Farallon Institute Annual Report 2017

Research for Healthy Ocean Ecosystems

Friends,

Dr. Jeffrey Dorman
Executive Director

During the summer of 2017, Farallon Institute marched past our 10-year anniversary-- a remarkable feat for any non-profit. We celebrated this milestone quietly in the office and took a moment to think about the goals and mission of Farallon Institute. Remarkably, the mission statement written 10 years ago by Founder, President, and Senior Scientist Bill Sydeman, remains as true today as it was in 2007. We continue to be "***dedicated to the understanding and preservation of healthy marine ecosystems***" and strive to "***provide the scientific basis for ecosystem-based management practices and policy reforms consistent with a productive marine world*****"**.

Farallon Institute had another strong year in 2017. We produced sound scientific results, published and presented those results in prestigious journals and conferences, and made our work available to management and policy forums. Farallon Institute continues to be a leader in interdisciplinary marine science that is influential to state and federal fisheries management. Under the leadership of Julie Thayer, our work on forage fish and its importance for top predator populations continues to be a big part of our research portfolio. Our long-term seabird datasets provide valuable insight into the impact of climate change on the California Current. Additionally, we are launching new multi-year initiatives aimed at understanding global ocean productivity and "life in a moving ocean" (supported by NASA), and coming up with the first coastwide krill biomass estimate for California. These are exciting times.

Farallon Institute has also been working to expand our outreach and education efforts. We kicked off 2018 with a "State of the Ocean" talk in Petaluma that was attended by over 150 people. We are aiming to bring this talk to other communities in northern California this year and have six more events scheduled in 2018. We could not do this work with the support of the larger community: scientists we collaborate with, the funding agencies who value our work, and individuals who support science and marine

conservation. Thank you and we hope to see you at one of our “State of the Ocean” talks later this year.

With warm regards,

Jeff

FARALLON INSTITUTE TEAM 2017

Jeffrey Dorman, Ph.D., Executive Director, Principal Scientist
William Sydeman, Ph.D., President, Senior Scientist
Marisol Garcia-Reyes, Ph.D., Principal Scientist
Emily Klein, Ph.D., Post-Doctoral Research Associate
Mike Litzow, Ph.D., Principal Scientist
Marcel Losekoot, M.Sc., Programmer/Analyst
Heather Robinson, M.Sc., Scientist
Maryanne Romanowski, M.Sc., Financial Administrator
Amber Szoboszlai, M.Sc., Scientist
Julie Thayer, Ph.D., Principal Scientist
Sarah Ann Thompson, M.Sc., Scientist
Ramona Zeno, M.Sc., Scientist
Canine Office Assistants Keshi, Julio, Charlie, and Lucy

HIGHLIGHTS

Climate and Marine Ecosystems

Seabird Surveys - 315 seabird nests on Alcatraz Island were monitored from March-September. 91 days at sea were logged during CalCOFI and NMFS juvenile rockfish surveys; over 50,000 individual seabirds from 55 species were tallied.

North Pacific Biogeography - Under new funding from NASA, Farallon Institute (in collaboration with Earth Space Research and Sir Alistair Hardy Foundation for Ocean Sciences) is studying the North Pacific Current and its effect on plankton communities.

Saildrone - Farallon Institute is partnering with Saildrone to pilot an autonomous sailing vehicle from San Francisco to Mexico, examining the variability in krill populations along the continental shelf.

Left: Saildrone autonomous sailing vehicle and the Golden Gate Bridge. Right: Brandt's cormorant on Alcatraz Island.

Forage & Fisheries Management

Anchovy Studies - Anchovy research continues to focus on understanding and predicting population dynamics and age structure relative to ocean climate.

Herring Fisheries Management Plan – We developed options for San Francisco herring fisheries management in relation to ecosystem considerations for the California Department of Fish and Wildlife. This work was done in collaboration with SeaChange Analytics.

Antarctic Marine Protected Areas – We used an ecosystem model to understand the potential of ocean warming, fishing, and alternative management strategies to impact Antarctic krill, their predators, and the krill fishery there. Results deliver scientific advice for current and future international policy decisions in the region, constituting a direct link between cutting-edge science and on-the-ground management strategies.

