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STATE OF THE SCIENCE EQUITY IN CALIFORNIA'S COASTAL COMMUNITIES

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Image: Sarah Dokowicz

About This Document

This report shares the results of a rapid assessment of the science landscape on marine equity and justice in California. It is part of a series of “State of the Science” reports on various topics for staff at the Ocean Protection Council. It was developed through a review of peer-reviewed and grey literature, along with several informal semi-structured interviews with experts. It distills the high-level, current state of the science in the California context, including case studies, resources, and identification of knowledge gaps within key topic areas of interest to the OPC. The resulting report is reflective of a broad exploration of the science landscape and is not intended to be comprehensive, but provides a foundation for further investigation. There are some topics not addressed in this report due to inclusion in other recent efforts (e.g., human dimensions of MPAs in California). A full list of references is included at the end of the document.

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Executive Summary

Equity within coasts and oceans is an extremely broad yet new field in the peer-reviewed literature and remains an underdeveloped concept in practice and measures. Environmental justice is commonly discussed as recognitional (respect for rights, knowledge-generation and values), procedural (inclusiveness in decision-making process), distributional (distribution of costs and benefits), and sometimes contextual (history of inequity), although distributional equity is discussed the most in the literature. When exploring environmental justice and equity in the context of coastal communities, the threats of climate change and the need for equitable adaptation strategies emerge as priority areas for evidence-based policy interventions. Data on coastal and marine social vulnerability within California is relatively sparse, with the exception of social vulnerability to sea level rise, specifically, and where it is examined is often done so from the dimension of distributive justice, with less attention on other dimensions. Equity issues discussed here span a breadth of topics including coastal resilience, representation, access, pollution, access to information, and more. Case studies from across the US explore the importance of meaningful engagement, representation, and acknowledgement of the history of injustice. Evidence suggests that everyone benefits if communities adapt in a way that is equitable and just. A significant knowledge gap that repeatedly emerged within multiple topics was a lack of proven strategies leading to more equitable outcomes. However, there are many useful and relevant guides that explore best practices for operationalizing equity within policy and research from community-centered perspectives.

Highlights from topical sections below include:

- **Access:** Data shows that access to coastal areas in CA is inequitably distributed along income and racial boundaries. Potential solutions include improved transportation from inland areas, investments in coastal infrastructure that improves access such as parking and affordable lodging, and broadening definitions of access to include these items within scientific inquiry.
- **Health, Environmental Quality, and Food:** Evidence shows uneven impacts of air pollution associated with maritime commerce, such as ports, and case studies suggest environmental justice implications of coastal water quality. A deeper understanding of equity dimensions of fisheries and especially subsistence pier fishing in California would foster identification and pursuit of solutions.
- **Vulnerability to Sea Level Rise:** Vulnerability to sea level risk is a relatively data-rich topic nationally but also in California, with large assessments revealing inequities along the coastline. Localized approaches would advance existing mapping and assessments of vulnerabilities and the interconnectedness of inland and coastal communities suggests that sea level rise may redistribute impacts.
- **Equity in Coastal Resilience Planning and Actions:** Some evidence suggests that resilience planning in California increasingly seeks to improve equity but deeper examination into specifically ocean and coastal resilience topics is needed. Strategic and intentional retreat from rising seas has the potential to ameliorate inequities inherent to managed retreat issues.

- **Meaningful Engagement:** Meaningful engagement strategies include centering the needs of vulnerable communities through all phases of research/policy development, sharing power, examining privilege, compensating fairly, ensuring transparency, and funding communities directly, for example. More research is needed to assess what engagement strategies lead to more equitable outcomes.
- **Measuring and Analyzing for Equity:** Developing metrics to analyze equity in collaboration with implementation partners and selecting metrics for their appropriateness to the local context can help capture effectiveness of social impacts and support integration of the results back into adaptive management.
- **Communication and Access to Information:** Recent and rapid development in best practices for more inclusive science communication include building trust with key members of communities, being responsive to cultural, experiential or language differences, illustrating relevance to daily life, going where the audience is, and investing in long-term relationships.
- **Representation:** Recent studies demonstrate that lack of representation within marine science academia, coastal policy, advocacy, and fisheries fields narrows the dialogue between science and policy and ultimately reduces the effectiveness of solutions. While there has been progress in improving representation (through mentoring, undergraduate research opportunities, financial support, and accountability for diversity), more work is needed to understand demographics with California ocean sciences and document and disseminate effective strategies.

A recurring theme was the lack of social science combined with overemphasis of natural science, which is a barrier specifically in advancing equity within ocean and coastal fields. Another recurring theme was the importance of considering the local context in understanding and addressing inequity, across vulnerability assessments, metric development, community engagement, inclusive communication, etc. For example, adaptation strategies may be most effective at addressing inequities when tailored to the local context. Lastly, scientific inquiries into equity or policies addressing equity must consider historical context, because understanding systemic causes is essential in identifying solutions.

Resources, Guides, and Assessments

The following list of resources provides example assessments of equity in California and/or guidance for operationalizing equity, including some informed by community perspectives. While many of these resources are referenced in this report, we acknowledge that this report is focused on compiling peer-reviewed literature on ocean and coastal equity, where possible, in an effort to inspire more scientific inquiry into these topics along with supporting evidence-based policy. However, peer-reviewed literature is not the same as the lived experience of structural inequalities. In fact, research and science can and do perpetuate inequalities. We highlight many of these resources below as evidence that there is great information on best practices for addressing inequalities for policymakers and scientists that is not from peer-reviewed sources.

Resources for operationalizing equity, community engagement

[SB 100 Toolkit: Planning for Healthy Communities](#), California Environmental Justice Alliance
[Making Equity Real in Climate Adaptation and Community Resilience Policies and Programs](#), Greenlining Institute

[Making Equity Real in Research](#), Greenlining Institute

Resilience Guidebook [Equity Checklist](#), [Community Engagement Best Practices](#), [Vulnerable Populations](#), Governor's Office of Planning and Research

[Community Engagement and Outreach of the General Plan Guidelines and Technical Advisories](#), Governor's Office of Planning and Research

[Defining Vulnerable Communities in the Context of Climate Adaptation](#), Governor's Office of Planning and Research

[Digital Environmental Engagement Resource Catalogue](#), California Natural Resources Agency
[Partnering with Community-Based Organizations for More Broad-Based Public Engagement](#), Institute for Local Government

[Guidelines for developing a code of conduct for marine conservation](#) (see Table 1 and Box 1)

[International Association for Public Participation](#)

[National Coalition for Dialogue & Deliberation](#)

Additional resources for best practices in community engagement available from the [San Francisco Bay Conservation and Development Coalition](#)

Assessments

[Mapping Resilience: A Blueprint for Thriving in the Face of Climate Disasters](#), Asian Pacific Environmental Network

[Climate Justice Report](#), California's Fourth Climate Assessment

[Chapter 2.6 Vulnerable Communities](#), Adapting to Rising Tides Bay Area

[Sea Level Rise Impacts and Flooding Risks in the Context of Social Vulnerability: An Assessment for the City of Los Angeles](#), City of Los Angeles

[City of Santa Cruz Climate Adaptation Plan Update 2018-2023](#), City of Santa Cruz

