



NOAA TECHNICAL MEMORANDUM NMFS-SEFSC-789

**SOUTHERN CALIFORNIA BIGHT AQUACULTURE
OPPORTUNITY AREA SITE SELECTED OPTIONS: COMMUNITY
SOCIAL VULNERABILITY PROFILES**

Adriane K. Michaelis

**U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149**

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Adriane K. Michaelis

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149

U.S. Department of Commerce
Gina M. Raimondo, Secretary

National Oceanic and Atmospheric Administration
Richard W. Spinrad, NOAA Administrator

National Marine Fisheries Service
Janet Coit, Assistant Administrator for Fisheries

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Author and affiliation:

Adriane K. Michaelis, ECS under contract with National Marine Fisheries Service, Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, FL 33149.

Questions, comments, or feedback on this report? Please contact:

Adriane Michaelis

adriane.michaelis@noaa.gov or adriane.michaelis@ecstech.com

ECS, under contract with NOAA Fisheries

75 Virginia Beach Drive

Miami, Florida 33149

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Acronyms

AOA	Aquaculture Opportunity Area
CDP	Census Designated Place
CSVI	Community Social Vulnerability Indicator
EAL	Expected Annual Loss
FEMA	Federal Emergency Management Authority
GDP	Gross Domestic Product
km	kilometer
NCCOS	National Centers for Coastal Ocean Science
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NRI	National Risk Index
PEIS	Programmatic Environmental Impact Statement
SBC	Santa Barbara Channel
SSO	Site Selected Option

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Abstract.

On May 22, 2022, NOAA Fisheries published a Notice of Intent (NOI) to Prepare a Programmatic Environmental Impact Statement for Identification of One or More Aquaculture Opportunity Area(s) in Southern California (87 FR 31210). Areas of analysis in the NOI include the Santa Barbara Channel and Santa Monica Bay. This document provides an overview of social vulnerability and natural hazard risk factors for communities within proximity to Aquaculture Opportunity Areas (AOA) of analysis in the Southern California Bight. Summaries are presented by groups of Site Selected Options (SSOs), polygons that have undergone a spatial analysis by the NOAA National Centers for Coastal Ocean Science (NCCOS) as the first step to identify AOAs. Two groups of SSOs are in the Santa Barbara Channel and one group occurs in Santa Monica Bay. This analysis was completed to help inform the identification of AOAs in the Southern California Bight and utilized NOAA Fisheries Social Vulnerability Indicators for Coastal Communities (CSVIs) to assess potential vulnerabilities in communities within 25 kilometer of SSOs. In addition to NOAA Fisheries CSVI data, the Federal Emergency Management Agency's (FEMA) National Risk Index was used to capture California-specific natural hazards and related risk to coastal communities.

Aim:

On May 22, 2022, NOAA Fisheries published a Notice of Intent (NOI) to Prepare a Programmatic Environmental Impact Statement (PEIS) for Identification of One or More Aquaculture Opportunity Area(s) in Southern California (87 FR 31210). Areas of analysis in the NOI include the Santa Barbara Channel and Santa Monica Bay. This document provides an overview of social vulnerability and natural hazard risk factors for communities within proximity to Aquaculture Opportunity Areas (AOA) of analysis in the Southern California Bight. Summaries are presented by groups of Site Selected Options (SSOs), polygons that have undergone a spatial analysis by the NOAA National Centers for Coastal Ocean Science (NCCOS) as the first step to identify AOAs.¹ Two groups of SSOs are in the Santa Barbara Channel (SBC; referred to as SBC East and SBC West in this analysis) and one group occurs in Santa Monica Bay. This analysis was completed to help inform the identification of AOAs in the Southern California Bight and utilized NOAA Fisheries Social Vulnerability Indicators for Coastal Communities (CSVIs) to assess potential vulnerabilities in communities within 25 kilometers of SSOs.² In addition to NOAA Fisheries CSVI data, the Federal Emergency Management Agency's (FEMA) National Risk Index was used to capture California-specific natural hazards and related risk to coastal communities.³

Background:

NOAA Fisheries developed social indicators for coastal communities engaged in fishing activities to characterize community well-being.⁴ These Community Social Vulnerability Indicators (CSVIs) include “14 statistically robust social, economic, and climate change indicators that uniquely characterize and evaluate a community’s vulnerability and resilience to disturbances.” Often, these “disturbances” take shape as changes to fishing regulations, extreme weather events, climate change impacts, or other major events (e.g., oil spills).

For the purposes of this analysis, offshore aquaculture industry development was treated as a potential “disturbance” in a broad sense, i.e., a potential change to the system. Specifically, the analysis focused on areas that could be relevant to the ongoing planning

¹ NCCOS. 2024. An Aquaculture Opportunity Area Atlas for the Southern California Bight. [Available at https://coastalscience.noaa.gov/data_reports/an-aquaculture-opportunity-area-atlas-for-the-southern-california-bight/]

² NOAA Fisheries. 2024. Social Indicators for Coastal Communities. [Available at <https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-coastal-communities>]

³ FEMA. 2024. National Risk Index. [Available at <https://hazards.fema.gov/nri/>]

⁴ Jepson, M., & Colburn, L. L. 2013. Development of social indicators of fishing community vulnerability and resilience in the US Southeast and Northeast regions. NOAA Tech. Memo. NMFS-F/SPO-129, 72. [Available at <https://repository.library.noaa.gov/view/noaa/4438>]

process to potentially identify Aquaculture Opportunity Areas (AOAs) for offshore aquaculture development in Southern California. An AOA is a discrete geographic area that may be suitable for commercial aquaculture. As of this writing, no AOAs have been identified as the NEPA process must first be completed through the Programmatic Environmental Impact Statement.