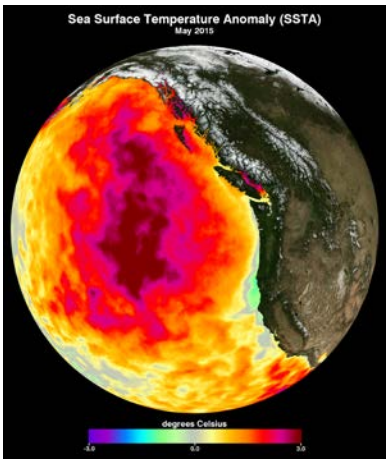
Krill Acoustics - Over 6,000 miles of coastal ocean in the California Current were surveyed for krill, extending our time series to eighteen years. Funding was secured to convert krill estimates to a biomass index to better inform management efforts.

Krill Camera - An autonomous camera was deployed on Cordell Bank in 85 meters of water for four months. Analysis of images is currently underway and redeployment is planned in March 2018.

Education and Outreach

State of the Ocean - We presented the "State of the Ocean" to Cordell Bank National Marine Sanctuary advisory body and laid the groundwork for multiple talks in early 2018.

Social Media - Expanded and launched Farallon Institute social media accounts.



Left: Sea surface temperature image showing the extent of the 2014–2015 Marine Heat Wave, from Gentemann et al. 2017 *Geophysical Research Letters*. Right: Heather Robinson and Bill Sydeman at the 2017 Pacific Seabird Group Annual Meeting in Tacoma, Washington.

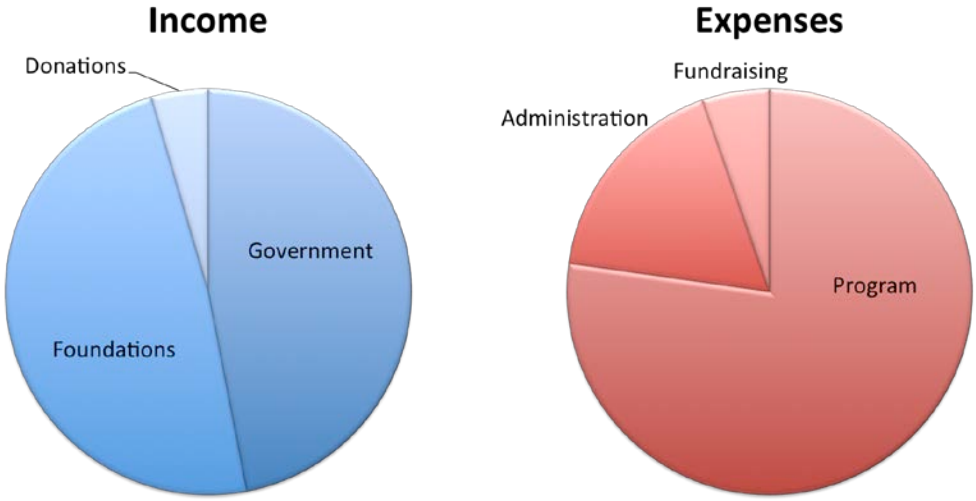
ACCOMPLISHMENTS BY THE NUMBERS

- 15 papers published in the peer-reviewed literature
- 3 technical reports published
- 5 papers in press
- 4 conferences or symposia attended
- 3 invited presentations given
- 10 oral presentations given
- 2 posters presented

*A full list of publications is shown on page 7, and a full list of presentations is shown on page 10.

FINANCIALS: JANUARY-DECEMBER, 2017

Farallon Institute continued to experience steady growth in 2017. Income and Expenses were approximately $800,000; we have 11 members on our team, 8 of whom are full-time employees, and all have advanced degrees. Our support sources and expenditures break-down have essentially stayed similar to previous years.



FUNDERS

We could not accomplish our research without the support of government agencies, private foundations, and individuals committed to our work. Thank you.