I. History & Context

Understanding social justice and equity are critical for effectively managing the marine environment and instrumental for long-term effective adaptation, especially in the face of climate change and growth in the blue economy. The United States' history of marginalization, exploitation, and exclusion of vulnerable groups results in real and immediate barriers to social well-being and resilience. This applies especially to communities of color, Black communities, and Indigenous communities. In California, Environmental Justice is defined by state law as the "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation and enforcement of environmental laws, regulations, and policies" (Gov. Code, § 65040.12, subd. (e)). Environmental injustice is intersectional and widespread. The health impacts of climate change will be felt most by vulnerable communities and poor regions, according to the IPCC.¹ It is well documented that communities of color and low-income communities are disproportionately impacted by polluting industries, and are burdened with higher rates of contaminated drinking water. Racial minorities, especially Black Americans, but also low-income people are more likely to die from air pollution.² Environmental racism, which refers to the unfair pollution or environmental health burdens experienced by people of color, manifests in historically redlined neighborhoods across US cities, where temperatures are ~ 5 degrees F (2.6 degrees C) hotter than non-redlined areas, due in part to reduced tree canopy and increased paved surfaces. Temperature differences in Western cities are more severe, directly increasing exposure to climate-induced heatwaves within predominantly low income and communities of color (Hoffmann et al. 2020). Vulnerability to climate change is also documented within Native American communities, along with increased exposure to pollution related to industry and military activities.³ In California, climate change is likely to further exacerbate existing racial and income disparities, increasing environmental health burdens and reducing opportunities for communities on the frontlines of climate impacts.⁴

Yet, solutions to environmental inequity can benefit many and require everyone. For example, intentionally addressing equity within climate adaptation can have profound effects on communities as a whole. When resilience is planned expressly to improve social, economic, and physical challenges of vulnerable and underrepresented populations, climate resilience for everyone can be improved, and the solutions are more durable through time.⁵ Concern about the impacts of climate change is greater among Hispanics / Latinos and African Americans than among whites, and understanding why these differences exist can help improve communication and effective action to address environmental challenges with a broad coalition.^{6,7}

Broadly, we found that the literature highlights the importance of considering the different dimensions of equity to support just transformations and equitable blue growth. Components of equity and justice have been defined in the literature as distributional (distribution of benefits and costs), procedural (who participates in decision-making), and recognition (acknowledgement of rights, culture, values, knowledge), and some add context (pre-existing social, environmental, and political

conditions).^{*8,9} Distributional equity surfaces most in the conservation literature. The peer-reviewed scientific literature is more developed as it relates to terrestrial issues, with an origin in spatial analysis of toxic sites and disproportionate exposure to low-income and communities of color. More recently, scholarship has expanded globally and into other fields including climate justice.¹⁰ In the last 10-15 years there has been a surge of publications on social equity in the field of sustainability and conservation science¹¹, see citations within Bennett et al., 2020.¹²

However, there are critical gaps within these fields. Lines of inquiry are needed specifically around ocean and coastal issues of equity, marine social science, and better understanding of how environmental vulnerabilities vary across coastal or near-coastal communities. For example, more and better exploration of Native American environmental justice scholarship are needed. Inequity within Native American communities is unique in part because “(1) Standard EJ indicators may not apply to Indigenous experiences of environmental injustice, given cultural distinctiveness; (2) there are challenges with defining “Native American”; and (3) tribal sovereignty requires different research approaches and policy prescriptions”.³ Relatively little equity research has focused on coastal and marine ecosystems (a recent review of conservation literature found less than 25% were done in ocean systems¹¹) and most do not have a lens specific to California context. Social science is critical to understanding the equity implications of sustainable ocean economies, including human well-being, participation and co-management, rights, access, livelihoods, and social impact, among others. A recent review of coastal and ocean planning processes revealed less than half included social science data and only about 1 in 10 include spatially characterized social data.¹³ Spatially explicit social science, more attention on socio-ecological linkages and stronger connections between the natural and social sciences, and true interdisciplinary work is also crucial to holistically, effectively, and justly address ocean issues and improve conservation practices.

While this relatively young field of “blue justice” is rapidly growing and has recently received considerably more attention from scientists, policymakers and practitioners in conservation and natural resource management, it is complex, multifaceted, and interwoven with a wide variety of factors inside and outside of the ocean and coastal landscape. We also found it challenging to make generalizations and draw conclusions across the literature as terms like equity and social vulnerability are not uniformly defined, addressed or well-incorporated across conservation and marine science literature, planning, and management. In many resources, they are either not explicitly defined, or are defined for a specific local context. Additionally, as related terms (such as underserved, vulnerable, low-income, disadvantaged, or environmental justice community) are often used interchangeably, future science and management endeavors would benefit from greater transparency and more explicit definitions of equity and vulnerability to the local context to which they pertain.¹⁴

*Definitions: “*Recognitional justice* refers to the acknowledgement of and respect for pre-existing governance arrangements as well as the distinct rights, worldviews, knowledge, needs, livelihoods, histories and cultures of different groups in decisions; *Procedural justice* refers to the level of participation and inclusiveness of decision making and the quality of governance processes; and, *Distributional justice* can be defined as fairness in the distribution of benefits and harms of decisions and actions to different groups across space and time.” (N. J. Bennett et al., 2019)⁸ p. 4-5, “Contextual equity... incorporates the pre-existing conditions that limit or facilitate people’s access to decision-making procedures, resources and, thereby, benefits.” (McDermott et al., 2013)⁹ p. 1.

Policy Context

Equity and justice are increasingly prioritized within state agencies in California, including coastal and marine agencies. In the last five years several agencies have adopted plans or policies seeking to address issues of justice, equity, diversity, and inclusion. These agencies include the California Coastal Commission, the San Francisco Bay Conservation and Development Commission, and the California State Lands Commission. The Governor's proposed budget also communicates a commitment to equity in air quality, public health, access to clean energy, and zero-emission transportation.

II. Access

Access to California's coasts and oceans is inequitably distributed based on income, age, and race, despite the fact that most Californians value the coast.¹⁵ Compared to other marine justice topics, access, as defined by proximity and recreation, is comparatively data rich in California. While 80% of California's 38 million residents live within 100km of shoreline access, the demographics of coastal residents is disproportionately wealthier, older, and less diverse than the general population of California. Within 1 km of a coastal access point, there are 52% fewer Hispanics or Latinos, 60% fewer Black Americans, 57% fewer Native Americans, 30% fewer Asians, and 18% fewer households below the poverty line compared to statewide averages. In addition, senior citizens are 30% more common and household income is 20% higher within 1km of the coast.¹⁶ Nearly all Californian's (89%) value the coast on a personal level. And most Californians appreciate the beach for the same reasons - for open space, for family time, and as a place to relax and explore.¹⁷ Beach recreation in Southern California is influenced by economic class, race, and immigration status. Wealth is also a predictor of beach visit frequency. For example, white Los Angeles County residents are more likely to go to the beach than Latino or African American residents. Los Angeles County immigrant residents recreate at the beach less often than US-born residents.¹⁸ A body of scientific inquiry explores the history of segregation and existing disparities in swimming access and risk. Evidence suggests that Black Americans have stronger inverse relationships between competitive swimming rates and drowning rates when compared to other racial groups and risks are higher for drowning among migrants, minority groups, First Nations, and ethnic minorities.^{20,21} While research is limited on ocean swimming specifically, these disparities carry implications for equitable access to safe beach recreation and use, as well as representation within aquatic and marine professional fields.