The AOA SSOs are not prescriptive to the types of aquaculture production that may occur at these locations or operational requirements or details (e.g., species in production, harvest methods, or landing locations). As such, the specific interactions between aquaculture in AOAs, once they are identified, and nearby coastal communities are not yet known. Attention to existing vulnerabilities during early planning and the AOA identification process can strengthen understanding of human dimensions and potential community impacts for any future aquaculture siting in the region.

To complement the CSVI data and provide information specific to natural hazards in Southern California that are not captured within CSVIs, National Risk Index (NRI) scores generated by FEMA were also considered in order to more broadly understand vulnerability and risk in SSO-adjacent communities. The NRI provides relative risk ratings based on data for expected annual loss (EAL) due to natural hazards, social vulnerability, and community resilience.^{5,6} As defined by FEMA, natural hazards are environmental phenomena with the potential to impact societies and the human environment and are distinct from manmade hazards. The NRI targets 18 unique natural hazards that may influence community vulnerability and risk to varying extents. Through this analysis, potential natural hazards were identified in order to better visualize how aquaculture development might influence these hazard risks and vice versa.

The analysis was carried out with the assumption that the identification of AOAs would lead to future siting of offshore aquaculture that may interact with nearby communities in various ways, depending on project-specific details and operational practices. There is no requirement that future farms be sited within AOAs, and the exact details of future farms (e.g., size, location, species and volume in production) are unknown. As such, the relationship between offshore aquaculture development and local communities is complex,

⁵ Zuzak, C., E. Goodenough, C. Stanton, M. Mowrer, A. Sheehan, B. Roberts, P. McGuire, and J. Rozelle. 2023. National Risk Index Technical Documentation. Federal Emergency Management Agency, Washington, DC. [Available at https://www.fema.gov/sites/default/files/documents/fema_national-risk-index_technical-documentation.pdf]

⁶ Zuzak, C., Mowrer, M., Goodenough, E., Burns, J., Ranalli, N., & Rozelle, J. 2022. The national risk index: establishing a nationwide baseline for natural hazard risk in the US. *Natural Hazards*, 114(2), 2331-2355. <https://doi.org/10.1007/s11069-022-05474-w>

and unlikely to be readily predicted as a simple set of positive or negative impacts at this stage. **The intent of this analysis was not to predict impacts for this nascent industry, but instead to highlight community-level characteristics related to social vulnerability and natural hazard risk that should be recognized and thoughtfully considered in both strategic planning and the potential siting of future operations.**

Methods:

This analysis utilized two publicly available data sources to conceptualize vulnerability and risk in coastal communities near SSOs in the Southern California Bight: 1) NOAA's Community Social Vulnerability Indicators (CSVIs) and 2) FEMA's National Risk Index (NRI).

Community Social Vulnerability Indicators.

The CSVIs are categorized into five indicator groups: fishing engagement and reliance, environmental justice, climate change, economic, and gentrification pressure. Within each group are specific indicators that contribute to the overall characterization of that particular component of social vulnerability (Table 1). Indicator scores range from 0 to 4, with 1 representing least vulnerable or at risk and 4 most vulnerable (relative to that indicator). Values of 0 correspond to no available data. For the full methodology of how indicators were generated, refer to Jepson and Colburn (2013).⁷

⁷ Jepson, M., & Colburn, L. L. 2013. Development of social indicators of fishing community vulnerability and resilience in the US Southeast and Northeast regions. NOAA Tech. Memo. NMFS-F/SPO-129, 72. [Available at <https://repository.library.noaa.gov/view/noaa/4438>]

