



Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO) Contributions, Challenges, and Recommendations for the MLPA Decadal Evaluation Review

A report submitted to the California Department of Fish and Wildlife, Marine Region
February 4, 2022

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Established in 1998, the Partnership for Interdisciplinary Studies of Coastal Oceans ([PISCO](#)) is a consortium of four academic institutions (Oregon State University, University of California - Santa Barbara, University of California - Santa Cruz, and Stanford University – Hopkins Marine Station). The consortium conducts research that advances scientific understanding of coastal marine ecosystems of the California Current System and engages in outreach geared toward informing academic, management, policy maker, stakeholder, and general public audiences. Since well before 2012, PISCO researchers contributed extensively to the science and policy of both the Channel Islands marine protected areas (MPAs) and California's unprecedented network of MPAs established by the Marine Life Protection Act (MLPA). PISCO's continued contributions leverage their longstanding research on the science of MPAs, which preceded the MLPA (e.g., the Science of Marine Reserves booklets) as well as the participation of several principal investigators on the MLPA Science Advisory Team, which informed the design of the MLPA network (e.g., Saarman et al. 2013¹, White et al. 2013, Carr et al 2020, Lubchenco et al 2020). That history of consistent strong engagement with the design and development of the MLPA has provided PISCO researchers with a deep familiarity of the goals and objectives of the network and its management. PISCO researchers have applied that knowledge in their

¹ See Appendix 2 for articles cited in the narrative

continuing contributions and collaborations with California's managers and policy makers involved with the MLPA. Here, we summarize PISCO's contributions and challenges to the MLPA program since 2012 and identify noteworthy examples. Working groups and advisory committees, peer-reviewed publications, and presentations are listed in the accompanying Appendix 1, Appendix 2 and Appendix 3, respectively.

Since the establishment of the Channel Islands MPA network in 2003, and the state-wide MLPA network from 2007 through 2012, PISCO researchers have contributed to two of the four "pillars" of the MLPA management program: monitoring and evaluation of the MLPA network, and outreach and education at local, state, federal and international levels. In addition, PISCO researchers have led the development of a coupled ROMS/Habitat-based connectivity contribution model developed to evaluate patterns and consequences of larval connectivity across the MPA network. In many instances, these efforts are interrelated, such as PISCO's outreach and advisory contributions on the design of monitoring studies to evaluate MPA network performance.

Monitoring and evaluation

PISCO's contributions to the MPA monitoring and evaluation has involved five key elements of a monitoring and evaluation program: articulation of performance questions, analytical frameworks to test hypotheses based on performance questions, monitoring designs informed by analytical frameworks, data management structures and repositories, and sampling protocols. All of these elements have been developed for the evaluation of standalone MPAs as well as the network as a whole. Until recently, PISCO's monitoring and evaluation studies focused on rocky intertidal and kelp forest ecosystems, and the development of population connectivity models to evaluate network performance.

PISCO's recent contributions in support of the 2022 MLPA decadal evaluation stems from a long history of collaborations with state managers that dates back to the earliest period of MPA implementation of the central coast region. Prior to the implementation of the central coast MPAs, PISCO researchers worked closely with California Ocean Science Trust staff to articulate evaluation questions, the analytical frameworks to address those questions, and the resulting spatial and temporal design of the monitoring program. Having developed and implemented monitoring studies associated with the baseline monitoring programs in the central, north-central, and southern California regions, PISCO researchers were well suited to work with California Department of Fish and Wildlife (CDFW) and Ocean Protection Council (OPC) staff and postdocs in the development of the MLPA Monitoring Action Plan.

More recently, PISCO researchers participated in the Decadal Evaluation Working Group (DEWG) sponsored by OPC. PISCO researchers contributed as lead writers and the liaison between the DEWG and the principal investigators of the long-term monitoring programs. Those contributions leveraged our familiarity with the MLPA Monitoring Action Plan and experience articulating questions and hypotheses to help inform analyses conducted by the long-term monitoring studies for the decadal evaluation program. One important contribution to that effort drew on PISCO researchers' ongoing development of a population connectivity model to

quantify the spatial patterns of larval connectivity across the network. That background helped to develop specific network evaluation questions that could be addressed with the connectivity model.

Simultaneous with PISCO's involvement in the DEWG, PISCO researchers participated directly and indirectly in the MPA Climate Resilience working group sponsored by OPC. PISCO researchers participated directly in the development of that report, and indirectly as one of the external reviewers of the report. Those contributions leveraged PISCO researchers' studies and understanding of the ecological consequences of environmental change (e.g., ocean acidification, hypoxia, marine heatwaves) and the role of MPAs in ameliorating the ecological impacts of climate change.

All of these advisory contributions drew upon PISCO researchers' rich history of conducting long-term monitoring of rocky intertidal and kelp forest ecosystems across the MLPA network. PISCO researchers have been conducting rocky intertidal and kelp forest ecosystem monitoring at many MPA and reference sites prior to and during the existence of many MPAs. The recent technical reports produced by the rocky intertidal and kelp forest monitoring programs for the decadal review identify the history of monitoring across sites. Consortia of research institutions from northern to southern California were organized and led by PISCO PIs in order to accomplish monitoring across the network within the limited annual field seasons. PISCO PIs led the analyses and production of the technical reports. PISCO PI Caselle (UC Santa Barbara) was also involved in two other monitoring programs (Mid-depth rocky reefs and the California Cooperative Fisheries Research Program (CCFRP)) and contributed to the design, implementation, analyses and technical report of those programs. Other groups participating in monitoring programs have also largely adopted PISCO survey methodology as the gold standard for long term field survey data collection in these habitats.