Addressing Barriers

Calls for considering the equity dimensions of access more broadly than physical proximity are increasing. Access can be related to institutional, regulatory, financial, capacity, and social barriers.¹² Given the interest in coastal proximity in California, coastal and marine policy related to "access" that

includes public transportation, amenities, and affordable overnight accommodations will better address equity issues.¹⁶ Surveys support this broad definition; cost is the single greatest barrier hindering overnight coastal visits but transportation/traffic issues is also a barrier for 25% of respondents.¹⁵ An in-progress study suggests that more diverse coastal communities in California are better at providing more access, using this broader definition, and work is being scoped to address how sea level rise will impact amenities and accessibility features at a jurisdictional level.²² Recommendations for making the coasts more accessible for all Californians include: improved transportation from inland areas including public funding for transportation, more affordable overnight locations near the coast, outdoor recreation opportunities for low-income families and for youth, and affordable and adequate parking options.¹⁷ Solutions to disparities in swimming and swimming risk include lesson programs for children from underrepresented backgrounds, training for adults as part of recruitment into aquatic/marine fields, and fishing safety programs.²¹

Health, Environmental Quality, and Food

The disproportionate burden of pollution born by low income communities, communities of color, and Indigenous communities is well-documented; coastal examples include port-adjacent areas exposed to poor air quality associated with diesel fumes from ships at port.²³ For example, discriminatory housing practices are linked to environmental health in the coastal zone, and higher rates of asthma within communities of color are linked to traffic-related pollution associated with ports in the Bay Area.²⁴ Gas-fired power plants that use ocean water for cooling are located along the coast in densely populated areas of Southern California and are also associated with high asthma rates in low-income communities and predominantly Latino communities.²⁵ However, more information is needed on the specific vulnerabilities to poor environmental quality within ocean and coastal communities in California.

While there are reports and case study examples on equity issues related to coastal water quality in California, we found it difficult to find peer-reviewed literature on the topic. However, in one case study in Goleta, CA, contaminated water closed a popular family beach after debris from the fire-induced mudslides in nearby affluent Montecito was intentionally relocated there.²⁶ The disparities in income and racial demographics between Montecito, which is predominantly white and affluent, and Goleta, which is 40% Hispanic and lower-income, illustrate inequity in beach access and water quality following climate-forced disasters. Coastal superfund sites have historically been associated with increased risk of contaminated seafood consumption in regions of California where pier fishing is known to occur (see discussion on subsistence fishing below and EPA report.)²⁷ A vulnerability assessment of the San Francisco Bay Area found that many communities are co-located with toxic sites and that flooding is likely to exacerbate pollution issues in communities with limited resources for cleanup.²⁸ A recent report projected that rising seas would raise the level of shallow groundwater in Alameda, CA, bringing known contaminants to the surface and exposing sensitive populations like children and the elderly.²⁹ While results were not available during the development of this report, an in-progress study is assessing how sea level rise will impact toxic sites in California (L. Cushing, personal communication, Dec 8th, 2020).

Inequitable access to open space also has implications for mental health, although this connection is not well-explored with respect to coastal open space. In urban environments, green spaces have been shown to have health benefits, although the causal relationship requires more study.³⁰ Access to “green space” has been linked to positive health metrics and outcomes in people including increased physical activity, body weight, and infant birth weight, among others.³¹ Mental health effects of access to coastal and ocean “blue spaces” requires further inquiry.

Ocean-based food insecurity and subsistence fishing in the US has also not received much research attention. Access to fishing via pier fishing, for example, is often overlooked. Individuals engaged in subsistence fishing are often members of underserved communities. Subsistence fishing is most often recognized within Indigenous and Native communities, yet it is documented in many underserved, non-Indigenous communities as well, particularly benefiting low-income, Latino and Asian/Pacific Islander fishers in southern California, for example. One study demonstrated higher risk of consumption of toxin contaminated seafood in low-income, immigrant communities, and communities of color.³² The researchers suggested this is likely due to the lack of consistent, permanent advisory signage and related distrust of the information provided in advisories, therefore, for many, the risks of contaminated seafood do not outweigh the cost-saving of dietary supplemental benefits. Part of the reason noted for high risk of consuming contaminated seafood in these areas in Los Angeles is the confluence of a history of toxic dumping (DDT and PCBs), lack of sufficient and accessible information, and populations with a higher rate of food insecurity. They also found that the intersectionality between food security and human health is an area that particularly needs more attention to help agencies identify and target outreach to more at-risk populations.³² These patterns likely differ across the state, although there is evidence that seafood contamination advisories are disproportionately misunderstood by Black and Latinx Americans and other communities of color, due to overly technocratic framing.³³ Additionally, assessing and addressing consumption of contaminated seafood in Native American Communities can be complex when food gathering or fishing has cultural or spiritual significance. For the Coast Salish Swinomish Indian Tribal Community of Washington State, for example, consuming salmon and shellfish has spiritual and communal benefits that improve health, even while these contaminated foods can cause significant physiological impacts.³⁴ Research indicates that more scientific inquiry into equity in fisheries management is needed.^{32,35}

Globally, fisheries research frequently explores distributional justice (like impacts of implementing individual transferable quotas), and fisheries management has often been critiqued for not adequately including the consideration of equity or distributional impacts of management decisions. California has a history of inequitable access in fisheries; indeed limited-entry has been an influential management approach for state-managed fisheries. As more people entered a fishery, and there was more pressure on stocks from more efficient commercial operations, conflict over the fishery generally occurred along ethnic and class boundaries.³⁶ Today most fishing ports are disproportionately white (with variability and more diversity in southern California).³⁷ However, less is known about how equity impacts extend to fishing communities in the developed world. There are multiple dimensions of equity considerations of fisheries management, including rights, culture, food security, health, climate adaptation, and access that could benefit from further examination. For example, co-management is a well-established approach in the literature to management of common pool resources, but examples of fisheries co-management research that explicitly investigates the many dimensions of equity discussed

throughout conservation literature are scarce.³⁸ Another dimension of equity in fisheries management is considering how climate change may affect fishing communities (e.g. distributional impacts of climate shocks like harmful algal blooms) and equitable distribution of benefits and harms of adaptation strategies, such as who has access. As fish stocks shift and change, developing governance frameworks to promote equitable allocations under new conditions may be required.³⁹ Results of two recent studies show that climate impacts on US fishing communities are not uniform (often disproportionately impacting smaller vessels) and the most effective adaptation strategies may not be accessible to many due to factors like financial constraints.^{40,41}

Vulnerability to Sea Level Rise

We found sea level rise to be relatively well-studied when compared to other coastal and marine equity issues across the country, but also in California. Evidence shows that flooding disproportionately affects communities of color, for example non-Hispanic Black and Hispanic residents of Florida⁴² and Black neighborhoods in Gulf States.⁴³ Vulnerability to flooding can vary based on immigration status.⁴⁴ Socioeconomic factors that may influence an individual's ability to recover from coastal flooding include health conditions, low-income, renting status, race/ethnicity, and occupation.⁴⁵

