. 4:2688. doi: 10.1038/ncomms3688
- B.K. Wells, I.D. Schroeder, J.A. Santora, **E.L. Hazen**, S.J. Bograd, E.P. Bjorkstedt, V.J. Loeb, S. McClatchie, E.D. Weber, W. Watson, A.R. Thompson, W.T. Peterson, R.D. Brodeur, J. Harding, J. Field, K. Sakuma, S. Hayes, W.J. Sydeman, M. Losekoot, S.A. Thompson, J. Largier, S.Y. Kim, F.P. Chavez, C. Barceló, P. Warzybok, R. Bradley, J. Jahncke, R. Goericke, G.S. Campbell, J.A. Hildebrandt, S.R. Melin, R.L. DeLong, J. Gomez-Valdes, B. Laveniegos, G. Gaxiola-Castro, R.T. Golightly, S.R. Schneider, N. Lo, R.M. Suryan, A.J. Gladics, C.A. Horton, J. Fisher, C. Morgan, J. Peterson, E.A. Daly, T.D. Auth, J. Abell. 2013. State of the California Current 2012-2013: Hold the Anchovies. *Calif. Coop. Oceanic Fish. Invest. Rep.* 54: 37-71.
- E.L. Hazen**, R. Suryan, J. Santora, Y. Watanuke, S.J. Bograd, and R. Wilson. 2013. Scales and mechanisms of marine hotspot formation. *Marine Ecology Progress Series*. 487: 177–183
- J.A. Goldbogen, B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, **E.L. Hazen**, E.A. Falcone, G.S. Schorr, A. Douglass, D. Moretti, C. Kyburg, M.F. McKenna, P.L. Tyack. 2013. Blue whales respond to simulated mid-frequency military sonar. *Proceedings of the Royal Society B*. 280: 20130657
- D.M. Palacios, **E.L. Hazen**, I.D. Schroeder, S.J. Bograd. 2013. Modeling the temperature-nitrate relationship in the coastal upwelling domain of the California Current. *Journal of Geophysical Research-Oceans*, 118, doi:10.1002/jgrc.20216.
- Lewis, R., B. Wallace, J. Alfaro-Shigueto, J. Mangel, S. M. Maxwell, **E.L. Hazen**. 2013. Fisheries bycatch: lessons learned from decades of research and conservation. In: J. Wyneken (ed). *The Biology of Sea Turtles, Volume 3*. CRC Press. Ch.12: 329-351.
- E.L. Hazen**, S.J. Jorgensen, R. Rykaczewski, S.J. Bograd, D.G. Foley, I.D. Jonsen, S.A. Shaffer, J. Dunne, D.P. Costa, L.B. Crowder, B.A. Block. 2013. Predicted Habitat Shifts of Pacific Top Predators in a Changing Climate. *Nature Climate Change*. 3: 234-238 DOI: 10.1038/nclimate1686
- I.D. Schroeder, J. Santora, B.A. Black, W.J. Sydeman, **E.L. Hazen**, S.J. Bograd, B.K. Wells. 2013. The North Pacific High and wintertime “pre-conditioning” of California Current productivity. *Geophysical Research Letters*, 40, doi:10.1002/grl.50100.
- J.S. Stewart, **E.L. Hazen**, D.G. Foley, S.J. Bograd, W.F. Gilly. 2012. Marine predator migration during range expansion: Humboldt squid *Dosidicus gigas* in the California Current System. *Marine Ecology Progress Series*, 471: 135-150
- E.L. Hazen**, L.B. Crowder. 2012. Fisheries Ecology in *Encyclopedia of Theoretical Ecology*: University of California Press. Hastings, A. and Gross L. (ed), Volume 4. pp. 280-287.