PISCO PIs have also led the development of the population connectivity model designed to evaluate the relative contributions of individual MPAs to the regional and system-wide connectivity of the network. That model combines larval particle tracking simulations (within numerical ocean circulation model fields (using the Regional Ocean Modeling System, ROMS, e.g., White et al 2014), seafloor habitat maps, species distribution models (based on monitoring data), and demographic models to predict larval dispersal and population dynamics to evaluate population responses of representative species to the network.

Based on their involvement in the long-term monitoring studies, connectivity modeling, and broader research on MPA science, PISCO PIs are participating and co-leading the MPA evaluation working group organized by the National Center for Ecological Analysis and Synthesis (NCEAS). The purpose of this CDFW and OPC sponsored working group is to conduct synthetic studies of the network performance by integrating results generated across the multiple monitoring programs.

Another contribution of PISCO that straddles the monitoring and evaluation program and the MLPA management program is our work in developing guidelines for scientific collecting within the MLPA MPAs. PISCO researchers participated in the Research in Marine Protected Areas

(RIMPA) Science Collecting in California Marine Protected Areas working group, sponsored by the CDFW. The modeling framework for those guidelines were provided to the department as a technical report and subsequently published (Saarman et al 2018).

The greatest challenge of PISCO's involvement in monitoring and evaluation of MPA performance has been the inconsistent funding over the existence of the network. Many of the analyses conducted by the monitoring programs are based on population and community response trajectories over time (e.g., inside versus outside MPAs). The number of MPAs for which a consistent time series was produced was limited by the funding available to consistently monitor sites over time. Another substantial challenge was the difficulty in using fishery landings data at appropriate spatial scales for interpreting the results of analyses. Knowledge of broadscale (among regions) and local scale (at reference sites associated with MPAs) fishing pressure or mortality is key to determining expectations and interpretations of population responses. While we have developed methods to indirectly assess fishing rates from our long-term survey data (White et al. 2016, 2021, Nickols et al. 2019), these are no replacement for data from the fisheries themselves. We strongly recommend that the MLPA management program invest in working groups to explore and generate spatially explicit metrics of fishing pressure or mortality. Other challenges and recommendations are detailed in the rocky intertidal and kelp forest monitoring program technical reports.

Coupled ROMS/Habitat based connectivity contribution model

One of the unique aspects of the MLPA is the emphasis on how the array of MPA's in California function as an ecological network and the degree to which locations within this array are connected. There are several components of that connectivity: how many larvae are produced in a given location, how they disperse, and whether there is suitable habitat at their destination? We have developed a three-part demographic-habitat-connectivity model to quantify and synthesize these metrics.

Our group uses the output of a ROMS (Regional Ocean Modeling System) model of the California Current, a 3-dimensional description of ocean currents over space and time. We then simulate the release of larvae and track how these currents would move the larvae through space during their development, to their destination.

We modeled dispersal periods based on species' larval or spore planktonic dispersal periods allowing estimation of where the spores or larvae were transported. This provides an estimate of the probability of larvae traveling from one part of the network to another.

The habitat sub-model describes the amount of key habitat (e.g. rocky intertidal, shallow rock and kelp forest) at each site. This information came from a suite of data sources (e.g. sea floor mapping, existing GIS data layers).

Habitat and ROMS sub-models were coupled using a coupling sub-model. Here raw connectivity between sites (ROMS output) was calibrated based on suitable habitat in the donor and recipient sites (habitat information). The logic of this coupling is: (1) the area of habitat in

donor sites should be a proxy for the reproduction of species that occupy those habitats and, (2) the area of habitat in recipient sites represents the “target” area suitable for species to colonize.

The final model output can then be queried to produce a series of metrics that allow estimation of network properties and how those properties are affected by regulatory protection under the MLPA. Examples of such metrics include the contribution, links, and diversity of links (1) of specific MPA's to other MPA's, (2) of specific MPA's to all sites, and (3) of all sites to specific MPA's.

To date there has been no incorporation of MPA protection in the model. We are awaiting results from the decadal assessments and estimates of harvest effort to parameterize this effort. However, we have detected the signal of protection in our assessment of community stability and resilience in habitats where it has been assessed. Our preliminary results suggest that stability and resilience are greater in MPA's that are well connected relative to those that are not.

Outreach and Education

PISCO researchers have engaged in MLPA outreach and education in three distinct ways. The first is the many working groups, committees (Appendix 1) and presentations (Appendix 3) for the purpose of informing managers, policy makers, stakeholders and the general public in California. The second is the many technical reports, peer-reviewed scientific and policy publications (Appendix 2), and presentations made at scientific meetings and conferences tailored to inform the scientific community. The third is the many national and international presentations, working groups and advisory committees that share the design, management and evaluation of the MLPA network as models to inform MPA efforts elsewhere around the world.

PISCO researchers have made numerous presentations and participated in working groups and advisory committees with local and California state managers, policy makers and stakeholders prior to and throughout the establishment of the MLPA network. These working groups and presentations, especially since 2012, have conveyed the importance of evaluating MPA performance, shared the scientific rationale for the design of evaluation studies, and presented monitoring and evaluation results.

Among the various approaches for communicating the distinctive aspects of the MLPA network design, management and evaluation to the scientific community, peer-reviewed publications have the greatest and broadest impact. PISCO researchers have published 45 articles and book chapters from 2012 to present. These articles have pertained to the design and evaluation of the ecological consequences of the MLPA MPAs or for which the MLPA network has informed research on MPAs more broadly.

Included among the many presentations made to inform the scientific community of the design, management and evaluation of the MLPA network, are those given at universities, at scientific

conferences and meetings, and in university courses taught by PISCO researchers (not summarized in the appendix).