Despite the abundance of literature, there is a need for improved integration of equity and social vulnerability into the field of sea level rise scholarship. Spatial distribution of social vulnerability and the relative importance of different vulnerability indicators are not static through time and social science information should be updated regularly, just as natural science projections of sea level rise are, to maintain most relevant information to aid planning.⁴⁶ A case study in Georgia's social vulnerability by Hardy and Hauer, 2018⁴⁷ does this by considering projections of population and demographic change along with sea level rise projections. Their analysis revealed that including these projections doubled the risk to socially vulnerable groups. They also found that women had the greatest risk of exposure across multiple sea level rise scenarios, while Hispanic/Latinx populations and 65+ saw the largest proportional increase in different sea level rise scenarios. However, the direct risk of sea level rise may not be borne by the most vulnerable groups in all cases and depends on location. In Florida, by contrast, flood risk disproportionately affects socially privileged residents, who live in affluent coastal neighborhoods with access to publicly-funded protective resources. Socially vulnerable communities do not have access to similar resources but are nonetheless burdened by inland flooding or pollution.⁴⁸ There is evidence that coastal climate impacts such as sea level rise will transfer impacts to inland areas as wealthier coastal residents migrate, potentially draining coastal communities of resources.⁴⁹ This suggests that addressing equity issues related to coasts and oceans will need to be considered in the context of systemic problems that extend farther inland than a narrow coastal band.

As noted previously, research shows coastal residents in California are wealthier, whiter, and older, suggesting that coastal residents of the state are comparatively less socially vulnerable to sea level rise. The coastlines of Ventura County and the San Francisco Bay area may be an exception: more than half of the population of communities vulnerable to sea level rise exhibit high social vulnerability.⁴⁵ In the San Francisco Bay Area, even low projected sea level rise (i.e., 12" of flooding) will impact economically and socially vulnerable communities, according to a vulnerability assessment. Communities in San Rafael and San Jose are on the immediate frontlines for impacts from sea level rise;

however, over time high density areas in Oakland and San Francisco will be affected, especially residential units in San Francisco's Mission Creek. Displacement is exacerbated by both sea level rise and gentrification together and poses risks to vulnerable communities by threatening community cohesion.²⁸ Sea level rise threatens affordable housing with the impact of flooding on affordable housing expected to triple by 2050 nationally. California ranks 7th out of 23 states in projected number of affordable units exposed to sea level rise by 2050. Foster City, Suisun City, and Corte Madera are among the top 20 cities nationally that faced recent threats from coastal flooding. Corte Madera and Suisun City have among the greatest disparities in exposure between affordable and general housing in the country, indicating that affordable housing in these cities is disproportionately at risk to sea level rise.⁵⁰ Sea level rise also puts cultural sites at risk in California. Archeology sites within the Channel Islands and the nearby mainland coastline are at risk from flooding, although this risk is greater within other states with less dramatic topography.⁵¹ While this demonstrates a need to consider risk to historic sites, it also points towards the need to consider the *current and existing* significance of these sites to tribal communities in California.

Addressing Barriers

A regional or local approach over a statewide approach to assessing and mapping vulnerability is recommended by both researchers and by practitioners, as important population detail and context is lost when data are aggregated. In addition, vulnerability mapping would be improved through community science practices that ground truth data and adds qualitative context.⁵² A recent sea level rise social vulnerability assessment conducted for the City of Los Angeles is a good example of how to understand social vulnerability to sea level rise at a local level. The report examined the distribution of socially vulnerable communities and what characteristics (e.g., language and cultural isolation, proximity to community services, age of home, home ownership or renting, limited mobility) influence adaptive capacity and sensitivity to sea level rise through a Social Vulnerability Index (SOVI) and the Climate Change Community Screening Tool developed by the California Department of Public Health. The locations of vulnerable communities identified using the two tools differed due to some of the underlying characteristics included in each. The study recommends integrating the resulting vulnerability scores to help prioritize areas of concern for climate adaptation planning, and suggests that understanding the underlying characteristics and their relative influence can help inform the development of specific adaptation strategies. The authors also point to the need to protect community serving facilities in disproportionately vulnerable locations to address social vulnerability⁵³. A thorough overview of climate vulnerability assessment tools and guidance for how to define vulnerable communities is provided by the Governor's Office of Planning and Research and appropriate to the California context (See Defining Vulnerable Communities in the Context of Climate Adaptation in Resources.⁵⁴

Knowledge Gaps

- *Coastal water quality and equity*: More investigation is needed to understand the impacts of coastal water quality on underserved and vulnerable populations in California, including coastal water quality at recreational beaches.
- *Heatwaves and air quality*: More research is needed on the health, economic, and social impacts of heatwaves and air quality within coastal areas, including better understanding of how coastal spaces are being used as cooling centers for both coastal and inland communities.
- *Natural Technological disasters*: Natural technological disasters are environmental disasters exacerbated by limited or failing responses to the event within social systems. One expert called for more research on these events to assess and mitigate risk and better understand how the disproportionate impacts of disasters affect frontline communities in California (L. Cushing, personal communication, Dec 8th, 2020).
- *Coastal cultural significance*: Several experts called for more research on the cultural, spiritual, and historical significance of coastal sites in California.
- *Coastal usership, recreation, & non-market values*: There is limited understanding of coastal usership and recreation in California, what factors drive or inhibit demand especially among disadvantaged communities, and non-market values of recreation. Research into how COVID19 response has impacted beach access is also needed.
- *Intersecting dimensions of equity in fisheries*: Research is needed on fishery dependence, management and marine resource toxin risk, along with studies on the socioeconomic value of small-scale fisheries (e.g. pier-based subsistence fishing).³²

III. Assessing Equity in Coastal Resilience Planning and Actions

Centering equity considerations within ocean sustainability and resilience initiatives is instrumental to their success. Social resilience is impacted by systemic inequalities, which erects and reinforces barriers that impede response to climate-driven coastal stress. Through our search we found there has been much more work done assessing equity in urban resilience plans than coastal resilience. Equity in coastal resilience is especially scarce in California. Case studies examining equity in resilience actions from other states and non-coastal areas may be a useful starting place for more California-specific investigations. More meaningful community engagement is needed in coastal resilience planning, specifically⁵ (See Engagement Section). This includes assessing the impacts of resilience strategies to examine how socially vulnerable populations will likely be affected by a proposed resilience action or decision, in addition to “adding seats to the table” (which alone has been shown to be insufficient to ensure resilience planning fully addresses needs of socially vulnerable populations). Additionally, it was demonstrated across the literature that the lack of considerations of inclusion and real or perceived inequities can lead to lack of local support for resilience actions or sustainable blue economy development.

Resilience Planning

A nationwide assessment of climate resilience planning by local governments finds that systemic inequity is a significant principle guiding many resilience plans, while noting that equity has largely been missing from the broader scholarship on the topic.⁵⁵ In the United States, adaptation planning has only started to integrate social vulnerability.^{46,56} Climate adaptation planning in California increasingly includes equity but much work remains before it leads to meaningful outcomes. Equity is increasingly mentioned within Climate Action Plans (CAPs) in California (60% currently use equity language) but there is evidence that this is not linked to specific local needs. Enforcing and funding localized needs assessments may help address this disconnect. Social equity is not discussed in CAPs in terms of green solutions like open space but in terms of gray solutions like housing.⁵⁷ A similar analysis of coastal planning documents like Local Coastal Programs was not found.

