Heather Welch, MSc.

Research Fellow

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I study climate variability and change in ocean ecosystems through the lens of marine predators and fisheries. My research focuses on the intersection of big data, statistical modeling, remote sensing, and decision-support science. I aim to produce practical methodologies and tools that can be widely applied, facilitating the applied management of our fundamentally dynamic world.

Education

2010	B.A. Biology – Environmental Studies
	Whitman College, Walla Walla, WA, USA
2013	MSc. Marine Science
	James Cook University, Townsville, QLD, AUS

Employment history

Apr. 2024 – Feb. 2025	Research Biologist NOAA National Marine Fisheries Service Ecosystem Science Division Monterey, CA, USA
Nov. 2020 – Apr. 2024	Assistant project scientist (NOAA affiliate) UC Santa Cruz Monterey, CA, USA
Nov. 2016 – Nov. 2020	Associate specialist (NOAA affiliate) UC Santa Cruz Monterey, CA, USA
Mar. 2015 – Oct. 2016	Geospatial Analyst (NOAA affiliate) Integrated Statistics Sandy Hook, NJ, USA
Jan. 2014 – Sep. 2014	Research Assistant The Australian Research Council's Centre for Excellence Townsville, QLD, AUS

Publications

2025

Hazen, Elliott, Briana Abrahms, Hannah Blondin, Kylie Scales, Heather Welch. "Building the scientific and analytical framework for Dynamic Ocean Management". Navigating Our Way to Solutions in Marine Conservation. Larry Crowder (Editor). 2025. [link]

2024

Nisi, Anna, **Heather Welch**, Stephanie Brodie [...] Briana Abrahms. "Ship collision risk threatens whales across the world's oceans". *Science*. DOI: 10.1126/science.adp1950 (2024). [link]

- Welch, Heather, Robert Ames, Namrata Kolla, David Kroodsma, Luca Marsaglia, Tommaso Russo, Jordan Watson, Elliott Hazen. "Harnessing AI to map global fishing vessel activity". *One Earth.* DOI: 10.1016/j.oneear.2024.09.009 (2024). [link]
- Santos, Bianca, Elliott Hazen, **Heather Welch**, Nerea Lezama-Ochoa, Barbara Block, Daniel Costa, Scott Shaffer, Larry Crowder. "Beyond boundaries: governance considerations for climate-driven habitat shifts of highly migratory marine species across jurisdictions". *npj Ocean Sustainability*. DOI: 10.1038/s44183-024-00059-5 (2024). [link]
- Farchardi, Nima, Heather Welch, Camrin D. Brawn, Andrew J. Allyn, Steven J. Bograd, Stephanie Brodie, Elliott L. Hazen, Alex Kerney, Nerea Lezama-Ochoa, Katherine E. Mills, Dylan Pugh, Riley Young-Morse, Rebecca L. Lewison. Marine heatwaves redistribute pelagic fishing fleets. *Fish and Fisheries*. DOI: 10.1111/faf.12828 (2024). [link]
- Cimino, Megan A., **Heather Welch**, Santora, Kroodsma, Hazen, Bograd, Warzybok, Jahncke, Shaffer. Tracked gulls help identify potential zones of interaction between whales and shipping traffic. *Marine Ornithology*, 52: 61-67 (2024). [link]
- Welch, Heather, Tyler Clavelle, Timothy White, Megan Cimino, David Kroodsma, & Elliott Hazen. Unseen overlap between fishing vessels and top predators in the northeast Pacific. *Science Advances*, DOI: 10.1126/sciadv.adl5528 (2024). [link]