Beyond informing scientists, managers and policy makers in California, PISCO researchers have shared lessons learned from their engagement in the MLPA with other state, national and international groups. Notable examples include the engagement on advisory committees and presentations made to inform the design and evaluation of the Northern Shelf Bioregion Marine Protected Area Network in British Columbia, Canada. This network is the first large scale, science designed network to emulate many aspects of the MLPA network. Another has been to inform the ongoing efforts by the Arctic Council/Protection of the Arctic Marine Environment (PAME) in the development of an Arctic-wide network of MPAs. PISCO researchers are also collaborating with Mexican scientists and NGOs in the design of a potential MPA network along northern Baja California, to extend the MLPA network to adjacent Mexican waters. PISCO researchers have also been engaged in the MPAs of the Oregon coast, and the design and review of Oregon's monitoring and evaluation program.

In the near future, PISCO researchers look forward to working with state managers as they prepare for the decadal evaluation and to sharing results of the continuing analyses we are conducting on the monitoring and evaluation studies, including the network modelling. We recommend that those preparing for the decadal evaluation work with PISCO researchers to ensure the accuracy of characterizations of the results of our studies.

The key challenge to the engagement of PISCO researchers in outreach and educational contributions is the time and cost involved in that work. Separate from state sponsored forums, working groups and advisory groups, sometimes supported by CDFW, OPC, and the Ocean Science Trust, PISCO has been extremely fortunate to have been funded by the David and Lucile Packard Foundation (DLPF) to compensate for these costs. One form of DLPF compensation has been to support or augment travel costs associated with attending local, state, national and international venues. The other source of support has been to compensate PISCO researchers' time to conduct this work and for personnel with expertise in the design and construction of presentations. Unfortunately, declining funding for all of these forms of support is reducing the capacity of PISCO researchers to maintain our past levels of engagement.

Appendix 1: Participation in working groups and advisory committees (2012-present)

White, JW and Caselle, JE. California Ocean Protection Council working group on Climate Resilience and California's Marine Protected Area Network. (2020-2021)

Kroeker, KJ. Reviewer: California Ocean Protection Council working group on Climate Resilience and California's Marine Protected Area Network Report. (2020-2021)

Caselle, JE. Invited Participant CNRA Coastal Conservation Panel Group. Advisory Panel on California 30 x 30 initiative. (2021)

Carr, M., Caselle J., White, W. Invited participants and presenters: *Marine reserve Size and Spacing Workshop 2.0* sponsored by The Nature Conservancy, Oregon State University, Corvallis, Oregon. (2020)

Carr, M. Invited participant and presenter: *Gwaii Haanas Zoning Effectiveness Monitoring Workshop* sponsored by Parks Canada and the Haida Nation, Skidegate, Haida Gwaii, British Columbia. (2020)

Caselle, JE. Invited panelist and presenter: Capitol Hill Ocean Week. Innovative Approaches for Restoration and Monitoring. (2020)

Caselle, JE. Invited panelist and presenter: Mobilizing Insights from California's MPA Network Monitoring Program to Inform MPA Network Planning in British Columbia. (2020)

Carr, M. Science Advisory Committee: California Marine Protected Areas Decadal Evaluation Working Group. Ocean Protection Council Science Advisory Team working group sponsored by Ocean Protection Council, Ocean Science Trust and the California Department of Fish and Wildlife. (2019-2020)

Carr, M., Raimondi, P. Science Advisory Committee: Once Through Cooling – MPA Mitigation Working Group. Ocean Protection Council Science Advisory Team working group sponsored by Ocean Protection Council, Ocean Science Trust and the California Department of Fish and Wildlife. (2018)

Caselle, JE. Panel member: Science planning for Once Through Cooling. Ocean Science Trust. (2018)

Caselle, JE. Cost-effective Visual Tools for California marine monitoring, Hosted by The Nature Conservancy & CA Seagrass, Monterey, CA. (2018)

Carr, M. Science Advisory Committee: Design of the Northern Shelf Bioregion Marine Protected Area Network, British Columbia, Canada, convened by Fisheries and Oceans Canada. (2017-2019)

Carr, M. Science Advisory Committee: US-China Joint Scientific Experts Group (JSEG) on Marine Protected Areas and Fisheries sponsored by NOAA and the US State Department (2017-2019)

Carr, M. Science Council: Global Ocean Refuge System (GLORES) sponsored by the Marine Conservation Institute. Tiburon, California. (2018)

Carr, M. Invited participant and presenter: *International Scientific Workshop on Marine Protected Area (MPA) Networks in a Changing Arctic Climate* sponsored by the Arctic Council/Protection of the Arctic Marine Environment (PAME), Helsinki, Finland. (2017)

Carr, M. Invited participant: *Oceans 20: Canada's Ocean Act Workshop*. Ottawa, Canada. (2017)

Carr, M. Invited participant: *Deep-water MPA Monitoring Workshop*, California Ocean Protection Council and California Department of Fish and Wildlife, Moss Landing Marine Labs. (2017)

Carr, M. Invited participant and presenter: *Workshop on Science and Tools for Developing Arctic MPA Networks: Understanding MPA Networks as Tools for Resilience in a Changing Arctic* sponsored by the Arctic Council/Protection of the Arctic Marine Environment (PAME), Copenhagen, Denmark. (2017)

Carr, M. Invited participant and presenter: *Marine Ecological Connectivity Workshop* - Hosted by Canadian Healthy Oceans Network (CHONe) and Canadian Parks and Wilderness Society (CPAWS), Vancouver, British Columbia, Canada. (2017)

Carr, M. Expert testimony: Canadian Parliamentary Committee – Fisheries and Oceans - MPAs. Invited expert testimony, Ottawa, Canada. (2017).