Framing coastal community resilience planning efforts in a “whole community” lens appears to offer opportunities to create the conditions in which democratic processes and civic engagement can flourish, ensuring that visions for a resilient future for the community reflect many perspectives, including those of frontline communities.⁵ Recognizing that planning documents are often ubiquitous, do not de facto represent a collaborative process, and may not even improve spatial understanding of risks/vulnerabilities, Malecha et al., 2019⁵⁸ proposes a scoring tool (the Plan Integration for Resilience Scorecard) to integrate plans for improved resilience.

Case Studies

When climate adaptation planning excludes local perspectives from decision-making, it can result in actions that further marginalize already vulnerable populations. Through a case study in Salepo Island, Georgia, Hardy et al., 2017⁵⁹ discuss how African American residents experience uneven vulnerabilities to flooding due to racial coastal formation history, the combination of barriers to

participation in adaptation planning and lack of representation in climate science combined with racial land development and employment policies. Through “race-aware adaptation planning”, uneven vulnerabilities to flooding are better understood through their historical context and thus better addressed. Coastal adaptation and sea level rise planning provides an opportunity to address racial injustice if the issue is conceptualized by researchers and policymakers as socio-ecological instead of purely economic, ecological, or technocratic. The authors also call for better integration of qualitative and non-traditional knowledge into research, as well as improved engagement (see Engagement section). While this analysis has not been replicated in California, racial coastal formation is part of California’s coastal history. For example, in Manhattan beach, Black landowners were forced out of businesses and coastal properties through racist attacks and government seizures, resulting in displacement, trauma, and loss of income, and a coastal residential population that is now predominantly white.⁶⁰

Several case studies in the San Francisco Bay area demonstrate how to integrate equity into projects that seek to protect communities from sea level rise. For example, flood hazard mapping is integrated with training and employment opportunities for community members by the Integrated Regional Water Management Program, PRBO Conservation Science provides K-12 education opportunities within ecological restoration projects, and Urban Tilth provides many different means for integrating communities into scientific studies on flooding (p33 Nutters, 2012⁶¹).

Managed Retreat

Retreat from coastal inundation is inevitable but often creates or exacerbates inequity.⁶² The challenge of managed retreat is that relocation processes are often inequitable but failure to move may also be harmful. Buyouts and managed retreat programs are often reactionary, last resort, and ad-hoc in the US, which means in practice that their impacts are frequently inequitable. Pitfalls include lack of transparency around decision criteria and an over-reliance on cost-benefit decision-making (e.g., common government eligibility criteria stipulate that repair reimbursements cannot cost > 50% of home value; thus, the same amount of damage would fail a low-value home but pass a high-value home). Lack of transparency combined with the highly politicized nature of buyouts creates opportunities for exploitation, including forced removal of low-income or communities of color.⁶³

Strategic, managed retreat shows promise when it is one of a suite of other climate adaptation strategies and is implemented through intentional planning specific to local/regional contexts. Best practices to avoid ad-hoc retreat include: addressing risk at both the coast and the relocation site, integrating with other climate adaptation strategies, clarifying when armoring is appropriate or intentional, relocation assistance designed to improve social mobility or protect community cohesion, etc.⁶² There are opportunities for integrating environmental justice into retreat by following methodologies and tools from the fields of migration and displacements. Research-practitioner partnerships can help address these gaps.⁶²

New Jersey’s Blue Acres Buyout Program could serve as a potential model for state-run buyouts for flood mitigation, according to some experts. Blue Acres is housed under a parent program, Green Acres, that allows the state to link both open space and flooding through buyouts. Blue Acres works by prioritizing the purchase of affected *neighborhoods* before individual properties. The program has also

found success through specialized financial teams that negotiate mortgage forgiveness. The program emphasizes relationship building and human infrastructure, case workers assigned to specific areas, diversified staff, and community engagement. Program funding initially came from state bonds, followed by a post-Hurricane Sandy FEMA grant, and finally through a state corporate business tax.⁶⁴ More case studies and lessons learned in managed retreat are explored in *Managing the Retreat from Rising Seas: Lessons and Tools from 17 Case Studies* by the Georgetown Climate Center.⁶⁵

Knowledge Gaps

- *Coastal resilience strategies that improve equity*: Broadly, more research is needed to understand the effects of coastal resilience strategies on equity, including how equity is considered and addressed in coastal planning in California.
- *Managed retreat, multi-hazards*: Knowledge gaps in managed retreat include a lack of data analysis that assesses outcomes of retreat programs, including relocation destinations, public trust in the process, longitudinal studies, and comparison studies.⁶³
- *Commons before the sea*: One study recommends research directions that apply the concepts of common pool resources to the environmental justice issues related to buyouts, adaptive capacity, managed retreat, disaster response, and shoreline hardening. This approach may better acknowledge the interconnectedness of this resource (e.g., shoreline hardening shifts erosion burdens) and potentially identify more inclusive management solutions.⁶⁶

IV. Meaningful Engagement in Coastal Resilience Research, Policy Development, and Management

There are increasing calls for more meaningful engagement within both policy development and within academic research. Most of the studies read during the development of this report, in fact, propose engagement as a means for addressing the equity issues they describe. Research has shown that more local engagement can result in more benefits to local communities. Public processes and engagement during California's Marine Life Protection Act show that participatory decision-making helps secure more agreement and durable solutions.⁶⁷ Other connected terms in the discourse include participatory research, community science, citizen science, community-based design, co-production of knowledge, incorporating traditional ecological knowledge, incorporating qualitative perspectives, and ground truthing data through engagement.

Discussion of the need for better engagement was often connected to critiques of the divide between the social and natural sciences within ocean and coastal fields^{59,68}, including qualitative social science, and misperception that "stakeholder engagement" can be a substitute for social science. There is often a lack of support within science and research project funding for evaluation of the effectiveness of engagement.⁶⁹ More robust peer-reviewed research examining how different engagement strategies can lead to more equitable outcomes is needed.

Barriers to engagement in coastal resource management can be significant and include time, limited resources to participate, lack of representation within the science and the policy workforce, and traumatic histories of marginalization or exploitation.^{59,70,70} Coastal resource agencies in California find that oceans may not be priority topics, given more urgent and pressing needs related to livelihood, safety, and health within inland communities.⁷⁰ Barriers to integrating traditional ecological and Indigenous knowledge into marine resource management include power dynamics, lack of trust, differences in values and objectives, and epistemological definitions of "knowledge" (For more on this topic, see OST's Summer 2020 Quarterly Science Summary).

Addressing Barriers

There are numerous strategies for improving engagement for coastal resilience, many of which call for centering the needs of vulnerable communities throughout all stages of knowledge development. Coastal resilience researchers need to recognize that their position in living socio-ecological systems "is always consequential, never neutral" and to acknowledge and seek to understand the history of inequity, including examining white fragility.⁷¹ Without this historical reflection, understanding the systemic causes of inequity, such as racial coastal formation, is limited.⁵⁹ A recurring theme in participatory research is considering the question "resilience of what, for whom, by whom".⁷¹ Resiliency researchers can engage in community-driven design for equity by supporting transdisciplinary action research, sharing power with community-based groups and building trusting relationships (Walsh, 2018 synthesis of case studies in Wilson, 2018^{71,72}).