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- E.L. Hazen**, S. Maxwell, H. Bailey, S.J. Bograd, M. Hamann, P. Gaspar, B.J. Godley, G.L. Shillinger. 2012. Ontogeny in marine tagging and tracking science: technologies and data gaps. *Marine Ecology Progress Series*, 457: 221-240.
- G.L. Shillinger, H. Bailey, S.J. Bograd, **E.L. Hazen**, M. Hamann, P. Gaspar, B.J. Godley, R.P. Wilson, J.R. Spotila. 2012. Tagging through the stages: technical and ecological challenges in observing life histories through biologging. *Marine Ecology Progress Series*, 457: 165-170.
- S.M. Maxwell, **E.L. Hazen**, L.E. Morgan, H. Bailey, R.L. Lewison. 2012. Finding Balance in Fisheries Management. (Response to “Reconsidering the consequences of selective fisheries”). *Science* 336: 413
- B. Espinasse, M. Zhou, Y. Zhu, **E.L. Hazen**, A.S. Friedlaender, D.P. Nowacek, D. Chu, F. Carlotti. 2012. Austral fall transition of mesozooplankton assemblages and krill aggregations in an embayment west of the Antarctic Peninsula. *Marine Ecology Progress Series* 452: 63-80
- G.L. Shillinger, E. Di Lorenzo, H. Luo, S.J. Bograd, **E.L. Hazen**, H. Bailey, J.R. Spotila. 2012. On the Dispersal of Leatherback Turtle Hatchlings from Meso-American Nesting Beaches. *Proceedings of the Royal Society B*. doi: 10.1098/rspb.2011.2348
- B.A. Block, I.D. Jonsen, S.J. Jorgensen, A.J. Winship, S.A. Shaffer, S.J. Bograd, **E.L. Hazen**, D.G. Foley, G.A. Breed, A-L. Harrison, J.E. Ganong, A. Swithenbank, M. Castleton, H. Dewar, B.R. Mate, G.L. Shillinger, K.M. Schaefer, S.R. Benson, M.J. Weise, R.W. Henry and D.P. Costa. 2011. Tracking Apex Marine Predator Movements in a Dynamic Ocean. *Nature* 475: 86–90. DOI:10.1038/nature10082
- E.L. Hazen**, D.P. Nowacek, L. St. Laurent, D. Moretti, P. Halpin. 2011. The Relationship among Oceanography, Prey Fields, and Beaked Whale Foraging Habitat in the Tongue of the Ocean. *PLoS ONE* 6(4): e19269. doi:10.1371/journal.pone.0019269
- D.P. Nowacek, A.S. Friedlaender, P.N. Halpin, **E.L. Hazen**, D.W. Johnston, A.J. Read, M. Zhou, Y. Zhu. 2011. Super-Aggregations of Krill and Humpback Whales in Wilhelmina Bay, Antarctic Peninsula. *PLoS ONE* 6(4): e19173. doi:10.1371/journal.pone.0019173
- P.A. Rudershausen, W.A. Mitchell, J.A. Buckel, E.H. Williams, **E.L. Hazen**. 2010. Developing a two-step fishery-independent design to estimate the relative abundance of deepwater reef fish: application to a marine protected area of the southeastern United States coast. *Fisheries Research* 105: 254-260.
- E.L. Hazen** and D.J. Johnston. 2010. Meridional patterns in the deep scattering layers and top predator distribution in the central equatorial Pacific. *Fisheries Oceanography* 19: 427-433.
- J.S. Shackeroff, **E.L. Hazen**, L.B. Crowder. 2009. Status and Drivers of Change in Marine Ecosystems. in *Ecosystem-based management for the Oceans: Applying Resilience Thinking*, Island Press. McLeod, K.L. and Leslie, H.M. (ed).
- N. Avissar, **E.L. Hazen**, N. Young, L.B. Crowder. 2009. Will it Float? Testing a new technique for reducing sea turtle damage to crab pots. *North American Journal of Fisheries Management* 29: 170-175.
- L.M. Campbell, N.G. Gray, **E.L. Hazen**, J.M. Shackeroff. 2009. Beyond baselines: rethinking priorities for ocean conservation. *Ecology and Society* 14(1): 14.
- A.S. Friedlaender, **E.L. Hazen**, D.P. Nowacek, C. Ware, M. Weinrich, D. Wiley, M. Johnson. 2009. Diel changes in humpback whale (*Megaptera novaeangliae*) feeding behavior in response to prey behavior and distribution. *Marine Ecology Progress Series* 395: 91-100.