Table 1. NOAA Fisheries Community Social Vulnerability Indicators

Indicator Group	Indicator	Definition
Fishing engagement and reliance	Commercial fishing engagement	Measures the presence of commercial fishing through fishing activity as shown through permits, fish dealers, and vessel landings. A high rank indicates more engagement.
	Commercial fishing reliance	Measures the presence of commercial fishing in relation to the population size of a community through fishing activity. A high rank indicates more reliance.
	Recreational fishing engagement	Measures the presence of recreational fishing through fishing activity estimates. A high rank indicates more engagement.
	Recreational fishing reliance	Measures the presence of recreational fishing in relation to the population size of a community. A high rank indicates increased reliance.
Environmental justice	Poverty	Is expressed as those receiving assistance, families below the poverty line, and individuals older than 65 and younger than 18 in poverty. A high rank indicates a high rate of poverty and a more vulnerable population.
	Population composition	Corresponds to the demographic makeup of a community including race, marital status, age, and ability to speak English. A high rank indicates a more vulnerable population.
	Personal disruption	Captures unemployment status, educational attainment, poverty, and marital status. A high rank indicates less personal capacity to adapt to changes and thus a more vulnerable population.
Climate change	Sea level rise	Signifies the overall risk of inundation from projected sea level rise between one to six feet over the next ~90 years. The indicator represents the possibility of inundation based upon the combined projections at each stage of sea level rise and could vary depending upon future circumstances. A high rank indicates a community more vulnerable to sea level rise.
	Storm surge risk	Refers to the overall flooding risk from hurricane storm surge categories 1-5. It represents the "worst-case" possibility of inundation based on the combined hurricane storm surge categories and could vary depending on future circumstances. A high rank indicates a community more vulnerable to a particular hurricane storm surge.
Economic	Labor force structure	Characterizes the availability of employment including females employed, population in the labor force, self-employment, and social security recipients. A high rank indicates fewer employment opportunities and a more vulnerable population.
	Housing characteristics	A measure of infrastructure vulnerability to coastal hazards including median rent and mortgage, number of rooms, and presence of mobile homes. A high rank means more vulnerable infrastructure and a more vulnerable population. On the other hand, the opposite interpretation might be that more affordable housing could be less vulnerability for some populations.
Gentrification pressure	Housing disruption	Represents factors that indicate a fluctuating housing market where some displacement may occur due to rising home values and rents including change in mortgage value. A high rank means more vulnerability for those in need of affordable housing and a population more vulnerable to gentrification.
	Retiree migration	Characterizes communities with a higher concentration of retirees and elderly people in the population including households with inhabitants over 65 years, population receiving social security or retirement income, and level of participation in the workforce. A high rank indicates a population more vulnerable to gentrification as retirees seek out the amenities of coastal living and move to these communities.
	Urban sprawl	Describes areas experiencing gentrification through increasing population density, proximity to urban centers, home values and the cost of living. A high rank indicates a population more vulnerable to gentrification.

Identification of Communities. The SSOs used in this study were generated by the NOAA National Centers for Coastal Ocean Science (NCCOS) in the Aquaculture Opportunity Area Atlas (AOA Atlas) for the Southern California Bight.⁸ The SSOs include two options in Santa Monica Bay, referred to here as “Santa Monica Bay SSOs” and eight options in the Santa Barbara Channel, separated as two groups and referred to here as “Santa Barbara Channel East (SBC East) SSOs” and “Santa Barbara Channel West (SBC West) SSOs” (see figures in “Results and Discussion” below).

NOAA Fisheries CSVI data were downloaded as a .csv file from the publicly available online NOAA CSVI mapping tool, using the most recent dataset (2018).⁹ The file was translated into a spatial layer using the “XY table to point” function in ArcGIS and integrated into a project file that included a shapefile of SSOs in the AOA Atlas. The “select by location” function was used to identify fishing communities within the CSVI dataset that were within a 25-kilometer radius of SSOs (Table 2). For this analysis, SSOs are considered as they are located within one of three groups (SBC East, SBC West, and Santa Monica Bay) and the radius extends from the full area of polygons mapped in ArcGIS.

Table 2. Fishing communities within 25 km of Southern California Bight SSOs

Communities within 25 km	SBC East		SBC West	Santa Monica Bay	
	Carpinteria	Oxnard	Carpinteria	Beverly Hills	Lennox
	Channel Islands Beach	Port Hueneme	Montecito	Calabasas	Los Angeles
	El Rio	Saticoy	Santa Barbara	Culver City	Malibu
	Meiners Oaks	Summerland	Summerland	Del Aire	Manhattan Beach
	Mira Monte	Toro Canyon	Toro Canyon	El Segundo	Marina del Rey
	Montecito	Ventura		Hawthorne	Redondo Beach
	Oak View			Hermosa Beach	Santa Monica
				Hidden Hills	Topanga
			Inglewood	View Park-Windsor Hills	
			Ladera Heights	West Hollywood	
			Lawndale		

The influence of offshore aquaculture is not expected to be bound by 25 kilometers, but this radius is thought to capture the vulnerability profiles of communities located closest to these potential offshore sites. In other words, if a particular offshore site were likely to

⁸ NOAA Fisheries. 2024. West Coast Region Southern California Aquaculture Opportunity Area. [Available at <https://www.fisheries.noaa.gov/west-coast/aquaculture/west-coast-region-southern-california-aquaculture-opportunity-area#proposed-action-and-preliminary-alternatives>]

⁹ NOAA Fisheries. 2024. Social Indicators Tool. [Available at <https://www.st.nmfs.noaa.gov/data-and-tools/social-indicators/>]

influence or be influenced by particular communities, those that are closest might be the most likely to have some sort of relationship to and with a developing offshore industry. These communities warrant exploration of documented vulnerabilities based on their proximity to SSOs to better understand the potential cumulative impact of offshore aquaculture development in the region. Because of this assumption, communities highlighted in this analysis should not be interpreted to be those that will absolutely experience impacts, nor the only communities that will experience impacts from the development of offshore aquaculture. Additionally, though communities will be analyzed and discussed individually, given the exploratory nature of this analysis, it is practical to consider not only individual community characteristics but also the collective profile of communities in each region as they relate to potential offshore aquaculture development.

Social Vulnerability Assessment. Categorical indicator rank scores for the identified communities were translated into stacked bar plots to visualize relative vulnerability for each SSO group (SBC East, SBC West, and Santa Monica Bay). Indicator scores ranged from 0 to 4, with 1 representing least vulnerable and 4 most vulnerable, relative to each vulnerability indicator. Values of 0 corresponded to no available data. Within the fishing engagement and reliance indicators, high scores correspond to high engagement in and reliance on commercial or recreational fishing activity (i.e., if the fisheries were impacted by an event, they would be highly vulnerable).