Additional strategies and considerations for improved engagement include: discussions with stakeholders and communities by policymakers at early planning phases of project development, advance communications about meetings, transparency in process and decision-making, providing

information up front about positive and negative outcomes of actions, valuing local knowledge of resource users, and allowing for flexibility to adapt based on feedback^{12,59} (See also Table 1 in Bennett et al., 2020¹²). Fair compensation for community engagement is recommended.^{14,73} Long-term commitments to engage are critical within both the policymaking and research communities alike.^{74(p100)} Not all projects benefit from community engagement but science funders can improve their ability to encourage and evaluate appropriate participatory research by requiring engagement plans within research grant applications. Practical guides for improving engagement practices within coastal and ocean policy and research in California are listed at the beginning of this report.

Case Studies

The Rising Voices Center for Indigenous and Earth Sciences provides a case study in a collective model for knowledge production towards understanding and preparing for climate-related impacts. “Rising Voices aims to advance science through collaborations that bring Indigenous and Earth (atmospheric, social, biological, ecological) sciences into partnership, supports adaptive and resilient communities through sharing scientific capacity, and provides opportunities for Indigenous students and early career scientists through scientific and community mentoring”.⁷⁵ The collaborative is administered by research institutions, Indigenous groups, and nonprofits.

The Thriving Earth Exchange is testing a new funding model way for supporting community science through a “Neighborhood Fund”. The effort aims to address social inequity and science funding disparities by directly funding communities for allocation towards a science activity of their choice. Among other things, this model seeks to directly compensate communities that may have been harmed by research in the past, incentivize scientists to collaborate with communities, and allow underserved communities to shape research agendas.⁷⁶

Knowledge Gaps

- *Engagement strategies for equitable outcomes:* Broadly, there is a need for more research that measures the impact of engagement and compares engagement strategies for improving equitable outcomes within both policy and knowledge development.
- *Native American communities & participatory research:* Future research directions include studying/comparing participatory research methods for positive outcomes and research into climate vulnerability of Indigenous and Native American communities.³

V. Measuring and Analyzing for Equity

Developing and Selecting Metrics

While ecosystem-based management has recognized the value of monitoring and evaluation in effective management for decades, the development of methods, metrics, and tools for assessment and monitoring of social impacts of conservation and adaptation plans has only begun more recently. Peer reviewed literature analyzing methods for measuring equitable outcomes is scarce, especially in a coastal-marine context. Additionally, when the socio-economic dimensions are included, quantitative metrics are most often used (e.g., income, age, etc.), but there is a growing call to assess more normative elements of social vulnerability to understand the greater context that informs perception of fairness and equity. Many sources recommend that indicators are carefully chosen for appropriations to the local context, specific project objectives, and to improve outcomes (for example Law et al., 2018⁷⁷). For example, common environmental justice indicators can lack alignment to Native American perspectives, limiting their applicability in measuring outcomes. In Native American communities, definitions for health may have communal or spiritual elements that are difficult to quantify. Even distance to a toxic site may not accurately represent connection to land.³

Choosing appropriate indicators is a balance between capturing the complexity of systemic inequities while maintaining feasibility. Using too few indicators may not adequately measure intersecting vulnerabilities⁷⁸ but choosing “achievable over comprehensive” is also recommended (p76 Mohnot et al., 2019¹⁴). In international coastal conservation, one study found that the use of standardized indicators, along with material definitions of equity, limited the ability for interventions to address inequities. This study and others suggest that developing metrics through improved dialogue (i.e., engagement) with community advocates and members can help address this challenge.^{14,79} Collaborating not just with program administrators but with implementation partners is important for developing appropriately scoped indicators within climate adaptation grant programs and their funded projects. Using metrics for both processes (for example, number of community-based organizations sitting on decision making entities, if community engagement changed course of project) and outcomes (e.g. increase in urban tree cover) is recommended.¹⁴ Additionally, literature indicates that while monitoring and considering the social context and impacts of conservation or adaptation action is critical to understanding and improving social outcomes and effectiveness, it is also crucial to take the next step and integrate the results of social impact monitoring back into adaptive management. Kaplan-Hallam and Bennett, 2018⁸⁰ provide a framework for adaptive social impact management, including guidance and potential methods for social indicator development, predictive assessments of social impacts, monitoring and evaluation, and more.

Example Indicators

There are many indicators of both vulnerability and resilience outcomes that provide a starting place for considering which are most appropriate for projects and locations (see list in NAACP, n.d.⁷⁸). Some indicators may be measures of both vulnerability and of resilience. Examples of vulnerability indicators categories include food security (homes identified as food insecure, distance to grocery

stores), environmental hazards (air quality, effective waste management), housing security (homes in flood plain, homes with flood proofing), etc. Examples of process/outcome indicator categories include infrastructure (coastal restoration projects, flood control projects, solar/wind installations), food security (households identified as food insecure, community seed banks), and economic development (new/local jobs created, community benefit agreements for new developments), etc.⁷⁸ The use of indicators of social well-being is gaining in popularity, while still not in common within resource management. Including indicators of well-being and how they relate to ecological outcomes is important for developing successful strategies that are effective and equitable.⁸¹ Breslow et al., 2016⁸² develop a detailed framework and example indicators for the West Coast and California current, using attributes such as sovereignty, industry & commerce, environmental quality, etc. Biedenweg et al., 2016⁸³ developed a useful framework for developing social attributes and indicators and a structure for selecting environmentally related human well-being indicators.

BCDC's Adapting to Rising Tides (ART) Program provides a case study of indicators used to assess vulnerability to flood risk in the Bay Area (p85 Toward Equitable Shorelines: Environmental Justices and Social Equity at the San Francisco Bay, 2019⁸⁴). The ART Program relies on contaminant indicators pulled from underlying data for CalEnviroScreen 3.0, but not the score itself, which weighs environmental effects differently. This program's social vulnerability indicators are developed in consultation with community advocates. Data on vulnerable groups is assessed at the scale of block groups and includes data on renters, children under 5, adults 65+ living alone, people of color, very low income, without a vehicle, people with disabilities, single parent families, limited English proficiency, without a high school degree, severely housing-cost burdened, and citizenship.

Knowledge Gaps

- *Metrics for improving equitable outcomes:* There is minimal peer-reviewed literature analyzing the use of metrics and their relationship to improving equitable outcomes across environmental justice fields but in the coastal marine literature as well. More specifically, there is a need for metrics that will support analysis of equity planning implementation and outcomes as it relates to Climate Action Plans.⁵⁷
- *No new vulnerability indicator sets:* Given the abundance of frameworks for climate vulnerability in California, a comprehensive platform that centralizes many existing frameworks would be more useful to policymakers than creating additional indicator sets.⁵²
- *Better local vulnerability data and ground truthing:* While mapping tools like CalEnviroScreen are described by researchers as great resources, experts also believe that more granular information is needed at the county or city level in order to assess vulnerability. Vulnerability mapping in California would be improved through community science practices that ground truths data and adds qualitative context.⁵²

VI. Communication and Access to Information

There is a persistent disconnect between the diversity of our society and the strategies and mechanisms used to communicate science. For example, a recent study identified the most common cited barriers to inclusive communication in two categories: barriers caused by presence and barriers caused by absence.⁶⁹ Barriers caused by presence include: organizational structures in research; inherent, unconscious, and implicit biases; spaces dominated by white communicators not sharing leadership spaces; laziness, stubbornness, or resistance toward inclusion efforts which result in fatigue for those doing inclusive science communication and public engagement; silo-ing of research and information; and geographic, linguistic, financial, cultural, and socioeconomic status factors. Barriers caused by absence include: lack of funding; lack of understanding, knowledge, training, or resources for doing inclusive science communication work; not assessing if inclusion efforts are actually inclusive; inadequate diversity among leadership in science communication efforts; limited opportunities or platforms; minimal networking, collaboration, or sharing of information; and few opportunities for diverse, young scientists to be engaged in science. To address these, the social science literature indicates that science communication practitioners and scholars must move beyond documenting the barriers to inclusion and diversity to strategies and solutions that can help increase inclusion, equity, and diversity, and assess the impacts of those strategies in reaching and engaging underserved audiences.