Carr, M. External reviewer: Fisheries and Oceans Canada, Canadian Science Advisory Secretariat (CSAS). CSAS Working Paper: Design Strategies for the Northern Shelf Bioregional Marine Protected Area Network. (2017)

Carr, M., White, J.W. Invited panelists and presenters: *Network Evaluation of California MPAs: Science, Policy, and Scales of Change*. Panel organized by the California Ocean Science Trust at Western Society of Naturalists, Sacramento, CA. (2015)

Carr, M. Marine Protected Areas Federal Advisory Committee (MPA FAC): National Oceanic and Atmospheric Administration (NOAA), US Department of Commerce. (2014-2018)

Carr, M. Invited participant and presenter: Arctic Council/Protection of the Arctic Marine Environment (PAME) Workshop on Science and Tools for Developing Arctic MPA Networks: Understanding Connectivity and Identifying Management Models. Washington, DC. (2016)

Caselle, JE. Invited presenter: Fish and Game Commission, San Diego CA. (2016)

Carr, M., Caselle JE. Invited participant and presenter: *Planning for Change: Developing Long-term Ecosystem Monitoring Recommendations for Marine and Coastal Decision Makers*, Sacramento, CA. (2015)

Carr, M. Invited panelist and presenter: U.S.- China Strategic and Economic Dialogue, Consultation on People-to-People Exchange, Joint US-China Breakout Session on Marine Protected Areas. Hosted by U.S. State Department, WA DC. (2015)

Carr, M., White, J.W. Invited participants and presenters: *MPAs and Fisheries on Canada's Pacific Coast: Science Forum and Science Workshop* sponsored by Commercial Fishing Caucus, B.C. Seafood Alliance, Canadian Parks and Wilderness Society, David Suzuki Foundation, Living Oceans Society and World Wildlife Fund, Vancouver, British Columbia, Canada. (2015)

Carr, M. Saarman, E. Advisory Committee: RIMPA Science Collecting in California Marine Protected Areas – California Department of Fish and Wildlife. (2013-2015).

Carr, M. Invited participant and Steering Committee member: *Developing Principles and Good Practice for Expert Judgments* working group, hosted by California MPA Monitoring Enterprise at NCEAS, Santa Barbara, CA. (2012)

Carr, M. Invited participant: Meeting with Canadian General Auditor on Marine Protected Areas and Monitoring Programs in Canada. Hopkins Marine Station, Pacific Grove, CA. (2012)

Carr, M. Invited participant: *Marine Reserve Science and Monitoring Workshop* sponsored by the Oregon Department of Fish and Wildlife, Corvallis, Oregon. (2012)

Carr, M. Advisory Committee: Oregon Department of Fish and Wildlife on the design and implementation of monitoring programs for marine reserves. (2010-present)

Appendix 2: PISCO MPA peer-reviewed publications (2012-present)

Publications listed in chronological order

Malone, D.P., K. Davis, S.I. Lonhart, A. Parsons-Field, J.E. Caselle, and M.H. Carr. 2022. Large-Scale, Multidecade Monitoring Data from Kelp Forest Ecosystems in California and Oregon (USA). *Ecology* e3630. <https://doi.org/10.1002/ecy.3630>

Hopf JK, Caselle JE, White JW. 2022. Recruitment variability and sampling design interact to influence the detectability of protected area effects. *Ecological Applications* In press DOI 10.1002/eap.2511

Freedman, R., J.A. Brown, C. Caldow, and J.E. Caselle. 2021. Species-specific thermal classification schemes can improve climate related marine resource decisions. *PLoS ONE* 16(4): e0250792. <https://doi.org/10.1371/journal.pone.0250792>

Ovando, D., Caselle, J.E., Costello, C., Deschenes, O., Gaines, S.D., Hilborn, R., and O. Liu. 2021. The regional effects of marine protected areas. *Conservation Biology*. 2021:1– 10 <https://doi.org/10.1111/cobi.13782>.

Perkins NR, Prall M, Chakraborty A, White JW, Baskett ML, Morgan SJ. 2021. How to quantify the statistical power of monitoring programs for adaptive management of marine protected areas. *Ecological Applications* 31: e2215

White JW, Yamane MT, Nickols KJ, Caselle JE. 2021. Analysis of fish population size distributions confirms cessation of harvest in marine protected areas. *Conservation Letters* 14: e12775

Barceló C, White JW, Botsford LW, Hastings A. 2021. Predicting the time scale of initial increase in fishery yield after implementation of marine protected areas. *ICES Journal of Marine Science* 78: 1860-1871

Hilty, J., G.L. Worboys, A. Keeley, S. Woodley, B. Lausche, H. Locke, M. Carr, I. Pulsford, J. Pittock, J.W. White, D.M. Theobald, J. Levine, M. Reuling, J.E.M. Watson, R. Ament, and G.M. Tabor. 2020. Guidelines for conserving connectivity through ecological networks and corridors. C. Groves (Editor). International Union for Conservation of Nature (IUCN) - Best Practice Protected Area Guidelines Series No. 30.

Easter EE, Adreani MS, Hamilton SL, Steele MS, Pang S, White JW. 2020. Influence of protogynous sex change on recovery of fish populations within marine protected areas. *Ecological Applications* 30: e02070

Eisaguirre, J.H., J.M. Eisaguirre, K. Davis, P. Carlson, S.D. Gaines, J.E. Caselle. 2020. Trophic redundancy and size class structure drive differences in kelp forest ecosystem dynamics. *Ecology*. 101(5): e02993. 10.1002/ecy.2993

Freedman, R.M., J.A. Brown, C. Caldow, and J.E. Caselle. 2020. Marine protected areas do not prevent marine heatwave-induced fish community structure changes in a temperate transition zone. *Scientific Reports* 10, 21081. <https://doi.org/10.1038/s41598-020-77885-3>

White, J.W., M.T. Yamane, K.J. Nickols, and J.E. Caselle. 2020. Analysis of fish population size structures confirm cessation of fishing in marine protected areas. *Conservation Letters*. 14: e12775. <https://doi.org/10.1111/conl.12775>

Lubchenco, J., B.A. Menge, J.A. Barth, M.H. Carr, J.E. Caselle, F. Chan, H.K. Fulton-Bennett, S.D. Gaines, K.J. Kroeker, K. Milligan, S.R. Palumbi, and J.W. White. 2019. Connecting science to policymakers, managers, and citizens. *Oceanography* 32(3):106–115.