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- E.L. Hazen**, A.S. Friedlaender, M. Thompson, C. Ware, M. Weinrich, P. Halpin, D. Wiley. 2009. Three dimensional prey aggregations and fine scale foraging ecology of Humpback whales (*Megaptera novaeangliae*). *Marine Ecology Progress Series* 395: 75-89.
- E.L. Hazen**, J.K. Craig, C.P. Good, L.B. Crowder. 2009. Vertical distribution of fish biomass in hypoxic waters on the Gulf of Mexico Shelf. *Marine Ecology Progress Series* 375: 195-207.
- L.B. Crowder, **E.L. Hazen**, N. Avissar, R. Bjorkland, K. Latanich, M. Ogburn. 2008. The Impacts of Fisheries on Marine Ecosystems and the Transition to Ecosystem-Based Management. *Annual Review of Ecology, Evolution and Systematics* 39: 259-278.
- E.L. Hazen**, J.K. Horne. 2004. Comparing the modelled and measured target-strength variability of walleye pollock, *Theragra chalcogramma*. *ICES Journal of Marine Science* 61:3, 363-377.
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PUBLICATIONS (submitted)

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- M. Jacox, S.J. Bograd, and **E.L. Hazen**, *in press*. Optimal Environmental Conditions and Anomalous Ecosystem Responses in the California Current, *Scientific Reports*
- E.L. Hazen**, D.M. Palacios, K.A. Forney, E.A. Howell, E. Becker, A.L. Hoover, L. Irvine, M. DeAngelis, S.J. Bograd, B.R. Mate, H. Bailey, *in review*. Predictive models of satellite-tag based blue whale density for use in near real-time management, *Journal of Applied Ecology*
- A.S. Friedlaender, D.W. Johnston, J.A. Goldbogen, R.B. Tyson, A. Kaltenberg, A.K. Stimpert, C. Curtice, **E.L. Hazen**, P.N. Halpin, A.J. Read, D.P. Nowacek, *in review*. Prey density drives the foraging strategies of a diving marine megafauna. *Journal of Animal Behavior*
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- E.L. Hazen**, A. Carlisle, S.G. Wilson, J.E. Ganong, M.R. Castleton, S.J. Bograd, B.A. Block, *in prep*. Impacts of the Deepwater Horizon oil spill on bluefin tuna spawning habitat in the Gulf of Mexico. *Proceedings of the Royal Society B*
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PUBLICATIONS (Technical reports)

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- A.J. Read, **E.L. Hazen**, L.J. Hazen, and L. Thorne (2007). Research required to understand the impact of tactical mid-frequency sonar transmission on fish, fisheries and fisheries habitat: Summary of Stakeholder Concerns and Prioritized Research Plan from the Workshop on Mid-Frequency Sonar and Marine Fishes

GRANTS CO-WRITTEN AND RECEIVED

- California Sea-Grant (Co-I)**, Integrating Survey-Based Habitat Models into the California Swordfish Fishery Dynamic Management Tool. 2016-2018 **\$292,831**
- ONR DURIP (Co-I)**, A mobile active acoustic system for measuring baleen whale prey fields to distinguish behavioral responses to military sonar from natural ecological dynamics. 2016 **\$ 329,545**
- NASA Earth Science Applications (Co-I)**, EcoCatch: Improving Ecological and Economic Sustainability of Marine Fisheries Using Remotely-Sensed Oceanographic Data. 2016-2018 **\$678,322**
- NOAA-JPSS (Co-I)**, NOAA JPSS Proving Ground/Risk Reduction Program - Training and Outreach to NMFS and NOS end-users 2015-2016 **\$59,000**
- Office of Naval Research (PI)**, Continuation: Interactions among behavioral responses of baleen whales to acoustic stimuli, oceanographic features, and prey availability 2015-2016 **\$150,319**
- NOAA ISA (Co-I)**, Improving recruitment indices for West Coast groundfish through analysis of spatial patterns and environmental influences. 2015-2016 **\$81,577**
- NOAA BREP (Co-I)**, Real-Time Fisheries Management for Ecological and Economic Sustainability. 2015-2016 **\$240,713**
- NOPP Marine Biodiversity Observation Network (Co-I)**, National Marine Sanctuaries as Sentinel Sites for a Demonstration Marine Biodiversity Observation Network (MBON). 2015-2019 **\$7,388,392**
- NASA Earth Science Applications (Co-I)**, EcoCatch: Improving Ecological and Economic Sustainability of Marine Fisheries Using Remotely-Sensed Oceanographic Data. 2014-2015 **\$247,770**
- National Resource Damage Assessment (Co-I)**, Modeling bluefin tuna habitat and exposure to oil in the Gulf of Mexico. 2012-2014 **\$319,633**
- NASA ROSES (Co-I)**, WhaleWatch: Using satellite telemetry to provide near real-time predictions of whale occurrence in the CCS to reduce anthropogenic impacts. 2012-2014 **\$507,388**
- Office of Naval Research (PI)**, Interactions among behavioral responses of baleen whales to acoustic stimuli, oceanographic features, and prey availability 2011-2014 **\$243,962**
- Fisheries and The Environment (Co-I)**, Humboldt squid as an agent of climate-driven ecosystem interactions in the California Current. 2013 **\$88,994**
- Pacific Islands Climate Change Cooperative (Co-I)**, Behavioral, Dietary, and Demographic Responses of Hawaiian Albatrosses to Environmental Change. 2012-2013 **\$184,231**
- Fisheries and The Environment (PI)**, Identifying hot-spot indices of Pacific Bluefin tuna using