To create stacked bar plots, the number of communities possessing each rank score was totaled on an indicator-by-indicator basis. For example, in the group of communities within 25 kilometers of SBC East, for the indicator of urban sprawl one community had no data (a score of 0), zero communities had scores of 1 or 2, eight communities had scores of 3, and four communities had scores of 4. These counts or totals were then visualized in the related plot for that area (Figure 2 in “Results and Discussion”). Plots and the overall data were qualitatively assessed and described, with consideration for how a developing offshore aquaculture industry might affect or be affected by these patterns of vulnerability.

National Risk Index.

National Risk Index (NRI) scores generated by FEMA were included to provide additional detail on specific natural hazard risks in communities adjacent to SSOs. As noted above, the NRI provides relative risk ratings based on data for expected annual loss (EAL) due to natural hazards and its relationship to social vulnerability and community resilience (Risk Index = Expected Annual Loss * Social Vulnerability / Community Resilience). The EAL is calculated using values related to exposure, annualized frequency, and historical loss (EAL = Exposure * Annualized Frequency * Historical Loss Ratio).

A community’s NRI score describes its relative ranking among communities at the same geographic level (e.g., county level) with attention to 18 unique natural hazards (Table 3).

Risk Index Scores range from 0 (lowest risk) to 100 (highest risk). For each indicator – Risk, Expected Annual Loss, Social Vulnerability, and Community Resilience – a qualitative ranking is assigned alongside the percentile value. These calculations place emphasis on monetary loss to calculate risk, and as such financial loss may not adequately capture the full impact of an event on a community (i.e., dollars may not translate adequately to reflect the overall damage caused by major flooding). Still, the index scores are useful alongside vulnerability profiles to consider how the risk from natural disasters and environmental hazards may compound or magnify vulnerabilities identified using the CSVIs.

Natural Hazard Risk Assessment. National Risk Index reports were generated from the FEMA National Risk Index online mapping tool for coastal counties containing communities from the CSVI analysis, including Santa Barbara, Ventura, and Los Angeles Counties.¹⁰ Reports included qualitative relative ranking of the overall risk index, expected annual loss, social vulnerability, and community resilience, in addition to providing percentile scores for each category. This analysis focused on overall risk, but social vulnerability and community resilience rankings are also presented for each county. The FEMA mapping reports also provide a risk index score by hazard type, which are presented for each county below to reflect hazards specific to the areas to better consider risk and vulnerability.

¹⁰ FEMA. 2024. Map – National Risk Index. [Available at <https://hazards.fema.gov/nri/map>]

Table 3. FEMA National Risk Index natural hazard categories

Natural Hazard	FEMA Description
Avalanche	A mass of snow in swift motion traveling down a mountainside
Coastal Flooding	When water inundates or covers normally dry coastal land as a result of high or rising tides or storm surges
Cold Wave	A rapid fall in temperature within 24 hours and extreme low temperatures for an extended period.
Drought	A deficiency of precipitation over an extended period of time resulting in a water shortage.
Earthquake	A shaking of the earth's surface by energy waves emitted by slowly moving tectonic plates overcoming friction with one another underneath the earth's surface
Hail	A form of precipitation that occurs during thunderstorms when raindrops, in extremely cold areas of the atmosphere, freeze into balls of ice before falling towards the earth's surface
Heat Wave	A period of abnormally and uncomfortably hot and unusually humid weather typically lasting two or more days with temperatures outside the historical averages for a given area.
Hurricane	A tropical cyclone or localized, low-pressure weather system that has organized thunderstorms but no front (a boundary separating two air masses of different densities) and maximum sustained winds of at least 74 mph
Ice Storm	A freezing rain situation (rain that freezes on surface contact) with significant ice accumulations of 0.25 inches or greater
Landslide	The movement of a mass of rock, debris, or earth down a slope
Lightning	A visible electrical discharge or spark of electricity in the atmosphere between clouds, the air and/or the ground often produced by a thunderstorm
Riverine Flooding	When streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow and water overflows the banks, spilling out into adjacent low-lying, dry land
Strong Wind	Damaging winds, often originating from thunderstorms, that are classified as exceeding 58 mph
Tornado	A narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground and is visible only if it forms a condensation funnel made up of water droplets, dust, and debris
Tsunami	A wave or series of waves generated by an Earthquake, Landslide, volcanic eruption, or even a large meteor hitting the ocean and causing a rise or mounding of water at the ocean surface
Volcanic Activity	Occurs via vents that act as a conduit between the Earth's surface and inner layers, and erupt gas, molten rock, and volcanic ash when gas pressure and buoyancy drive molten rock upward and through zones of weakness in the Earth's crust
Wildfire	An unplanned fire burning in natural or wildland areas such as forests, shrub lands, grasslands, or prairies
Winter Weather	Winter storm events in which the main types of precipitation are snow, sleet, or freezing rain

Results and Discussion:

This analysis resulted in the identification of 13 communities within 25 kilometers of Santa Barbara Channel East SSOs, 5 communities within 25 kilometers of Santa Barbara Channel West SSOs, and 21 communities within 25 kilometers of the Santa Monica Bay SSOs (using the communities characterized in the NOAA Fisheries CSVI dataset; Table 2 above).