Kroeker, K.J., M.H. Carr, P.T. Raimondi, J.E. Caselle, L. Washburn, S.R. Palumbi, J.A. Barth, F. Chan, B.A. Menge, K. Milligan, M. Novak, and J.W. White. 2019. Planning for change: Assessing the potential role of marine protected areas and fisheries management approaches for resilience management in a changing ocean. *Oceanography* 32(3):116–125.

Carr, M.H., J.W. White, E. Saarman, J. Lubchenco, K. Milligan, and J.E. Caselle. 2019. Marine protected areas exemplify the evolution of science and policy. *Oceanography* 32(3):66-75.

Nickols K.J., J.W.White, D. Malone, M.H. Carr, R.M. Starr, M.L. Baskett, A. Hastings, and L. W. Botsford. 2019. Setting ecological expectations for adaptive management of marine protected areas. *Journal of Applied Ecology* 2019;00:1–10. <https://doi.org/10.1111/1365-2664.13463>

Baetscher, D.S., Anderson, E.C., Gilbert-Horvath, E.A., Malone, D.P., Saarman, E.T., Carr, M.H. and Garza, J.C. 2019. Dispersal of a nearshore marine fish connects marine reserves and adjacent fished areas along an open coast. *Molecular Ecology* 28:1-13. <https://doi.org/10.1111/mec.15044>

Carr, M.H. and E.L. Hazen. 2019. Chapter 9: Ecological connectivity in the ocean. Pages 216-237 *In: Hilty, J.A., A.T.H. Keeley, W.Z. Lidicker Jr., and A.M. Merenlender. Corridor Ecology: Linking Landscapes for Biodiversity Conservation and Climate Adaptation. Second Edition. Island Press.*

Kaplan KA, Yamane L, Botsford LW, Baskett ML, Hastings A, Worden S, White JW. 2019. Setting expected timelines of fished population recovery for the adaptive management of a marine protected area network. *Ecological Applications* 29: e01949

Caselle, J.E., Davis K., and L.M. Marks. 2018. Marine management affects the invasion success of a non-native species in a temperate reef system in California, USA. *Ecology Letters*. 21:43–53. doi:10.1111/ele.12869

Claisse, J.T., C.A. Blanchette, J.E. Dugan, J.P Williams, J. Friewald, D.J. Pondella, N.K. Schooler, D.M. Hubbard, K. Davis, L.A. Zahn, C.M. Williams and J.E. Caselle. 2018. Biogeographic patterns of communities across diverse marine ecosystems in southern California. *Marine Ecology*. 39: e12453. <https://doi.org/10.1111/maec.12453>.

Friewald J., R. Meyer, J.E. Caselle, and 7 others. 2018. Citizen science monitoring of marine protected areas: case studies and recommendations for integration for among monitoring programs. *Marine Ecology*. 39: e12470 <https://doi.org/10.1111/maec.12470>

Robinette, D.P., J. Howar, J.E. Caselle, and J. Claisse. 2018. Can nearshore foraging seabirds detect variability in juvenile fish distribution inside and outside of marine reserves? *Marine Ecology*. 39:e12485. <https://doi.org/10.1111/maec.12485>

Young, M.A., L.M. Wedding, and M.H. Carr. 2018. Applying landscape ecology for the design and evaluation of marine protected area networks. In Simon J. Pittman (Ed.), *Seascape Ecology* (pp. 429-452). Hoboken, NJ: John Wiley & Sons, Inc.

Saarman, E.T., B. Owens, S.N. Murray, S.B. Weisberg, R.F. Ambrose, J.C. Field, K.J. Nielsen, and M.H. Carr. 2018. An ecological framework for informing permitting decisions on scientific activities in protected areas. *PloS ONE*. 13(6): e0199126. <https://doi.org/10.1371/journal.pone.0199126>.

Carr, M.H., S.P. Robinson, C. Wahle, G. Davis, S. Kroll, S. Murray, E.J. Schumacker, and M. Williams. 2017. The central importance of ecological spatial connectivity to effective marine protected areas and to meeting the challenges of climate change in the marine environment. *Aquatic Conservation: Marine and Freshwater Ecosystems* 27(S1):6–29.

Teck, S., J. Lorda, N.T. Shears, T. W. Bell, J. Cornejo-Donoso, J. E. Caselle, S. L. Hamilton and S. D. Gaines. 2017. Disentangling the effects of fishing and environmental forcing on demographic variation in an exploited species. *Biological Conservation* 209:488-498.