2023

- Nerea Lezama-Ochoa, Stephanie Bodie, Heather Welch, Michael G. Jacox, Mercedes Pozo Buil, Jerome Fiechter, Megan Cimino, Barbara Muhling, & Elliott Hazen. Divergent responses of highly migratory species to climate change in the California Current. *Diversity and Distributions*, 00, 1–14 (2023). [link]
- Brodie, Steph, Mercedes Pozo Buil, Heather Welch, Steven J. Bograd, Elliott L. Hazen, Jarrod A. Santora, Rachel Seary, Isaac D. Schroeder, and Michael G. Jacox. "Ecological forecasts for marine resource management during climate extremes". *Nature Communications* 14, no 7701 (2023). [link]
- Welch, Heather, Owen R. Liu, Leena Riekkola, Briana Abrahms, Elliott L. Hazen, and Jameal F. Samhouri. "Selection of planning unit size in dynamic management strategies to reduce human-wildlife conflict." *Conservation Biology* (2023). https://doi.org/10.1111/cobi.14201 [link]
- Welch, Heather, Matthew S. Savoca, Stephanie Brodie, Michael G. Jacox, Barbara A. Muhling, Thomas A. Clay, Megan A. Cimino et al. "Impacts of marine heatwaves on top predator distributions are variable but predictable." *Nature Communications* 14, no. 1 (2023): 5188. [link]
- Rubbens, Peter, Stephanie Brodie, Tristan Cordier, Diogo Destro Barcellos, Paul Devos, Jose A. Fernandes-Salvador, Jennifer I. Fincham, Heather Welch, et al. "Machine learning in marine ecology: an overview of techniques and applications." *ICES Journal of Marine Science* 80, no. 7 (2023): 1829-1853. [link]
- Braun, Camrin D., Nerea Lezama-Ochoa, Nima Farchadi, Martin C. Arostegui, Michael Alexander, Andrew Allyn, Steven J. Bograd, **Heather Welch**, et al. "Widespread habitat loss and redistribution of marine top predators in a changing ocean." *Science Advances* 9, no. 32 (2023): eadi2718. [link]

- Braun, Camrin D., Martin C. Arostegui, Nima Farchadi, Michael Alexander, Pedro Afonso, Andrew Allyn, Steven J. Bograd, **Heather Welch**, et al. "Building use-inspired species distribution models: Using multiple data types to examine and improve model performance." *Ecological Applications* (2023): e2893. [link]
- Adamson, Adewole S., **Heather Welch**, and H. Gilbert Welch. "Melanoma Incidence by Sex, Indoor Tanning, and Body Site—Reply." *JAMA Internal Medicine* 183, no. 4 (2023): 390-391. [link]
- Smith, James A., Mercedes Pozo Buil, Barbara Muhling, Desiree Tommasi, Stephanie Brodie, Timothy H. Frawley, Jerome Fiechter, Heather Welch, et al. "Projecting climate change impacts from physics to fisheries: A view from three California Current fisheries." *Progress in Oceanography* 211 (2023): 102973. [link]
- Frawley, Timothy H., Barbara Muhling, Stephanie Brodie, Hannah Blondin, Heather Welch, Martin C. Arostegui, Steven J. Bograd et al. "Dynamic human, oceanographic, and ecological factors mediate transboundary fishery overlap across the Pacific high seas." *Fish and Fisheries* (2023). [link]

2022

- Welch, Heather, Tyler Clavelle, Timothy D. White, Megan A. Cimino, Jennifer Van Osdel, Timothy Hochberg, David Kroodsma, and Elliott L. Hazen. "Hot spots of unseen fishing vessels." *Science Advances* 8, no. 44 (2022): eabq2109. [link]
- Adamson, Adewole S., Heather Welch, and H. Gilbert Welch. "Association of UV radiation exposure, diagnostic scrutiny, and melanoma incidence in US counties." *JAMA Internal Medicine* 182, no. 11 (2022): 1181-1189. [link]
- Frawley, Timothy H., Barbara Muhling, Heather Welch, Katherine L. Seto, Shui-Kai Chang, Francisco Blaha, Quentin Hanich et al. "Clustering of disaggregated fisheries data reveals functional longline fleets across the Pacific." One Earth 5, no. 9 (2022): 1002-1018. [link]
- Cimino, Megan A., Scott A. Shaffer, **Heather Welch**, Jarrod A. Santora, Pete Warzybok, Jaime Jahncke, Isaac Schroeder, Elliott L. Hazen, and Steven J. Bograd. "Western Gull Foraging Behavior as an Ecosystem State Indicator in Coastal California." *Frontiers in Marine Science* 8 (2022): 790559. [link]