Federal and State Agencies

National Park Service
National Science Foundation
National Oceanic and Atmospheric Administration
Southern California Ocean Observing System
Office of Naval Research
United States Geological Survey
North Pacific Research Board

Foundations

Marisla Foundation
National Fish and Wildlife Foundation
Golden Gate National Parks Conservancy
SunLight Time Foundation
Google.org
The Pew Charitable Trusts
Strong Foundation

Individual Donors

California Current Level > $1000

Chelle Gentemann
Hope Millholland
Spencer Seidman
Heather Haggarty & Jon Levine
Ann & Bob Phillips
Richard Thayer

Gulf of the Farallones Level > $500

Tom Baudendistel & Lisa Kinoshita
Bill & Kia Conn
Harry & Jo Dorman
Adam Bauserman
Courtney & Jeff Dorman
Bahman Rabii

Cordell Bank Level > $100

Ruth Dietrich
Richard & Janis Kinoshita
Curt Mason
John Raff
Tony Freicas & Sandy Profeta
Dominic Mantua
Glen Boehm & Mozhgan Mizban
Kathleen and Vern Winters

<u>Volunteers and Supporters</u>

Tanner Boeger
Chris Carney
Kate Ciungan
Rick Johnston
Ron LeValley
Emma Roach
Laura Burgess
Tien Chang
Leah Drapkin
Joey Kolasinsky
Sherie Michaile

PUBLICATIONS

Black, B.A., P. van der Sleen, E. Di Lorenzo, D. Griffin, W.J. Sydeman, J.B. Dunham, R.R. Rykaczewski, M. Garcia-Reyes, M. Safeeq, I. Arismendi, and S.J. Bograd. Rising synchrony controls western North American ecosystems. *Global Change Biology*, in press.

Davison, P., W.J. Sydeman, and J.A. Thayer. Are there temporal or spatial gaps in recent estimates of anchovy off California? *CalCOFI Reports* 58:56-68.

Delegation of the USA, with E.S. Klein. Model-based ecosystem risk assessments of MPA scenarios in Planning Domain 1. SC-CAMLR-XXXVI/BG/27. Hobart, Australia.

Garcia-Reyes, M. and W.J. Sydeman. California Multivariate Ocean Climate Indicator (MOCI) and marine ecosystem dynamics. *Ecological Indicators* 72:521–529.

Garcia-Reyes, M., T. Lamont, W.J. Sydeman, B.A. Black, R.R. Rykaczewski, S.A. Thompson, and S.J. Bograd. A comparison of modes of upwelling variability in the Benguela and California current ecosystems. *Journal of Marine Systems*, in press.

Gentemann, C.L., M.R. Fewings, and M. Garcia-Reyes. Satellite sea-surface temperatures along the west coast of the United States during the 2014-2016 northeast Pacific marine heat wave. *Geophysical Research Letters* 44:312–319.

Harvey, C., N. Garfield, G. Williams, K. Andrews, C. Barcelo, K. Barnas, S. Bograd, R. Brodeur, B. Burke, J. Cope, L. deWitt, J. Field, J. Fisher, C. Greene, T. Good, E. Hazen, D. Holland, M. Jacox, S. Kasperski, S. Kim, A. Leising, S. Melin, C. Morgan, S. Munsch, K. Norman, W.T. Peterson, M. Poe, J. Samhouri, I. Schroeder, W. Sydeman, J. Thayer, A. Thompson, N. Tolimieri, A. Varney, B. Wells, T. Williams, and J. Zamon. Ecosystem status report of the California Current for 2017: A summary of ecosystem indicators compiled by the California Current Integrated Assessment Team (CCIEA). U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-139. 61 pp.

ICES, with E.S. Klein. Interim report of the working group on the history of fish and fisheries. (WGHIST). ICES CM 2016/SSGEPI:20. 51 pp.

Kaplan, I.C., T.B. Francis, A.E. Punt, L.E. Koehn, E. Curchitser, F. Hurtado-Ferro, K.F. Johnson, S.E. Lluch-Cota, W.J. Sydeman, T.E. Essington, N. Taylor, K. Holsman, A.D. MacCall, and P.S. Levin. A multi-model approach to understanding the role of Pacific sardine in the California Current food web. *Marine Ecology Progress Series*, in press.