White, J.W., Nickols, K.J., Malone, D., Carr, M.H., Starr, R.M., Cordoleani, F., Baskett, M.L., Hastings, A. and Botsford, L.W., 2016. Fitting state-space integral projection models to size-structured time series data to estimate unknown parameters. *Ecological Applications*, 26(8), pp.2677-2694. <https://doi.org/10.1002/eap.1398>

Easter EE, White JW. 2016. Spatial management for protogynous sex-changing fishes: a general framework for coastal systems. *Marine Ecology Progress Series* 543: 223-249

Liebowitz, D.M., K.J. Nielsen, J.E. Dugan, S.G. Morgan, D.P. Malone, J.L. Largier, D.M. Hubbard, and M.H. Carr. 2016. Ecosystem connectivity and trophic subsidies of beach ecosystems. *Ecosphere*. 7(10) <https://doi.org/10.1002/ecs2.1503>

Caselle, J.E., A. Rassweiler, S.L. Hamilton and R.R. Warner. 2015. Recovery trajectories of kelp forest animals are rapid yet spatially variable across a network of temperate marine protected areas. *Scientific Reports* 5:14102. doi:10.1038/srep14102

Hamilton, S.L and J.E. Caselle. 2015. Exploitation and recovery of size structure of a sea urchin predator has implications for the resilience of southern California kelp forests. *Proceedings of the Royal Society B*. 282: 20141817. <http://dx.doi.org/10.1098/rspb.2014.1817>

White JW. 2015. Marine reserve design theory for species with ontogenetic migration. *Biology Letters* 11: 20140511

Young, M.A. and M.H. Carr. 2015. Assessment of habitat representation across a network of marine protected areas with implications for the spatial design of monitoring. *PLoS ONE* 10(3): e0116200. doi: 10.1371/journal.pone.0116200

Botsford, L.W., J.W. White, M.H. Carr, and J.E. Caselle. 2014. Marine protected area networks in California, USA. *In: Johnson, M.L. and J. Sandell (editors): Marine Managed Areas and Fisheries. Advances in Marine Biology* 69:205-251.

Grorud-Colvert, K., J. Claudet, B.N. Tissot, J.E. Caselle, M.H. Carr, J.C. Day, A.M. Friedlander, S.E. Lester, T. Lison de Loma, D. Malone, W.J. Walsh. 2014. Marine protected area networks: assessing whether the whole is greater than the sum of its parts. *PLoS ONE* 9(8): e102298.

Burgess SC, Nickols KJ, Griesemer CD, Barnett LAK, Dedrick AG, Satterthwaite EV, Yamane L, Morgan SG, White JW, Botsford LW. 2014. Beyond connectivity: how empirical methods can quantify population persistence to improve marine protected area design. *Ecological Applications* 24: 257-270

White JW, Schroeger J, Drake PT, Edwards CA. 2014. The value of larval connectivity information in the static optimization of marine reserve design. *Conservation Letters* 7: 533-544

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Appendix 3. PISCO outreach and educational presentations (2012-present)

This list of presentations on the MLPA network or motivated by knowledge generated by the MLPA network, includes presentations based on the design, management and monitoring and evaluation studies. These presentations have raised national and international recognition of the distinctive design and evaluation of the network.

2021

White, J.W. "Analysis of fish population size distributions confirms cessation of fishing in marine protected areas" Ecological Society of America annual meeting, August 2021 (remote)

White, J.W. "Predicting patterns and documenting successes in marine protected areas by linking models and data" Oregon chapter American Fisheries Society annual meeting, February 2021 (remote)

White, J.W. "Marine reserves and marine protected areas" Guest lecture to York University, Toronto Canada (remote). March 2021

2020

Carr, M. "Design, Applications, and Evaluation of MPAs in a Changing Global Climate", Marine reserve Size and Spacing Workshop 2.0 sponsored by The Nature Conservancy, Oregon State University, Corvallis, Oregon, March, 2020

White, J.W. "What have we learned about connectivity and MPA design in 12 years?", Marine reserve Size and Spacing Workshop 2.0 sponsored by The Nature Conservancy, Oregon State University, Corvallis, Oregon, March, 2020

Carr, M. "Engaging Citizens in Science and Marine Monitoring: Lessons learned from California", sponsored by Parks Canada and the Haida Nation, Skidegate, Haida Gwaii, British Columbia, February, 2020

Carr, M. "Evaluating a Network of Marine Protected Areas: Lessons from California", Gwaii Haanas Zoning Effectiveness Monitoring Workshop sponsored by Parks Canada and the Haida Nation, Skidegate, Haida Gwaii, British Columbia, February, 2020

White, J.W. "Linking models and data for adaptive management of marine protected areas" Invited seminar. Department of Biology, California State University Northridge, March 2020 (remote)

White, J.W. "Linking models and data for adaptive management of marine protected areas" Invited seminar. NOAA Southwest Fishery Science Center, August 2020 (remote)

White, J.W. "Adaptive management of marine protected areas: combining theory and data" Invited seminar. Helmholtz Institute for Functional Marine Biodiversity, University of Oldenburg, Germany, September 2020 (remote)

White, J.W. "Setting expectations for MPA adaptive management using data and population models" Contributed talk. International Marine Conservation Congress 6, Kiel, Germany (delivered remotely), August 2020

2019

Carr, M. "Sustaining MPA Benefits in a Changing Ocean: A Call to Action from the Marine Protected Areas Federal Advisory Committee" (with C. Wahle, B. Baird and S. Murray) Webinar co-sponsored by the NOAA National MPA Center, MPA News, and the EBM Tools Network (co-coordinated by NatureServe and OpenChannels.org). March, 2019

Carr, M. "California's Network of MPAs" Invited discussant with Indonesian MPA managers sponsored by USAID-Indonesia. 2019

Caselle, J.E. and White J.W. "Twenty years of monitoring coastal ecosystems by PISCO: linking ecological theory and data to inform management and policy" Contributed talk. CalCOFI annual symposium. La Jolla, CA, December 2019

White, J.W. "Transient population dynamics, uncertainty, and the adaptive management of marine reserves" Invited talk. Ecological Society of America annual meeting. Louisville, KY. August 2019