Santa Barbara Channel East (SBC East)

Thirteen communities from the CSVI dataset were located within 25 kilometers of the five Santa Barbara Channel East (SBC East) SSOs (Figure 1).

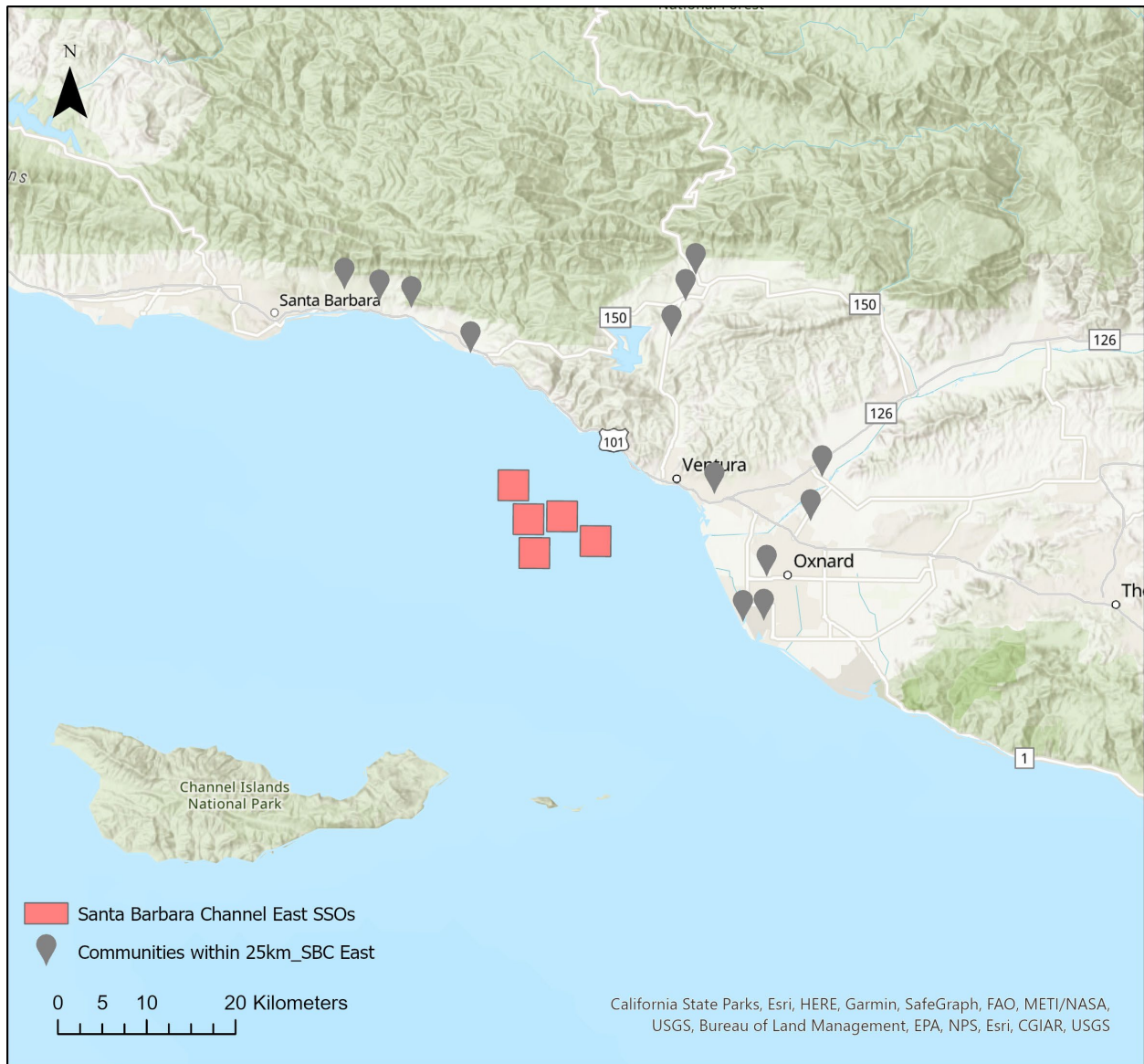


Figure 1. Communities within 25 km of Santa Barbara Channel East SSOs. SSOs are shown in red polygons; NOAA-identified fishing communities within 25 kilometers of SSOs are indicated by gray markers.

Community Social Vulnerability. CSVI data for communities within 25 kilometers of SBC East SSOs are presented below (Figure 2). Recreational fishing reliance and engagement, as well as storm surge data were not available and are shown as scores of zero in the plot. Broadly, these communities show the greatest vulnerabilities related to environmental justice (population composition and personal disruption), economic (labor force structure), and gentrification pressure (housing disruption, retiree migration, and urban sprawl).