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movement models, foraging events, and environmental data. 2012-2013	\$145,236
NSF Biological Oceanography (SP) , Collaborative Research: The ecological role of a poorly studied Antarctic krill predator: the humpback whale, <i>Megaptera novaeangliae</i> , 2008-2010	\$917,598

PRESENTATIONS

Invited Oral Presentations

Bluefin Futures, Monterey, CA - invited speaker	2016
UC Santa Cruz – Department of Ocean Sciences invited seminar	2016
UC Santa Cruz – Department of Ecology and Evolutionary Biology invited seminar	2014
UC Santa Barbara – Bren School invited seminar	2014
Society for Conservation Biology, <i>International Congress for Conservation Biology</i>	2013
Moss Landing Marine Lab Invited Seminar	2013
Moss Landing Marine Lab Vertebrate Ecology Guest Lecture	2013
Oregon State University Invited Seminar	2013
UNC Wilmington Invited Seminar	2013
SUNY Stonybrook Seminar Series	2013
Society for Conservation Biology, <i>North American Chapter</i>	2012
PICES/ICES Young Scientist Conference	2012
Southern California Marine Mammal Workshop, Panel Lead	2012
Pennsylvania State University, Department of Acoustics Seminar	2012
Society for Marine Mammalogy Biennial – Ecological Modeling Workshop	2009, 2011
San Jose State Seminar Series	2011
Stanford University - Hopkins Marine Station Seminar Series	2011
Southwest Fisheries Science Center – Protected Species Division Retreat	2011
California State University Monterey Bay Guest Lecture	2010
Southwest Fisheries Science Center Seminar Series	2010
Western Washington University Seminar Series	2008
Pelagic Fisheries Research Program	2008
Duke University Marine Lab Guest Lecture	2006

Contributed Oral Presentations

PICES – North Pacific Ocean Conference	2009-2015
CLIOTOP – Climate Change and Top Predators, 2nd symposium	2013, 2015
American Fisheries Society	2003, 2012
Society for Marine Mammalogy Biennial	2007, 2009, 2011, 2013, 2015
Ocean Sciences	2006, 2010, 2012
Eastern Pacific Ocean Conference	2010
International Council for the Exploration of the Seas (ICES)	2002, 2008

Poster Presentations

Biologging III in Hobart, Tasmania	2011
Society for Marine Mammalogy Biennial	2009

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COURSES TAUGHT

Stanford @ SEA 323H, visiting instructor, May 9-25, 2013. Mentored undergraduate students and gave lectures on: 1) ecology of the central tropical Pacific, 2) fisheries acoustics theory and practice, and 3) spatial statistics and habitat modeling

Stanford - Physiological Ecology, guest lecturer, Feb-Mar, 2015. Gave lectures on: 1) climate change and top predators, 2) fine scale foraging ecology, and 3) spatial statistics and habitat modeling

Satellite remote sensing techniques and spatial habitat modeling short course – This course is tailored to students to bring their own projects to analyze the relationship between environmental variables and species distributions using ArcGIS, MATLAB, and R.

- University of Washington, Aug 25-27, 2014; Sep 2-4, 2015
- Oregon State University, Mar. 22-25, 2011; Aug 20-22, 2013;
- Charleston, SC, Mar. 14-18, 2012
- Monterey Peninsula College, Aug 2-11, 2010

Green by Design, Duke University Marine Lab, Fall 2007. The goal of this course was to teach students how to implement environmentally sustainable practices in a practical manner within a variety of settings including businesses, academic institutions, marinas, homes, and restaurants.