White, J.W. "Linking models and data for adaptive management of marine protected areas" Invited seminar. Hatfield Marine Science Center, Oregon State University, October 2019

White, J.W. "Linking models and data for adaptive management of marine protected areas" Invited seminar. NOAA Northwest Fishery Science Center, January 2019

White, J.W. "Linking models and data for adaptive management of marine protected areas" Invited seminar. Oregon Institute of Marine Biology, University of Oregon, July 2019

White, J.W. "Estimating fishery harvest rates to assess the efficacy of marine protected areas in the Santa Barbara Channel Islands" Contributed talk. Western Society of Naturalists annual meeting. Ensenada, Mexico. November 2019

White, J.W. "Environmental variability introduces time lags into the fishery benefits of marine protected areas" Contributed talk. Eastern Pacific Ocean Conference. Fallen Leaf Lake, CA. September 2019

2018

Carr, M. "Ecological Connectivity in the Sea: Implications for Purposes and Design of Marine Protected Areas" Invited Webinar. Connected Conservation Initiative, United States National Park Service. November 2018

Carr, M. "Win-Win: Local Kelp Rockfish populations replenish themselves and other coastal populations simultaneously. Contributed paper (w/ John Carlos Garza, Eric Anderson, Chris Edwards, Diana Baetscher, Anna Lowe, Patrick Drake, Dan Malone, Emily Saarman). Western Society of Naturalists 100th Annual Meeting, Tacoma, Washington, November 2018

Carr, M. "The Science of California's MPA Network" Invited presentation: California Department of State Parks. Hosted by California Department of Fish and Wildlife. Asilomar, California, October 2018.

Carr, M. "Ecological Connectivity and MPA Network Design and Evaluation" Invited presentation: Swedish Marine and Water Authority, Gothenburg, Sweden, September 2018

Carr, M. "Science-based "rules of thumb" for the design of marine protected area networks". Invited presentation: National Advisory Panel on Marine Protected Areas, Vancouver, Canada, April 2018

White, J.W. "Bring the noise: the influence of larval recruitment variability on the adaptive management of marine protected areas" Larval Fish Conference, Victoria, British Columbia. June 2018

2017

Carr, M. "Science-based "rules of thumb" for the design of marine protected area networks". Invited presentation: Oceans 20: Canada's Ocean Act Workshop. Ottawa, Canada, June 2017

Carr, M. "Long-term marine ecosystem monitoring by the University of California" invited presentation to California State Assembly Select Committee on Coastal Protection hearing. Sacramento, CA June 2017

Carr, M. "Recent changes in coastal ecosystems of the Sanctuary: Understanding their causes and consequences" Invited public talk for the Monterey Bay National Marine Sanctuary. Santa Cruz, CA May, 2017

Carr, M. "Implications of spatial connectivity and climate change for the design and application of marine protected areas" invited presentation, (w/ Sarah Robinson). Webinar co-sponsored by the NOAA National MPA Center, MPA News, and the EBM Tools Network (co-coordinated by NatureServe and OpenChannels.org). March, 2017

Carr, M. "Ecological Connectivity and Resilience: Implication for Marine Protected Areas" invited keynote presentation. Arctic Council/Protection of the Arctic Marine Environment

(PAME) Workshop on Science and Tools for Developing Arctic MPA Networks: Understanding MPA Networks as Tools for Resilience in a Changing Arctic, Copenhagen, Denmark, February, 2017

Carr, M. "Spatial ecological connectivity: what it is, why it's important, how to estimate it, and how to account for it in MPA networks" invited keynote presentation. Marine Ecological Connectivity Workshop - Hosted by Canadian Healthy Oceans Network (CHONE) and Canadian Parks and Wilderness Society (CPAWS), Vancouver, British Columbia, Canada, January, 2017

Carr, M. "Developing a coherent network of MPA's, the California experience" invited keynote presentation. Marine Ecological Connectivity Workshop - Hosted by Canadian Healthy Oceans Network (CHONE) and Canadian Parks and Wilderness Society (CPAWS), Vancouver, British Columbia, Canada, January, 2017

White, J.W. "Short-term trajectories of sex-changing fish populations inside MPAs: implications for monitoring" Contributed talk. Western Society of Naturalists annual meeting, Tacoma, WA. November 2017.

2016

Carr, M. "Spatial ecological connectivity: what it is, why it's important, how to estimate it, and how to account for it in MPA networks" invited keynote presentation. Arctic Council/Protection of the Arctic Marine Environment (PAME) Workshop on Science and Tools for Developing Arctic MPA Networks: Understanding Connectivity and Identifying Management Models. Washington, DC, September, 2016

Carr, M. "Developing a coherent network of MPA's, the California experience" invited keynote presentation. Arctic Council/Protection of the Arctic Marine Environment (PAME) Workshop on Science and Tools for Developing Arctic MPA Networks: Understanding Connectivity and Identifying Management Models. Washington, DC, September, 2016

Carr, M. "Monitoring California's MPA Network: Laying a Foundation for the Future" invited presentation to California MPA Leadership Team, California State Secretary of Resources, and Santa Cruz Representative Mark Stone. Sacramento, CA February, 2016

White, J.W. "Linking models and data for the design and assessment of marine protected areas" Invited seminar, Hatfield Marine Science Center, Oregon State University. April 2016

White, J.W. "Linking models and data for the design and assessment of marine protected areas" Invited seminar, Stony Brook University. August 2016

2015

Carr, M. "What is long-term monitoring and what is its value?" Invited workshop speaker: Planning for Change: Developing Long-term Ecosystem Monitoring Recommendations for

Marine and Coastal Decision Makers, organized by California Ocean Science Trust. Sacramento, CA, November, 2015