Klein, E.S., M.R. Barbier, and J.R. Watson. The dual impact of ecology and management on social incentives in marine common-pool resource systems. *Royal Society Open Science* 4:170740.

Koehn, L.E., T.E. Essington, K.N. Marshall, W.J. Sydeman, A.I. Szoboszlai, and J.A. Thayer. Trade-offs between forage fish fisheries and their predators in the California Current. *ICES Journal of Marine Science* 74:2448–2458.

Lamont, T., M. Garcia-Reyes, S.J. Bograd, C.D. van der Lingen, and W.J. Sydeman. Upwelling indices for comparative ecosystem studies: variability in the Benguela Upwelling System. *Journal of Marine Systems*, in press.

Litzow, M.A. Indications of hysteresis and early warning signals of reduced community resilience during a Bering Sea cold anomaly. *Marine Ecology Progress Series* 571:13–28.

Piatt, J.F., M. Arimitsu, W.J. Sydeman, S.A. Thompson, H. Renner, S. Zador, D. Douglas, S. Hatch, A. Kettle, and J. Williams. Biogeography of pelagic food webs in the North Pacific. *Fisheries Oceanography*, in press.

Puritty, C., L.R. Strickland, E. Alia, B. Blonder, E.S. Klein, M.T. Kohl, E. McGee, M. Quintana, R.E. Ridley, B. Tellman, and L.R. Gerber. For diversity initiatives, current best efforts may not be enough. *Science* 357:1101-1102.

Santora, J.A., J.G. Dorman, and W.J. Sydeman. Modeling spatiotemporal dynamics of krill aggregations: size, intensity, persistence, and coherence with seabirds. *Ecography* 40:1300–1314.

Santora, J.A., W.J. Sydeman, I.D. Schroeder, J.C. Field, R.R. Miller, and B.K. Wells. Persistence of trophic hotspots and relation to human impacts within an upwelling marine ecosystem. *Ecological Applications* 27:560–574.

Silber, G.K., M. Lettrich, P.O. Thomas, J. Baker, M. Baumgartner, E.A. Becker, P. Boveng, D.M. Dick, J. Fiechter, J. Forcada, K. Forney, R.B. Griffis, J. Hare, A.J. Hobday, D. Howell, K.L. Laidre, N. Mantua, L. Quakenbush, J.A. Santora, K. Stafford, P. Spencer, C. Stock, W. Sydeman, K. Van Houtan, and R. Waples. Projecting marine mammal distribution in a changing climate. *Frontiers in Marine Science*, in press.

Sydeman, W.J., S.A. Thompson, J.F. Piatt, M. García-Reyes, S. Zador, J. Williams, M. Romano, and H.M. Renner. Regionalizing indicators for marine ecosystems: Bering Sea - Aleutian Island seabirds, climate, and competitors. *Ecological Indicators* 78:458–469.

Sydeman, W.J., J.F. Piatt, S.A. Thompson, M. García-Reyes, S. Hatch, M. Arimitsu, L. Slater, J. Williams, N. Rojek, S. Zador, and H. Renner. Puffins reveal contrasting relationships between forage fish and ocean climate in the North Pacific. *Fisheries Oceanography* 26:379–395.

Sydeman, W.J., S.A. Thompson, T. Anker-Nilssen, M. Arimitsu, A. Bennison, S. Bertrand, P. Boersch-Supan, C. Boyd, N. Bransome, R.J.M. Crawford, F. Daunt, R. Furness, D.

Gianuca, A. Gladics, L. Koehn, J. Lang, E. Logerwell, T. Morris, E.M. Phillips, J. Provencher, A. Punt, C. Saraux, L. Shannon, R. Sherley, A. Simeone, R. Wanless, S. Wanless, S. Zador. Best practices for assessing forage fish fisheries-seabird resource competition. *Fisheries Research* 194:209–221.