2021

- Hazen, Elliott L., Briana Abrahms, Stephanie Brodie, Gemma Carroll, Heather Welch, and Steven J. Bograd. "Where did they not go? Considerations for generating pseudo-absences for telemetrybased habitat models." *Movement Ecology* 9 (2021): 1-13. [link]
- Breece, Matthew W., Matthew J. Oliver, Dewayne A. Fox, Edward A. Hale, Danielle E. Haulsee, Matthew Shatley, Steven J. Bograd, Elliott L. Hazen, and Heather Welch. "A satellite-based mobile warning system to reduce interactions with an endangered species." *Ecological Applications* 31, no. 6 (2021): e02358. [link]
- Brodie, Stephanie, Briana Abrahms, Steven J. Bograd, Gemma Carroll, Elliott L. Hazen, Barbara A. Muhling, Mercedes Pozo Buil, James A. Smith, Heather Welch, and Michael G. Jacox.
 "Exploring timescales of predictability in species distributions." *Ecography* 44, no. 6 (2021): 832-844. [link]

Smith, James A., Desiree Tommasi, Heather Welch, Elliott L. Hazen, Jonathan Sweeney, Stephanie Brodie, Barbara Muhling, Stephen M. Stohs, and Michael G. Jacox. "Comparing dynamic and static time-area closures for bycatch mitigation: a management strategy evaluation of a swordfish fishery." *Frontiers in Marine Science* 8 (2021): 630607. [link]

2020

- Becker, Elizabeth A., James V. Carretta, Karin A. Forney, Jay Barlow, Stephanie Brodie, Ryan Hoopes, Michael G. Jacox, Heather Welch, et al. "Performance evaluation of cetacean species distribution models developed using generalized additive models and boosted regression trees." *Ecology and evolution* 10, no. 12 (2020): 5759-5784. [link]
- Savoca, Matthew S., Stephanie Brodie, Heather Welch, Aimee Hoover, Lee R. Benaka, Steven J. Bograd, and Elliott L. Hazen. "Comprehensive bycatch assessment in US fisheries for prioritizing management." *Nature Sustainability* 3, no. 6 (2020): 472-480. [link]
- Welch, Heather, S. Brodie, M. G. Jacox, D. Robinson, C. Wilson, S. J. Bograd, M. J. Oliver, and E. L. Hazen. "Considerations for transferring an operational dynamic ocean management tool between ocean color products." *Remote sensing of Environment* 242 (2020): 111753. [link]
- Welch, Heather, Stephanie Brodie, Michael G. Jacox, Steven J. Bograd, and Elliott L. Hazen. "Decisionsupport tools for dynamic management." *Conservation Biology* 34, no. 3 (2020): 589-599. [link]
- Smith, James A., Desiree Tommasi, Jonathan Sweeney, Stephanie Brodie, Heather Welch, Elliott L. Hazen, Barbara Muhling, Steven M. Stohs, and Michael G. Jacox. "Lost opportunity: quantifying the dynamic economic impact of time-area fishery closures." *Journal of Applied Ecology* 57, no. 3 (2020): 502-513. [link]