Addressing Barriers

As science communication grows ever more important and inequitable distribution of access to information is increasingly recognized, there has been a recent and rapid development in best practices for more inclusive science communication (e.g. see [InclusiveSciComm Resources](#) and special Frontiers research topic [Inclusive Science Communication in Theory and Practice](#) - several papers from which are cited below). For example, a recent review distilled seven common principles for inclusive science communication: Listen, “reduce the distance” between the communicator and audience, illustrate relevance to daily life, going where the people are, cooperation is key, mind the “openness paradox” (i.e. the more open a project is, the more prior knowledge and initiative the participants need to be engaged), and implement long-term activities.⁸⁵ Cross cutting elements to these recommendations are explored further below:

Trust

Building and maintaining trust are mentioned across the literature as crucial aspects of successful communication of information, developing two-way conversations and pathways to share information. This includes listening, truly collaborating, and creating safe spaces. This also may include working with key communicators or other trusted members of communities, and/or establishing partnerships with other organizations or groups already engaging with the target audience. This can contribute to understanding the audience needs, identifying potential or existing barriers, and acting as trusted conduits between the communicator and the audience. Often when the messages come from trusted communicators, they will be more effective and successful. Building trust is time and resource intensive, and one-time communications or engagements can produce the opposite effect in making

underserved communities feel more marginalized.⁸⁵ Literature and recommendations state that this should be considered in funding and design of projects in order to ensure more equitable outcomes and access to information.⁷³

Language

Throughout the literature, language is identified as an important element of equity in science information accessibility. Often science is communicated to audiences in only English and from the white-dominant perspective and can act as a gatekeeper to scientific discourse.⁸⁶ In addition to being able to understand the language in which information is presented, language also influences how people perceive and conceptualize the world and often intersects with other marginalized identities in ways that can compound marginalization.⁸⁷ Effective and inclusive communication of science recognizes the culture, perspectives, experiences and knowledge of the audience and aims to cultivate belonging and engagement of the audience or collaborator.⁸⁸ Health advisories for contaminated seafood, for example, that have taken into account the cultural background of the potential readers, literacy levels, and other factors targeted at specific audiences are more effective.³³

Science can also be a third language to non-native English speakers, making it even more challenging to understand.⁸⁹ And often translating terms directly into another language does not capture the intent or scientific concepts accurately. Literature suggests that one must understand how different terms are used in different languages and how best to translate and interpret concepts. One study recommended that translators ensure the intended audience understands concepts at each step instead of solely focusing on maximizing technical precision.⁹⁰ Other recommendations include creating partnerships with translators who are language justice advocates and using mediums like images, drawings, and graphic recordings to share information.⁷³ For example, results of a recent pilot study indicated significant benefits of using context-rich images alongside traditional Western science for reporting information about the local context and experience of environmental changes.⁹¹ Lastly, language has been noted as a barrier to more communication between science disciplines (especially between natural and social sciences) as each has its own language and set of terms that need translating and clearer communication to achieve effective communication.⁶⁸

Framing and Structure

Similar to language, framing and culturally responsive communication are key to reaching intended audiences. Framing that places concepts in the audience's world view and includes culturally relevant context to everyday life can influence the understanding and support for a given topic or issue.^{85,92} Studies have shown that communications that are culturally-responsive in design, include multiple ways of knowing, and exhibit co-creation and collaborative design can result in benefits such as improved science learning and science capital for underrepresented communities, and greater empathy among technical experts.⁸⁸ As one study notes, optimal communication connects knowledge of concepts with the knowledge of the backgrounds and experiences of the receivers.⁹⁰ Other examples of successful framing and structures to engage with diverse communities include storytelling (narratives), using art as a communication tool, and community science. Narratives can be particularly effective in public

health.^{86,93} Qualitative social science approaches can help understand further why and how people exhibit certain behavior in response to information.

Venues

Location of communication also matters for accessibility and can influence what the audience thinks of the information. This includes physical location as well as online channels. Often financial, temporal, or geographical barriers can inhibit individuals from participating and accessing information in the physical venues in which it is presented. For example, trip costs can be hard to afford for individuals from underserved and lower socio-economic backgrounds so if information sharing is held far away and/or during work hours, it leaves these venues inaccessible. Venues that are within a community and feel more welcoming and familiar can also ease information access and exchange. Thus, efforts to provide accessible venues can be important to access information, as well as meaningful engagement.⁸⁵ Additionally, online channels of information sharing have steadily increased recently. Social media use, for example, has increased significantly over the past 10 years and has developed into a platform in which science communication happens more regularly, especially connecting with other scientists. As these platforms are available at low or no cost, if used in conjunction with strategies to support efforts that are culturally relevant and in languages in addition to English, they have the potential to effectively lower the barriers of access to knowledge.^{86,94}

Venue selection should carefully consider who the target audience is and when they would need to access information. For example, a recent study on risk and information access regarding contaminated seafood and subsistence fishing found that while relevant information was available in several languages online, many of the fishers were not aware of the risks. This indicates that the information is still not reaching the target audience, those who partake in the subsistence fishing activities. There were no signs with warnings or information at the potentially contaminated fishing locations, and the study showed that people were relying on word of mouth. Underrepresented groups and those for whom English is not a first language were most likely to be unaware of the risks.³² This example underscores the importance of using multiple communication tools and venues to be more effective and inclusive in information sharing.

Knowledge Gaps

- *Inclusivity verification & effectiveness:* More study is needed to assess if inclusive communication is successful in practice and in documenting / sharing effective strategies.
- *Effects of culture & ways of knowing:* Few studies have explored how cultural processes and epistemological orientations inform effective science communication (as noted in Canfield et al., 2020⁸⁸)

VII. Representation in Marine Science Academia, Coastal Management, and Policy

Lack of representation in any sector influences the effectiveness of solutions. The literature notes that dialogue between scientists and policymakers often creates “patterns of reciprocal influence” in which policy questions drive scientific exploration as much as the scientific results influence policy and management decisions. Therefore, who is represented in the dialogue in ocean science and management influences the production, application and circulation of knowledge in both the science and the policies around how to address ocean issues. For example, in a recent study on sea-level rise adaptation in Georgia (also described in the Resilience Planning section) researchers argue that “underrepresentation of African Americans in science and the environmental movement more generally work together to perpetuate colorblind adaptation planning in sea-level rise vulnerability projects”.⁵⁹ Below we examine the state of representation in the ocean sciences.

Much of the available information on representation focuses on the demographics and retention rates under the umbrella of STEM (science, technology, engineering and math) and the geosciences broadly, but these patterns appear to be mirrored in ocean and coastal sciences. Below, we discuss at the level of ocean sciences where data are available, otherwise we note patterns in geosciences broadly. It is important to note that the data and information captured below only includes natural science. The demographics of marine social science were not readily discovered during our search and should be investigated further, as marine social science and the representation therein will be critical to addressing marine and coastal issues effectively. It was noted in our search that mentorship to foster more social science through the “pipeline”, including more application-based social science is needed.