Sydeman, W.J., J.A. Santora, R. Zeno, J. Hassrick, M. Losekoot, S.A. Thompson, P. Davison, J.C. Field, S. Hayes, and W.T. Peterson. Sensing and mapping krill distribution and abundance in the California Current. NOAA Technical Memo, in press.

Thayer, J.A., A.D. MacCall, P.C. Davison, and W.J. Sydeman. California anchovy population remains low, 2012-2016. *CalCOFI Reports* 58:69-76.

Thompson, S.A., W.J. Sydeman, J.A. Thayer, A. Weinstein, K. Krieger, and D. Hay. Trends in the Pacific herring (*Clupea pallasii*) metapopulation in the California Current Ecosystem. *CalCOFI Reports* 58:77-94.

Wells, B.K., and 43 other authors including W.J. Sydeman. State of the California Current 2016-2017: Still anything but "normal" in the north. *CalCOFI Reports* 58:1-55.

MANUSCRIPTS IN PREPARATION

Caswell, B., E.S. Klein, R. Thurstan, H. Alleway, T. Fortibuoni, J. Hentati-Sundberg, P. Jones, J. Kittinger, M. McKenzie, J. Pandolfi, S. Raicevish, and R. Thorpe. Something old, something blue: 200 years of a blue alga growth agenda. *ICES Journal of Marine Science*, in preparation.

Klein, E.S., J.T. Hinke, and G.M. Watters. Outcomes of marine spatial planning for the krill-centric ecosystem and international fishery in the Scotia Sea. Journal yet to be determined, in preparation

Klein, E.S., S.L. Hill, J.T. Hinke, T. Phillips, and G.M. Watters. Impacts of rising sea temperature on krill increase risks for predators in the Scotia Sea. *PLoS ONE*, in revision.

MacCall, A.D., T.B. Francis, A.E. Punt, D.R. Armitage, J.S. Cleary, S.C. Dressel, R.R. Jones, H. Kitka, L.C. Lee, P.S. Levin, J. McIsaac, D.K. Okamoto, M. Poe, S. Reifenstuhl, A.O. Shelton, J.O. Schmidt, J.J. Silver, M.C. Siple, T.F. Thornton, R. Voss, and J. Woodruff. A heuristic model of learned migration behavior exhibits distinctive spatial and reproduction dynamics. *ICES Journal of Marine Science*, submitted.

Robinson, H., J. Thayer, W. Merkle, and V. Seher. Breeding ecology of Brandt's cormorants and western gulls on Alcatraz Island, 2017. Final Report to the Golden Gate National Recreation Area (GGNRA) National Park Service (NPS), in preparation.

Robinson, H., J. Thayer, and M. Weise. Changes in California sea lion diet during a period of extraordinary climate variability. *CalCOFI Reports*, in preparation.

Sydeman, W.J., J.A. Santora, R. Zeno, J. Hassrick, M. Losekoot, S.A. Thompson, P. Davison, J.C. Field, S. Hayes, and W.T. Peterson. Sensing and mapping krill distribution and abundance in the California Current. *Progress in Oceanography*, in preparation.

Sydeman, W.J., M. Garcia-Reyes, A.I. Szoboszlai, and J.A. Thayer. Forecasting herring biomass using environmental and population parameters. *Fisheries Research*, submitted.

Sydeman, W.J. and S.A. Thompson. Potential climate change impacts on California's marine fisheries: a regional case history. *Progress in Oceanography*, in preparation.

Szoboszlai, A.I., J.A. Thayer, and W.J. Sydeman. Synthesis of anchovy and sardine consumption by seabirds, fish, and mammals in the California Current. *ICES Journal of Marine Science*, in preparation.

Thayer, J.A., and W. Sydeman. One-third for the (sea)birds, marine mammals and fish? Forage thresholds for productivity of marine vertebrates in the California Current. *Ecosphere*, in revision.

van der Sleen, P., R.R. Rykaczewski, B.D. Turley, W.J. Sydeman, M. Garcia-Reyes, S.J. Bograd, C.D. van der Lingen, J.C. Coetzee, T. Lamont, and B.A. Black. Non-stationary responses in Cape anchovy (*Engraulis encrasicolus*) recruitment to coastal upwelling in the Southern Benguela. *ICES Journal of Marine Science*, in preparation.