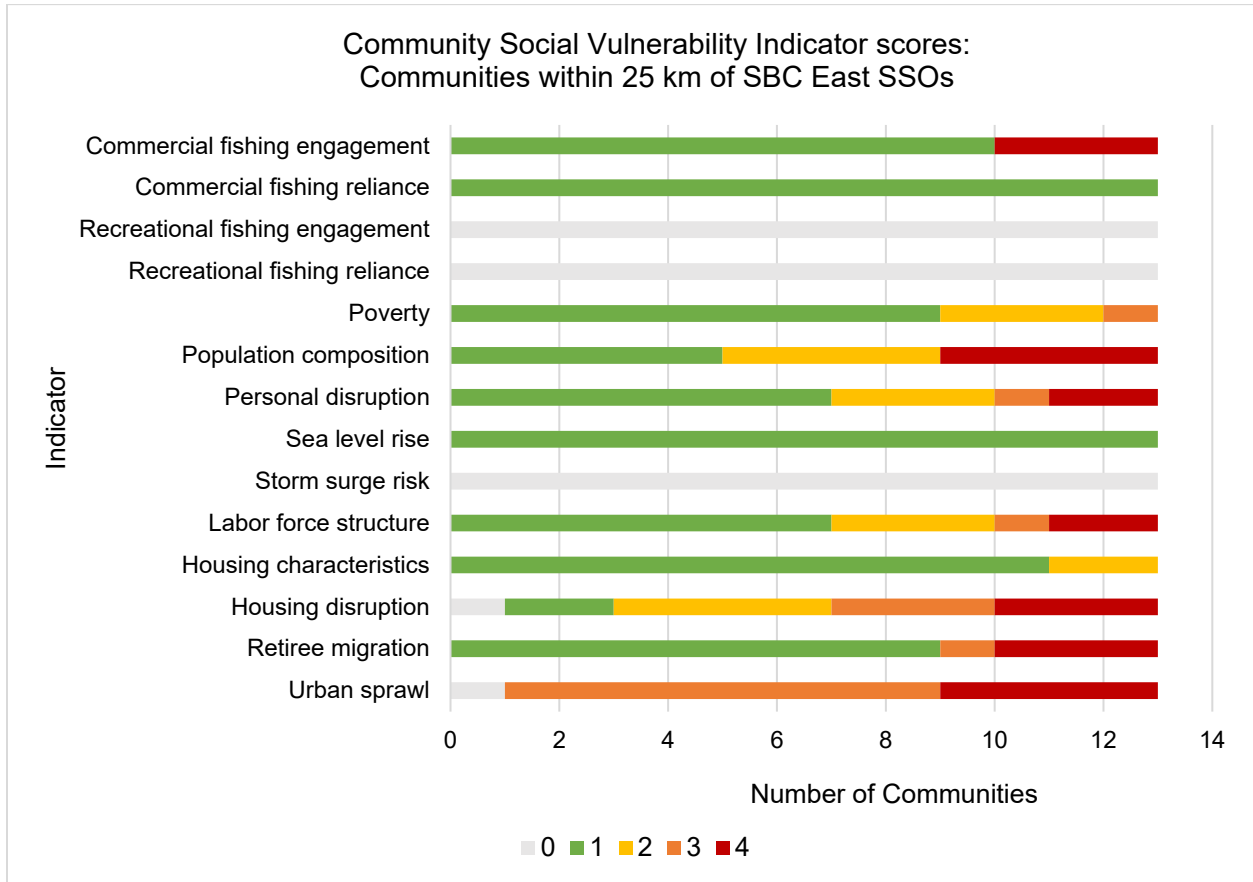


Figure 2. Community Social Vulnerability Indicator scores: Communities within 25 km of SBC East SSOs. Categorical indicator rankings are presented by indicator for 13 communities identified to be within 25 kilometers of SBC East SSOs. The number of communities possessing each score is indicated by x-axis values, with color used to distinguish how many communities within the group of 13 possessed each score. Indicator scores of 0 represent no data and are plotted in gray. Other scores range from 1 to 4, with higher scores corresponding to greater vulnerability. Scores of 1 are shown in green, 2 in yellow, 3 in orange, and 4 in red.

Commercial fishing engagement and reliance. Generally, communities within 25 kilometers of the SBC East SSOs possessed low vulnerability scores related to commercial fishing engagement and reliance, however, three communities deviated from the others with high engagement scores (each with a score of 4; Table 4). Oxnard, Port Hueneme, and Ventura are all immediately coastal communities (i.e., boundaries touch the coast rather than being

slightly inland but within 25 kilometers of SSOs) at the southern extent of the 25 kilometers bound for analysis. Though all three communities possessed relatively low commercial fisheries reliance scores (each with a score of 1), high fishing engagement corresponds to a higher number of commercial permit-holders, fish dealers, and vessel landings. Relative to offshore aquaculture development, this could mean that these communities are particularly vulnerable to negative disruptions such as competition over space or markets, but could also represent areas with high potential for collaborative development due to the presence of existing industry and infrastructure. Exact impacts would depend on the specifics of each new aquaculture operation (e.g., species grown, type of gear used, etc.).

Environmental justice. Vulnerability related to environmental justice is characterized by the indicators of poverty, population composition, and personal disruption. In each of these categories, more than half of the communities within 25 kilometers of the Santa Barbara Channel East SSOs possessed relatively low vulnerability scores of 1 or 2, however four communities had scores of 3 or 4 in at least one indicator. El Rio is recognized as vulnerable across all three indicators. Oxnard and Port Hueneme had high population composition vulnerability scores (4). Saticoy also had a high population composition vulnerability score (4) in addition to high vulnerability related to personal disruption (4). These indicator scores suggest that a large number of households in these communities may be limited by resources in various ways (e.g., income, education, English language skills), and could be less able to adapt to changes brought on by a developing new industry such as offshore aquaculture. At the same time, these communities could present an opportunity for thoughtful collaboration and equitable engagement by new operations to work with community members to reduce vulnerability.