2019

- McHenry, Jennifer, **Heather Welch**, Sarah E. Lester, and Vincent Saba. "Projecting marine species range shifts from only temperature can mask climate vulnerability." *Global Change Biology* 25, no. 12 (2019): 4208-4221. [link]
- Abrahms, Briana, **Heather Welch**, Stephanie Brodie, Michael G. Jacox, Elizabeth A. Becker, Steven J. Bograd, Ladd M. Irvine, Daniel M. Palacios, Bruce R. Mate, and Elliott L. Hazen. "Dynamic ensemble models to predict distributions and anthropogenic risk exposure for highly mobile species." *Diversity and Distributions* 25, no. 8 (2019): 1182-1193. [link]
- Maxwell, Sara M., Kylie L. Scales, Steven J. Bograd, Dana K. Briscoe, Heidi Dewar, Elliott L. Hazen, Rebecca L. Lewison, Heather Welch, and Larry B. Crowder. "Seasonal spatial segregation in blue sharks (Prionace glauca) by sex and size class in the Northeast Pacific Ocean." *Diversity and Distributions* 25, no. 8 (2019): 1304-1317. [link]
- Welch, Heather, Elliott L. Hazen, Dana K. Briscoe, Steven J. Bograd, Michael G. Jacox, Tomoharu Eguchi, Scott R. Benson et al. "Environmental indicators to reduce loggerhead turtle bycatch offshore of Southern California." *Ecological Indicators* 98 (2019): 657-664. [link]
- Welch, Heather, Elliott L. Hazen, Steven J. Bograd, Michael G. Jacox, Stephanie Brodie, Dale Robinson, Kylie L. Scales, Lynn Dewitt, and Rebecca Lewison. "Practical considerations for operationalizing dynamic management tools." *Journal of Applied Ecology* 56, no. 2 (2019): 459-469. [link]

2018

- Hazen, E. L., K. L. Scales, S. M. Maxwell, D. K. Briscoe, Heather Welch, S. J. Bograd, H. Bailey et al. "A dynamic ocean management tool to reduce bycatch and support sustainable fisheries. Sci Adv 4: eaar3001." (2018). [link]
- Welch, Heather, and Jennifer McHenry. "Planning for dynamic process: An assemblage-level surrogate strategy for species seasonal movement pathways." *Aquatic Conservation: Marine and Freshwater Ecosystems* 28, no. 2 (2018): 337-350. [link]
- Welch, Heather, Robert L. Pressey, and April E. Reside. "Using temporally explicit habitat suitability models to assess threats to mobile species and evaluate the effectiveness of marine protected areas." *Journal for Nature Conservation* 41 (2018): 106-115. [link]
- Brodie, Stephanie, Michael G. Jacox, Steven J. Bograd, **Heather Welch**, Heidi Dewar, Kylie L. Scales, Sara M. Maxwell et al. "Integrating dynamic subsurface habitat metrics into species distribution models." *Frontiers in Marine Science* (2018): 219. [link]

2016

Welch, Heather, Robert L. Pressey, Scott F. Heron, Daniela M. Ceccarelli, and Alistair J. Hobday. "Regimes of chlorophyll-a in the Coral Sea: Implications for evaluating adequacy of marine protected areas." *Ecography* 39, no. 3 (2016): 289-304. [link]

Research funding

- NOAA IRA Remote Sensing (Collaborator) Expanding Dynamic Ocean Management beyond the US West Coast. 2024-2026 \$513,805
- NOAA IRA Data Modernization (Collaborator) Creating operational forecasts and long term projections for protected species. 2024-2026 \$883,315
- NOAA Office of Habitat (Senior personnel, led proposal) Dynamic Essential Fish Habitat for Pacific Highly Migratory Species. 2023 \$105,000
- NSF OPP (Co-PI) Collaborative Research: Harvesting Long-term Survey Data to Develop Zooplankton Distribution Models for the Antarctic Peninsula 2022-2024 \$398,000
- NOAA CPO (PI) Projecting changes to habitat suitability and connectivity for predators and prey in California sanctuaries 2022-2024 \$499,948
- CA OPC (Senior personnel) Near-Real Time Ecosystem Data for Risk Assessment and Mitigation of Whale Entanglements in California's Dungeness Crab Fishery. 2022-2023 \$599,661
- CA OPC (PI) Monitoring leatherback turtle distribution and migration to reduce entanglement risk in the California Current. 2022-2023 \$550,342
- CA RAMP (Senior personnel) Spatial conservation tools to reduce blue and humpback whale entanglement risk while supporting California's Dungeness crab fishery. \$105,000

- NOAA IUU FY20 (Collaborator) A dynamic prediction system for potential IUU activities including unauthorized transshipments, and the distributions of key shark and tuna species to guide OLE enforcement activities, 2020-2021 \$571,360
- NOAA IUU FY20 (Senior personnel, led proposal) Dynamic decision-support tools to counter IUU fishing for North Pacific albacore, 2020-2021 \$508,748