PRESENTATIONS

Klein, E.S. Beyond catch statistics: Uncovering resilience and change in Gulf of Maine coastal herring. Invited oral presentation at the Laws of Herring Workshop. Maine Historical Society, Portland, ME.

Klein, E.S. In a complex world, how do we understand and manage complex marine systems? Invited oral presentation for the Biomath Seminar, College of William & Mary. Williamsburg, VA.

Robinson, H.J. and J.A. Thayer. Diet of Brandt's cormorants (*Phalacrocorax penicillatus*) during breeding season: A novel approach. Oral presentation at the Pacific Seabird Group Annual Meeting. Tacoma, WA. February 2017.

Robinson, H., J. Thayer, W. Sydeman, and M. Weise. Changes in California sea lion diet reflect declines in small pelagic populations. Poster presentation at the CalCOFI Annual Meeting. San Diego, CA. December 2017.

Santora, J.A., W.J. Sydeman, J. Dorman, R. Zeno, and S.A. Thompson. Submarine canyons: an essential habitat network for krill in the California Current. Poster presentation at the CalCOFI Annual Meeting. San Diego, CA. December 2017.

Sydeman, W.J. CalCOFI: 30 years of at-sea seabird observations and counting. Oral presentation at the Pacific Seabird Group Annual Meeting. Tacoma, WA. February 2017.

Sydeman, W.J. and S.A. Thompson. Small pelagics fisheries competition with seabirds: Review and application. Oral presentation at the PICES International Symposium "Drivers of dynamics of small pelagic fish resources". Victoria, BC. March 2017.

Sydeman, W.J., A.D. MacCall, M. Garcia-Reyes, and J.A. Thayer. Non-fishery collapse of northern anchovy in California: climatic and biotic hypotheses. Oral presentation at the PICES International Symposium "Drivers of dynamics of small pelagic fish resources". Victoria, BC. March 2017.

Sydeman, W.J., S.A. Thompson, R. Crawford, A. Makhado, and Y. Watanuki. Prey switching in seabirds: scales, thresholds and some other thoughts... Oral presentation at the CalCOFI Annual Meeting. San Diego, CA. December 2017.

Thayer, J.A. Predator data for development of forage indicators. NOAA Forage Fish Summit Workshop. Santa Cruz, CA. January 2017.

Thayer, J.A., A.I. Szoboszlai, and W.J. Sydeman. Predator forage needs: How much do they need vs. how much do they eat? Oral presentation at the CalCOFI Annual Meeting. San Diego, CA. December 2017.

Thayer, J.A., A.I. Szoboszlai, and W.J. Sydeman. Predator forage needs: Comparison and synthesis of bioenergetics and numerical response models. Oral presentation at the PICES International Symposium "Drivers of dynamics of small pelagic fish resources". Victoria, BC. March 2017.

Thompson, S.A. and W.J. Sydeman. Puffins as samplers of forage fish in Alaska. Invited oral presentation to the Marine Birds Lunch Group, University of Washington. Seattle, WA. October 2017.

Thompson, S.A. The NE Pacific and marine heat wave: a story of connectedness. Oral presentation to Outer Shores Expeditions tour group. Haida Gwaii, BC. August 2017.

Thompson, A.R., C.J. Harvey, C. Barceló, S.J. Bograd, R.D. Brodeur, J. Fiechter, J.C. Field, N. Garfield, T.P. Good, E.L. Hazen, M.E. Hunsicker, M.G. Jacox, A. Leising, S.R. Melin, J.A. Santora, I.D. Schroeder, W.J. Sydeman, J.A. Thayer, B.K. Wells, and G.D. Williams. Dynamics of forage in the California Current: Large-scale synchrony between 1998 and 2016. Oral presentation at the CalCOFI Annual Meeting. San Diego, CA. December 2017.