Climate change. For all communities, the only climate change indicator data that were available in the CSV dataset was sea level rise risk. All communities had a relatively low score of 1. Refer to Table 5 below for additional coastal hazard discussion using NRI data.

Economic. Most community economic indicator scores (labor force structure, housing characteristics) were low for the communities within 25 kilometers of the SBC East SSOs, however, three communities – Montecito (4), Summerland (4), and Toro Canyon (3) – had high vulnerability scores tied to labor force structure. This suggests few employment opportunities in these communities; aquaculture development could help reduce vulnerability in this regard if it creates accessible job opportunities for community members.

Gentrification pressure. Vulnerability related to gentrification pressure was more widespread for these communities than were the other vulnerability indicator categories. This pressure is characterized by three indicators: housing disruption, retiree migration,

and urban sprawl. Six out of the thirteen communities had relatively high housing disruption scores of 3 (El Rio, Oak View, Port Hueneme) or 4 (Channel Island Beach, Meiners Oaks, Summerland). Four community scores suggest vulnerability related to retiree migration (Mira Monte, Montecito, Summerland, Toro Canyon). Every community except for Saticoy, which had no data for this indicator, possessed high vulnerability scores related to urban sprawl. With aquaculture development in mind, this vulnerability could prove an obstacle for an expanding workforce if affordable housing is not available.

Overall social vulnerability. An exploration of CSVI data for communities within 25 kilometers of SBC East shows that vulnerabilities related to labor opportunities and housing availability might be most challenging for the region. While aquaculture can potentially provide job opportunities, new operations must be thoughtful about how accessible those opportunities are (e.g., where will employees live?). Although most communities were not vulnerable from a fishing engagement and reliance standpoint, the few that were highlight the need to understand the interaction between new aquaculture activities and existing commercial fisheries in Oxnard, Point Hueneme, and Ventura (a vulnerability compounded by additional high vulnerability scores tied to environmental justice and gentrification in Oxnard and Port Hueneme).

Table 4. SBC East indicator scores by community. Categorical ranked scores are presented for 13 communities where indicator data were available. Communities are listed alphabetically. Data were not available for three indicators (recreational fishing engagement, recreational fishing reliance, and storm surge risk). Refer to Table 1 for indicator definitions. High vulnerability scores of 3 or 4 are emphasized in red.

Community	Fishing Engagement and Reliance		Environmental Justice			Climate Change	Economic		Gentrification Pressure		
	Comm. Eng.	Comm. Rel.	Poverty	Pop. Comp.	Personal Disruption	Sea Level Rise Risk	Labor Force	Housing Char.	Housing Disruption	Retiree Migration	Urban Sprawl
Carpinteria	1	1	1	2	1	1	1	1	1	1	3
Channel Islands Beach	1	1	1	1	3	1	1	1	4	1	4
El Rio	1	1	3	4	4	1	2	1	3	1	3
Meiners Oaks	1	1	2	2	2	1	1	1	4	1	3
Mira Monte	1	1	1	1	1	1	2	2	2	3	3
Montecito	1	1	1	1	1	1	4	1	1	4	4
Oak View	1	1	1	2	1	1	1	1	3	1	3
Oxnard	4	1	2	4	2	1	1	1	2	1	3
Port Hueneme	4	1	1	4	2	1	1	1	3	1	3
San Buenaventura (Ventura)	4	1	1	2	1	1	1	1	2	1	3
Saticoy	1	1	2	4	4	1	2	2	0	1	0
Summerland	1	1	1	1	1	1	4	1	4	4	4
Toro Canyon	1	1	1	1	1	1	3	1	2	4	4

Natural Hazard Risk. The SBC East SSOs are within 25 kilometers of communities in two counties: Santa Barbara and Ventura. The overall risk index for Santa Barbara County was categorized as relatively high, with a score of 99.4. This reflects the national percentile score, in that 99% of US counties have a lower risk index than Santa Barbara County. Within California, 84% of counties have a lower risk index. This high relative risk is driven by multiple hazards (Table 5). For Santa Barbara County, FEMA described social vulnerability was very high and community resilience was relatively moderate. The overall risk index for Ventura County was also categorized as relatively high, with a national score of 99.4 and a state score of 86. FEMA described social vulnerability for Ventura County is relatively high and community resilience is relatively moderate.

Table 5. Hazard type risk index: Santa Barbara and Ventura counties. Hazard type risk index scores are shown by hazard type and reflect a community's Expected Annual Loss (EAL) value and community risk factors. Hazard types are listed in order of highest to lowest EAL.