Catena Foundation (Co-PI, led proposal) Illuminating Suspicious Activity at Sea, 2019-2021 \$150,000

NASA SDG14 (Collaborator) Supporting climate-ready and sustainable fisheries, 2018-2021 \$852,084

- NOAA FIS/NOP (Collaborator) Enhancing the quality and utility of data collected by observers and increasing the accessibility of National Bycatch Report data, 2019 \$93,529
- NOAA JPSS (Senior personnel), Using VIIRS to operationalize dynamic EBFM tools on the U.S. East and West Coasts, 2018-2020 \$590,399
- Benioff Ocean Initiative (Senior personnel), Downscaling models for blue whales from tracking data in the California Current, 2018-2020 \$465,883
- NOAA COCA (Collaborator), Understanding Climate Impacts on Fish Stocks and Fisheries in the California Current Large Marine Ecosystem, 2018-2021 \$1,998,615
- NASA Earth Science Applications (Collaborator), A satellite-based mobile warning system to reduce
Atlantic Sturgeon interactions in Delaware waters, 2017-2018\$419,501
- NOAA BREP (Collaborator), El Niño Watch revised An improved index for reducing Loggerhead Turtle bycatch in the California Current. 2016-2017 \$215,436
- NASA Earth Science Applications (Collaborator), EcoCatch: Improving Ecological and Economic Sustainability of Marine Fisheries Using Remotely-Sensed Oceanographic Data. 2016-2018

\$1,125,712

Synergistic activities

1. Mentorship

Josh Cullen | UC Santa Cruz postdoc | 2024-present Max Czapanskiy | UC Santa Cruz postdoc | 2024 Megan Kavanaugh | Hollings Scholar | 2024 Alexis Hadinger | Hollings Scholar | 2024 Jamon Jordan | MSI NERTO fellow | 2023 Tatum Delaney | Hollings Scholar | 2023 Lorenzo Davidson Hollings Scholar | 2023 Kaila Frazer | LaPenta Scholar | 2023 Adena Schonfeld | UC Santa Cruz postdoc | 2022-present Ryan Gasbarro | UC Santa Cruz postdoc | 2022-present Nima Farchadi | UC Davis PhD student | 2021-2024 Dan Palance | UC Santa Cruz PhD student | 2021-present Nerea Lezama Ochoa | UC Santa Cruz postdoc | 2020-present

2. Presentations and workshops

NOAA Openscapes | workshop | attendee | virtual | 2024 The Nature Conservancy | workshop | invited presentation | virtual | 2024 NOAA National Marine Sanctuaries | workshop | invited presentation | virtual | 2024 Greater Farallon's Association | workshop | invited presentation | virtual | 2024 Salish Sea Science Roundtable | seminar series | invited talk | virtual | 2023 Pacific Grove Library | seminar | invited presentation | USA | 2023 Pacific Fisheries Management Council | council meeting | invited talk | virtual | 2023 Machine Learning in Monterey Bay | workshop | co-convenor | USA | 2021 NOAA Environmental Data Workshop | workshop | invited presentation | virtual | 2021 ASLO | conference | invited presentation | virtual | 2021 NOAA Northwest Fisheries Science Center | seminar series | invited presentation | virtual | 2020 AGU | conference | invited presentation | USA | 2019 AFS/TWS | conference | invited presentation | USA | 2019 Global Fishing Watch | workshop | attendee | USA | 2019 Species on the Move | conference | presentation | South Africa | 2019 Species on the Move | workshop | co-convenor | South Africa | 2019 Ocean Visions | conference | invited presentation | USA | 2019 OCTO / EBM Tools | seminar series | invited presentation | virtual | 2019 OCTO / EBM Tools | seminar series | invited presentation | virtual | 2019 Ocean Sciences | conference | poster | Oregon | 2018 IMCC | conference | presentation | Borneo | 2018 ICCB | conference | presentation | Columbia | 2017 IMCC | conference | presentation | Newfoundland | 2016