Academia

There has been significant attention in the last few decades on the disparities in educational outcomes in the STEM fields, and the literature reveals persistent inequality in STEM degree attainment not found in other fields. Black and Latinx students leave STEM fields at higher rates than their white counterparts and leave STEM at higher rates than other fields.⁹⁵ Of the various STEM disciplines, ocean and coastal sciences has grown over the past few decades, but it continues to be one of the least diverse. National Science Foundation data shows that 13% of graduate students in ocean sciences identify as underrepresented vs. 18% of graduate students in biological sciences identify as underrepresented (National Science Foundation website⁹⁶, cited by C. Garza). This pattern is even more stark at the PhD level and has not changed in the last 40 years.^{97–99} In 2016, only 6% of geoscience PhD were awarded to students from underrepresented minorities, a population that made up 31% of the US population. Women of color in particular only made up 1.46% of awarded doctorates over the last 40 years.⁹⁷ In contrast, significant gains have been made in gender balance over the last few decades, with between 50-60% women in ocean science graduate programs. (Databases: [NSF](#), [IPEDS](#), and [OSER](#))

Ocean Workforce

Across the literature there is strong evidence that students from underrepresented backgrounds are interested in the environmental and conservation careers broadly. Yet, while progress has been made in gender parity at the student level in academia (as noted above), there is still a lack of gender and racial diversity in the ocean workforce, including academic positions. For example, only 20% tenured faculty are women and only 3.8% of tenured or tenure-track faculty in the top earth science departments are from underrepresented groups.^{97,100} Similarly, outside of academia, lack of diversity is still rather stark. For example, in the fisheries profession about 1 in 4 are women and less than 10% are non-white. The U.S. holds the largest gap between its demographic makeup and what's reflected in the fisheries profession, and it is most stark in the Western region.^{101,102} In environmental NGOs more broadly, most organizations do not report demographics of staff, therefore it is difficult to understand the current state of representation and diversity that exists in that sector of ocean sciences.¹⁰³ Studies do suggest there is significant opportunity for employment growth for underrepresented minorities in several dimensions of ocean and coastal science careers over the next 10-15 years.

Addressing Barriers

The barriers and challenges associated with DEI in the ocean sciences and related workforce are multifaceted and complex, including financial, academic, and social barriers. For example, underrepresented students are more likely to come from families of lower income, work part-time, face microaggressions and lack of support, and face the presence of stereotype threat. Additionally, the literature indicates that underrepresented students may be selecting fields of study outside of the ocean sciences based on considerations of relevancy to communities (i.e. desires to contribute to positive change in their communities), perceived lack of career and advancement opportunities, desire for social justice focus, limited exposure to career paths and role models/mentors, and long, underpaid or unpaid research experiences.¹⁰⁴ Barriers between education and workforce also include, feeling “othered” in field experiences, discrimination, lack of mentorship, existing diversity of an organization, and limited promotion opportunities.^{105,106} Additionally, the vast majority of scientific journals, especially highly regarded and influential ones, are only published in English. When academic and career advancement is based on publishing in influential journals and English is not an individual's first language, it is often more difficult to advance.⁸⁶

To address the above issues and barriers, many organizations, academic institutions, and professional societies have taken steps towards change. The American Fisheries Society (AFS), for example, has held several symposia and has made commitments towards diversity in the profession. Their programs focus efforts on the link between education and the workforce, a critical point for engaging underrepresented groups in the marine and conservation sciences.¹⁰⁷ Mentoring programs (peer-peer, multidimensional, and culturally competent mentoring) have been demonstrated to play a pivotal role in addressing factors contributing to underrepresentation in STEM (e.g. mentoring programs at professional societies like ASLO Multicultural Program and minority-serving organizations like Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS). See Johnson et al., 2016¹⁰⁴ for more). Additionally, institutional bridge programs, systemic pedagogy and curriculum

reforms, purposeful work to improve campus culture, undergraduate research experiences, career counseling, financial support, and accountability for diversity are successful types of programs that strengthen the systems that surround and foster underrepresented students' success.^{108,109}

Knowledge Gaps

- *California-specific ocean science demographic data:* The above data are reflective of the entire US. Data analyzed separately for California were not found during our search. While it may exist, it is not easily found, communicated, or referenced.
- *Evidence for effective strategies:* Limited research on effectiveness of peer- and cohort support networks and other efforts to make STEM more inclusive and engaging for all students. Geosciences need to be more proactive in documenting and sharing lessons learned around effective strategies to the broader research community.
- *Lack of student retention in the workforce:* More research is needed to understand the disconnect between underrepresented students' interest in a marine and coastal or environmental career and the persisting disproportionately white workforce.
- *Demographic reporting in the workforce:* While federal agencies report diversity demographics, the majority of environmental organizations still do not.¹⁰³ To better understand and address the diversity issues in the ocean workforce, research and reporting can help illuminate the extent to which minorities are underrepresented across various ocean sectors.

VIII. Emerging Concerns & Related Issues

With attention on the oceans for new growth and economic opportunities, experts noted that the ability to understand the distribution of social and economic benefits and harms of the blue economy is important, yet still relatively undeveloped. This includes potential inequities in tourism, increased pollution levels, desalination, space use (e.g., aquaculture and marine renewables), access to fishing industry, concentrated ownership, and social and cultural changes. Authors of a recent publication chart a course to equitable blue economy development including calling for insights and investments in interdisciplinary science and lessons learned communicated to inform and design blue-economy more broadly.¹¹⁰ Recommendations from Bennett et al., 2020¹² may be a useful starting place for exploring how ocean-based economic development can address injustice, although they may require fine-tuning for the California context. A few examples of blue growth strategies that show promise in other places in the US: regenerative ocean development, community-based blue economies, and community-supported fisheries.¹²

The equity impacts of poor environmental quality and environmental disasters - such as air quality, heatwaves, fire, and landslides - are more conventionally within the domain of land-based resource management but still occur within the coastal zone. For example, environmental justice screening analysis reveals that low-income and communities of color within the Los Angeles Air basin are disproportionately exposed to toxic sites, air pollution, and at greater health risk.²³ Following fires and mudslides in Montecito in 2017, recovery and relief services did not equitably reach low-wage and immigrant workers. For example, transit-dependent workers could not travel due to road closures, farmworkers were exposed to poor air quality with little protection, and drinking water contamination warnings failed to be clearly translated for Spanish-speaking households.¹¹¹ Ultimately, this disaster also resulted in beach closures in lower income communities (See section discussing environmental quality above). These examples illustrate the interconnectedness of systemic inequality across natural landscapes.

IX. Conclusion

While full consideration of “terrestrial” equity issues is beyond the scope of this report, the widespread nature of inequity suggests unconventional approaches outside what is traditionally considered ocean and coastal resource management. This rapid assessment begins to describe broad and far-reaching inequalities within California’s coastal and marine socio-ecological systems and suggests research directions for evidence-based policy in this area. Ultimately, solutions to environmental equity demand broad engagement across policy and science. When resilience efforts center underrepresented and vulnerable communities, the results can benefit everyone and be more durable through time.

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