White, J.W. "Evaluation of MPA networks" Panelist/discussant. Roundtable on MPA networks hosted by California Ocean Science Trust, Western Society of Naturalists annual meeting, Sacramento, CA. November 2015

White, J.W. "Filling in the gaps: a new method to detect subtle effects of MPAs on fish size distributions" Contributed talk, Western Society of Naturalists annual meeting, Sacramento, CA. November 2015

Carr, M. "Science-based design of MPA networks: California case study" U.S.- China Strategic and Economic Dialogue, Consultation on People-to-People Exchange, Joint US-China Breakout Session on Marine Protected Areas. Hosted by U.S. State Department, WA DC, June, 2015

Carr, M. "Tools to integrate biodiversity conservation and healthy fisheries for designing MPA networks: California case study" Invited presentation and panelist: *MPAs and Fisheries on Canada's Pacific Coast: Science Forum and Science Workshop* sponsored by Commercial Fishing Caucus, B.C. Seafood Alliance, Canadian Parks and Wilderness Society, David Suzuki Foundation, Living Oceans Society and World Wildlife Fund, Vancouver, British Columbia, Canada, April, 2015

White, J.W. "Do spillover and larval export from MPAs provide a benefit to fisheries?" Invited presentation and panelist: *MPAs and Fisheries on Canada's Pacific Coast: Science Forum and Science Workshop* sponsored by Commercial Fishing Caucus, B.C. Seafood Alliance, Canadian Parks and Wilderness Society, David Suzuki Foundation, Living Oceans Society and World Wildlife Fund, Vancouver, British Columbia, Canada, April, 2015

White, J.W. "Linking models and data for the adaptive management of marine protected areas" Invited seminar. University of Delaware. February 2015.

2014

Carr, M. "Coastal Sustainability at UCSC: synergies of education, research and informing policy" Invited presentation and panelist for U.S. Visiting Fulbright Scholars Annual Retreat. Asilomar, CA November, 2014

Carr, M. "Coastal Sustainability at UCSC: synergies of education, research and informing policy" Invited Speaker: UC California Naturalist Program First Statewide Annual Conference. Asilomar, CA October, 2014

Carr, M. "Coastal Sustainability at UCSC: synergies of education, research and informing policy" Invited talk to Santa Cruz Rotary Club, Santa Cruz, CA, August, 2014

Carr, M. "Coastal Sustainability at UCSC: synergies of education, research and informing policy" Invited talk to UCSC Office of Development Original Thinkers Series, Hollywood, CA, May, 2014

White, J.W. "Accounting for non-equilibrium transient dynamics in the design and assessment of marine reserves" Contributed talk. Ecological Society of America annual meeting, Sacramento, CA. November 2014

White, J.W. "Linking models and data for marine protected area planning and assessment" Invited seminar. Department of Biology, University of North Carolina. Chapel Hill, NC. March 2014.

2013

Carr, M. "Policy success; California's Marine Life Protection Act." Invited speaker and panelist 2020 Vision of Canada's Oceans Dialogue, sponsored by the Canadian Healthy Oceans Network (CHONe) in Partnership with the Centre for Coastal Science and Management, Simon Fraser University. Vancouver, Canada, December 2013

Carr, M. "Critical insights and information revealed only by long-term monitoring studies" Invited presentation and panel participation to California Fish and Game Commission (Organized by COMPASS), Los Angeles, CA, May, 2013.

Carr, M. "Characterization of and initial changes in intertidal communities in MPA's along Central California" Invited presentation with Pete Raimondi - State of the Central California Coast Symposium: Reflecting on the First Five Years of MPA Monitoring, Management and Partnership. Monterey, CA, February, 2013

Carr, M. "Characterization of and initial changes in kelp forest communities in central California MPAs" Invited presentation and media briefing panel - State of the Central California Coast Symposium: Reflecting on the First Five Years of MPA Monitoring, Management and Partnership. Monterey, CA, February, 2013

White, J.W. "Expected population responses to the implementation of MPAs on California's Central Coast" Invited presentation. State of the Central California Coast Symposium: Reflecting on the First Five Years of MPA Monitoring, Management and Partnership. Monterey, CA, February, 2013

Carr, M. "Towards an Integrative Design and Evaluation of California's MLPA Network of Marine Protected Areas" Invited seminar, Department of Biology, Humboldt State University, February, 2013.

Carr, M. "Critical insights and information revealed only by long-term monitoring studies" Invited presentation and panel participation to state legislative and agency staff (Organized by COMPASS), Sacramento, CA, February, 2013.

2012

Carr, M. "Kelp Forest Ecosystems of Central California: MLPA Baseline Surveys" (w/ D. Malone and E. Saarman) Invited presentation at Developing Principles and Good Practice for Expert Judgments workshop, sponsored by the California Monitoring Enterprise, National Center for Ecological Analysis and Synthesis (NCEAS) Santa Barbara, CA, January, 2012.

Carr, M. "The Many Applications of Monitoring Kelp Forest Ecosystems to Inform Management and Policy" Invited Keynote Lecture to the MARINE Monitoring Program (<http://www.marine.gov/>), UC Santa Cruz, CA February, 2012.

White, J.W. "Transient responses of exploited populations to establishment of no-take marine reserves" Contributed talk. Ecological Society of America annual meeting. Portland, OR. August 2012.

White, J.W. 'Design and assessment of marine reserves: theory and practice" Invited seminar. Moss Landing Marine Laboratory. Moss Landing, CA. November 2012.

White, J.W. 'Design and assessment of marine reserves: theory and practice" Invited seminar. Rutgers University, New Brunswick, NJ. October 2012.

White, J.W. 'Design and assessment of marine reserves: theory and practice" Invited seminar. University of North Carolina Institute for Marine Science. Morehead City, NC. October 2012.