3. Long-term collaborations

Benioff Ocean Initiative | 2018-present Global Fishing Watch | 2019-present California Department of Fish and Wildlife | 2021-present Ecological Forecasting Initiative | 2018-present NOAA's West Coast Regional Office | 2017-present

Popular Science Writing

- **2024.** The Conversation. "Sharks, turtles, and other sea creatures face greater risk from industrial fishing than previously thought we estimated added pressure from 'dark' fishing vessels" [link]
- **2023.** LA Times. "Opinion: Oceans are heating up. Who will protect the turtles, whales and fish crossing boarders into cooler waters?" [link]
- **2022. The Conversation.** "When fishing boats go dark at sea, they're often committing crimes we mapped where it happens" [link]
- **2019.** LA Times. "Op-Ed: A new strategy is saving endangered California sea turtles from deadly fishing nets" [link]

- **2019. MPA News.** "Perspective: Building environmental change into spatial closures to reduce sea turtle bycatch" [link]
- 2019. The Skimmer. "New tools for dynamic ocean management: EcoCast vs. Marxan and more" [link]
- **2018. Eco Magazine.** "Protecting changing oceans: ecological forecasts to improve fisheries sustainability" [link]
- 2018. The Conversation. "Fishing forecasts can predict marine creature movements" [link]
- **2018.** The Conversation. "To conserve ocean life, marine reserves need to protect species that move around" [link]
- 2016. PLoS Blogs. "Conserving ocean life: three ways to improve U.S. marine protected areas" [link]

Select media appearances

2025. ABC. Fired NOAA scientists detail how federal layoffs could impact NorCal coast 'for generations to come'. [<u>link</u>]

2024. UC Santa Cruz. Fewer than 7% of global hotspots for whale-ship collisions have protection measures in place. [link]

2024. National Fisherman. AI to combat illegal fishing and enhance vessel tracking. [link]

2024. The Lever. Deadly harvest: The hidden cost of your Filet-O-Fish. [link]

2024. UC Santa Cruz. Industrial fishing poses greater risk to marine life due to untracked activity. [link]

2023. The New York Times. Where will the whales be? Ask the climate model. [link]

2023. The LA Times. As heat waves warm the Pacific ocean, effects on ocean life remain murky. [link]

2023 Newsweek. Here's which sea animals are most hurt by US heatwaves. [link]

2023 NOAA Fisheries. New research predicts effects of marine heatwaves on top ocean predators. [link]

2023. The Washington Post. A boat went dark. Finding it could help save the world's fish. [link]

2023. The Conversation. Protecting the ocean: 5 essential reads on invasive species, overfishing and other threats to sea life. [link]

2022. Science Magazine. AI may help authorities track 'ghost' fishing boats. [link]

2022. The Guardian. At last 6% of global fishing 'probably illegal' as ships turn off tracking devices. [link]

2022. Nature. Suspected illegal fishing revealed by ships' tracking data. [link]

2022. UC Santa Cruz. Global analysis shows where fishing vessels turn off their identification devices. [link]

2022. The Academic Minute. Illuminating dark fishing vessels at sea. [link]

2022. Quirks and Quarks. Tracking illegal fishing by watching when ships go into stealth model. [link]

2022. Global Fishing Watch. Global analysis shows where fishing vessels' identification devices have been switched off. [link]

2020. Earth Island Journal. Going Mobile: Are dynamic marine protected area the solution to our rapidly changing ocean ecosystems? [link]

2018. Scientific American. To protect ocean life, marine reserves have to be redrawn based on science. [link]

Analytical skillset

Programming languages: R, bash, markdown, arcpy, VBA, SQL, CDO, git Statistical modeling: GAMs, GLMs, linear regression Machine learning models: BRT, BART, maxent Database management: MS Excel, arc geodatabase, Oracle Data visualization techniques: tidyverse, rmarkdown, gifs, leaflet Optimization algorithms: Marxan, PrioritizR Geospatial data repositories: CMEMS, ERDDAP, PSL Geospatial data access: ftp, THREDDS, curl, OPeNDAP Interactive web applications: https://welch.sites.ucsc.edu/shiny-apps/ Operational tools: https://welch.sites.ucsc.edu/operational-tools/