MENTORING EXPERIENCE

Ellen Willis-Norton, UC Santa Cruz – MSc advisor: Climate vulnerability analyses for US Fisheries. 2015-present

Mark Morales, UC Santa Cruz – MSc advisor: Climate change effects on US fisheries. 2015-present

Kylie Scales, PhD – CIMEC researcher, co-advised 2015-present

Aaron Carlisle, PhD – NRC Postdoctoral Fellow, co-advised 2014-present

Sabrina Fossette, PhD – NRC Postdoctoral Fellow, co-advised 2012-2014

Sheanna Steingass, Oregon State University – PhD committee member 2015-present

Theresa Kirchner, Oregon State University – MSc committee member 2015-present

Elizabeth McHuron, UC Santa Cruz – PhD committee member 2013-present

Melinda Connors, UC Santa Cruz – PhD committee member 2013-present

Chandra Goetsch, UC Santa Cruz – PhD committee member 2012-present

Justine Jackson-Ricketts, UC Santa Cruz – PhD committee member 2012-present

Ellen Willis-Norton, Hollings Scholar – co-advised: Climate change effects on eastern Leatherback turtle foraging habitat. NOAA ERD, 2011

SELECTED MEDIA COVERAGE

Press associated with: Hazen et al (2015) **Blue whales (*Balaenoptera musculus*) optimize foraging efficiency by balancing oxygen use and energy gain as a function of prey density**. DOI: 10.1126/sciadv.1500469

Daily Mail. “Big gulp: feeding strategy of blue whales revealed”

<http://www.dailymail.co.uk/wires/reuters/article-3257969/Big-gulp-feeding-strategy-blue-whales-revealed.html>

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NPR Science Friday. <http://www.sciencefriday.com/segment/10/02/2015/paxil-reanalysis-mouse-drug-avatars-and-pricey-patties.html>

Washington Post. “Study reveals how the biggest animals on the planet manage to live on teeny tiny shrimp.” <https://www.washingtonpost.com/news/science/wp/2015/10/05/study-reveals-how-the-biggest-animals-on-the-planet-manage-to-live-on-teeny-tiny-shrimp/>

Gizmodo. “How Blue Whales Are Able to Maintain Their Monstrous Size.” <http://gizmodo.com/how-blue-whales-are-able-to-maintain-their-monstrous-si-1734729469>

Press associated with: Hazen et al (2013) **Predicted habitat shifts of Pacific top predators in a changing climate.** *doi:10.1038/nclimate1686*

USA Today. “Ocean creatures face climate consequences” <http://www.usatoday.com/tech/sciencefair/story/2012/09/24/climate-shifts-ahead-for-pacific-ocean-sharks-and-whales/57836736/1>

Washington Post. “Climate change will shift marine predators’ habitat, study says” http://www.washingtonpost.com/national/health-science/climate-change-will-shift-marine-predators-habitat-study-says/2012/09/23/3dbc5ae8-0507-11e2-8102-ebee9c66e190_story.html

San Diego Union Tribune. “Ocean Grocery Store Moving North” <http://www.utsandiego.com/news/2012/sep/24/ocean-grocery-store-moving-north/>

Also: Honolulu Star-Advertiser, Greenwire, Quirks and Quarks – CBC Radio, Talkabout - KZSC Radio, Scorre Nuova energia – Italy, Tehran-Times, UPI

Press associated with: Goldbogen et al (2013) **Blue whales respond to simulated mid-frequency military sonar.** *Proc. B. 280: 20130657*

BBC News. “Blue and beaked whales affected by simulated navy sonar” <http://www.bbc.co.uk/news/science-environment-23115939>

Washington Post. “U.S. military sonar may affect endangered blue whales, study suggests” http://www.washingtonpost.com/national/health-science/us-military-sonar-may-affect-endangered-blue-whales-study-suggests/2013/07/08/ebc76eea-e574-11e2-aef3-339619eab080_story.html

Telegraph, UK. “Blue whales are disturbed by military sonar” <http://www.telegraph.co.uk/earth/wildlife/10158068/Blue-whales-are-disturbed-by-military-sonar.html>

Nature. “Whales hear the noise” http://www.nature.com/nature/journal/v500/n7464/full/500505e.html?WT.ec_id=NATURE-20130829

Press associated with: Nowacek et al (2011) **Super-Aggregations of Krill and Humpback Whales in Wilhelmina Bay, Antarctic Peninsula.** *PLoS ONE 6(4): e19173*

Science Magazine News. “Biggest Ever Assemblage of Whales Isn’t Necessarily Good News” <http://news.sciencemag.org/sciencenow/2011/04/biggest-ever-assemblage-of-whale.html>

Nicholas School of the Environment. “Record Number of Whales, Krill Found in the Antarctic Bays” <http://www.nicholas.duke.edu/news/record-number-of-whales-krill-found-in-the-antarctic-bays>

Press associated with: Block et al (2011) **Tracking apex marine predator movements in a dynamic ocean.** *doi:10.1038/nature10082*

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Nature News. "Migration tracking reveals marine Serengeti"

<http://www.nature.com/news/2011/110622/full/news.2011.379.html>

Washington Post. "West Coast boasts underwater Serengeti, study finds"

http://www.washingtonpost.com/national/health-science/west-coast-boasts-underwater-serengeti-study-finds/2011/06/21/AG9jzzfH_story.html

Press associated with **research and expert opinion**:

Wired Online, "Starving Sea Lion Pups Still Washing Up by the Hundreds in California".

<http://www.wired.com/wiredscience/2013/04/starving-sea-lions-pups/>

New York Times, "Close to Shore, Humpbacks Are Far From Safe".

http://www.nytimes.com/2012/08/21/science/earth/close-to-cape-cod-shore-humpback-whales-are-far-from-safe.html?pagewanted=all&_r=0

<http://green.blogs.nytimes.com/2012/08/22/managing-the-ocean-for-humans-and-whales/>

Monterey Herald, "Monterey Bay Affected by Climate Change".

http://www.montereyherald.com/localnews/ci_23826835/monterey-bay-affected-by-climate-change

HONORS AND AWARDS

ICES/PICES Young Investigator Conference Travel Award April 24-27, 2012

PICES NSF Travel Award October 11-23, 2011

National Research Council Research Associate Program, September 2009-2010

Oak Foundation Teaching Fellowship, Spring 2008

Oak Foundation Writing Fellowship, Summer-Fall 2008

1st Annual Eco-Daredevil Award, April 2008

Duke University Environmental Leadership Award, March 2008

Preparing Future Faculty Fellow, 2007-2008

ICES Young Scientist Travel Award, Fall 2007

Best Poster at Duke University Graduate Student Symposium, Fall 2006

Duke International Research Fellowship, Summer 2006

ASLO Travel Grant, Winter 2006

Duke University Graduate Travel Fellowship, Winter 2006, Spring 2007, Spring 2008

School of Aquatic and Fisheries Sciences Travel Grant, Winter, 2003

Fisheries Society of the British Isles Travel Grant, June 2002

Western Society of Naturalists Travel Grant, September 2001

ARCS (Achievement Rewards for College Scientists) Fellowship 2000-2002

EDITORIAL ACTIVITIES

Editorial Board: *PLoS One* 2014-present

Guest Editor: *Oceanography Magazine* – Special Volume on Fisheries Oceanography. 2014

Deep Sea Research II – Top predators and ocean fronts. 2014

Marine Ecology Progress Series – Physical-biological coupling in marine hotspots. 2013

Marine Ecology Progress Series – Tagging through the stages. 2012

Reviewer: *Science*, *Proceedings of the National Academy of Science*, *PLoS One*, *Marine Ecology Progress Series*, *Proceedings of the Royal Society B*, *Transactions of the American Fisheries Society*, *Transactions in GIS*, *Marine Mammal Science*, *Endangered Species Research*, *Journal of Applied Ecology*, *Fisheries Oceanography*, *Progress in Oceanography*, *Ecological Indicators*, *Methods in Ecology and Evolution*, *Deep Sea Research II*, *Estuaries and*

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Coasts, National Science Foundation, North Pacific Research Board, National Geographic, University of Queensland Thesis

SERVICE

Society for Marine Mammalogy, International Biennial, Co-Organizer, 2014-2016
CLIOTOP III Conference: Co-Organizer, 2015
CLIOTOP, Working Group 2: Physiology, Behaviour and Distribution, Co-Chair, 2013-present
Center for Ocean Solutions Working Group on Dynamic Ocean Management, Member, 2013-2014
NSF “Ocean Tracks,” Scientific Advisor helping to bringing oceanographic, prey, and tracking data into high school curricula. 2012-present
Ocean Sciences: Technology and Climate Change, Session co-organizer, Feb 25, 2012
Global Ocean Biodiversity Initiative Working Group on Ecologically and Biologically Significant Areas, Member, May, 2011
Center for Ocean Solutions Working Group on Coastal Hypoxia, Member, 2011-2012
Center for Ocean Solutions Working Group on Climate Change and Predators, Member, 2011
SMM Ecological Modeling Workshop, Co-organizer, 2011-present
CoML2 Planning Committee, Member, 2011- present
PICES 2011 Session Chair: Bio-physical coupling of marine hotspots, October 16, 2011
Biologging IV Workshop Organizer: Tagging Through the Stages, March 16, 2011
PICES Marine Bird and Mammal Advisory Panel, Member, 2010-present
Nicholas School Technology Committee Representative, 2006-2007
DUML Graduate Student Representative, 2005-2006
American Fisheries Society, Member of UW chapter – chair of outreach and education 2000-2001
FINS president, Fisheries Graduate student council that organizes graduate events. 2000-2001
Salmon in the Classroom, Environmental Education for Washington schools on salmon. 2000-2002

CRUISE EXPERIENCE

SoCAL Behavioral Response Cruise, R/V Truth, Acoustic Technician. Designed and conducted SIMRAD EK-60 echosounder surveys to examine whale behavior relative krill school distribution. July & September 2011, 2012, 2013, 2014, 2015.

Stanford @ SEA, SSV Robert C. Seamans, Visiting Instructor. Helped operate and analyze ADCP and CTD data to examine ecology of the central tropical Pacific. May 2013.

Stellwagen Bank Marine Sanctuary Cruise, R/V Nancy Foster & R/V Auk, Acoustic Technician. Operated and processed SIMRAD EK-60 echosounder data to examine fine scale foraging of humpback whales on sand lance. July-August, 2006-2009, 2011, 2012.

Antarctic Multiscale Habitat of Whales and Prey Cruise, ASRV LM Gould, Acoustic team leader. Operated and processed SIMRAD EK-60 echosounders and ADCP to examine prey field relative to oceanography and foraging whales. April-June, 2009.

Bahama Beaked Whale Habitat Cruise – AUTEK, R/V Roger Revelle, Acoustic Technician. Assembled and conducted SIMRAD EK-60 echosounder surveys, ADCPs, and CTDs to examine oceanography and beaked whale prey field. September, 2008.

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Central Pacific Mammal Assessment Survey, R/V Oscar E. Sette, Acoustic Technician and Mammal Observer. Assembled, conducted, and analyzed SIMRAD EK-60 echosounder surveys to examine broad scale changes in deep scattering layer. March, 2006.

Cross Seamount Survey, R/V Oscar E. Sette, Acoustic Technician. Operated SIMRAD EK-60 echosounder to examine predator foraging on Deep Scattering Layer. April, 2005.

Cape Hatteras Eddy Hunting Cruise, R/V Hatteras, Acoustic Technician. Used SIMRAD EK-60 echosounder to examine plankton distribution relative to physical oceanographic fronts. Summer, 2004.

Gulf of Mexico Hypoxic Zone Sampling, R/V Tommy Munro, Acoustic Technician, Northern Gulf of Mexico. Used SIMRAD EK-60 echosounder to assess fish biomass and vertical distribution in the water column relative to low oxygenated waters. Summer, 2004.

NOAA Juneau Groundfish Assessment, *SS Viking Storm, Auke Bay and surrounding areas*. Acoustic survey and midwater trawls for groundfish around Steller sea lion haulouts. Summer, 2002.

Larval Fish Assessment, *Nugget, San Juan Island*. Helped perform Kvichak and Tucker trawls for larval Rockfish to assess the effectiveness of marine reserves. Spring, 2001.

NOAA AFSC, *Miller Freeman, Gulf of Alaska, Shelikof Strait survey*. Evaluated length-frequencies and sexed Gulf of Alaska species. Winter, 2001.

TIES Research Cruise, *SS Henlopen, Chesapeake Bay*. Conducted Bongo, Tucker and Otter trawls, processed adult length-frequencies, and sorted larval fish. Summer, 1999.

PROFESSIONAL AFFILIATIONS

American Fisheries Society, Ecological Society of America, Fisheries Society of the British Isles, Society of Marine Mammalogy, Society of Conservation Biology, The Oceanographic Society, Western Society of Naturalists