Santa Barbara County		Ventura County	
Hazard Type	Risk Index Score	Hazard Type	Risk Index Score
Drought	100	Earthquake	99.7
Earthquake	99.1	Riverine flooding	99.5
Wildfire	99.5	Wildfire	99.8
Riverine flooding	91.3	Drought	97.7
Heat wave	77.8	Tornado	46.7
Landslide	96	Landslide	97.2
Coastal flooding	50.7	Heat wave	73
Lightning	23.1	Lightning	53.2
Strong wind	8	Strong wind	14.6
Tornado	5.3	Hail	12.5
Hail	17.2	Coastal flooding	27.6
Tsunami	43.2	Tsunami	45.9
Winter Weather	2	Winter Weather	2.1
Cold wave	0	Cold wave	0
Avalanche	-	Avalanche	-
Hurricane	-	Hurricane	-
Ice storm	-	Ice storm	-
Volcanic activity	-	Volcanic activity	-

For both Santa Barbara and Ventura counties, the relatively high risk associated with a number of hazards (e.g., drought, earthquake, riverine flooding, wildfire, and landslides) poses concern for the aquaculture industry as well as local communities through direct hazard impacts. These risks are highlighted here to draw attention to amplified

vulnerability beyond that identified in the CSVIs for individual communities within these counties.

Santa Barbara Channel West (SBC West)

Five communities from the CSVI dataset were located within 25 kilometers of the SCB West SSOs (Figure 3).

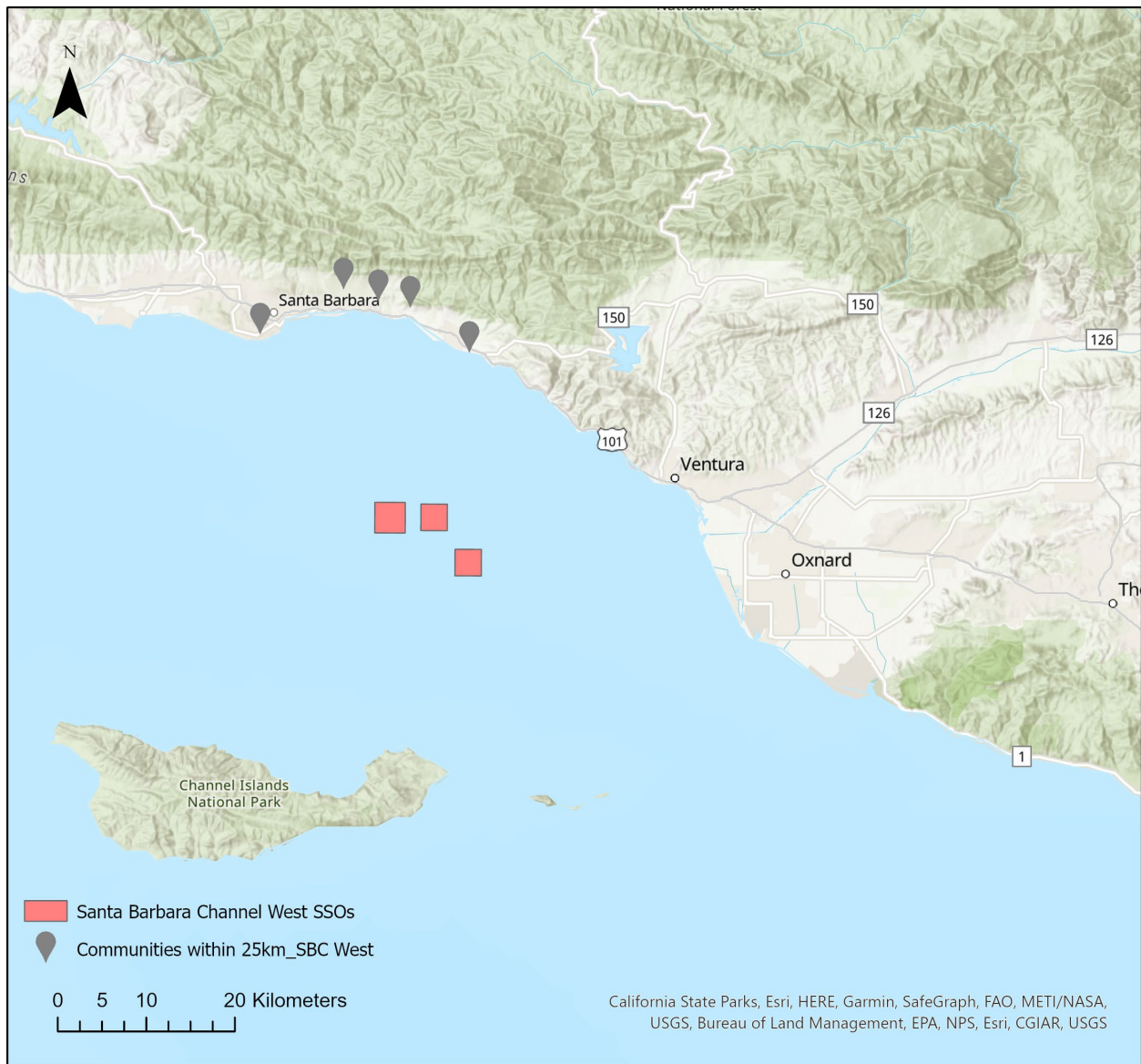


Figure 3. Communities within 25 km of potential SBC West SSOs. SSOs are shown in red polygons; NOAA-identified fishing communities within 25 kilometers of SSOs are indicated by gray pins/balloons.

Community Social Vulnerability. CSVI data for the Santa Barbara West group (SBC West) are presented below (Figure 4). Recreational fishing reliance and engagement, as well as storm surge data were not available and are shown as scores of zero in the plot. Broadly,

the communities within 25 kilometers of SBC West show the greatest vulnerabilities related to economic (labor force structure) and gentrification pressure (retiree migration and urban sprawl) indicators.

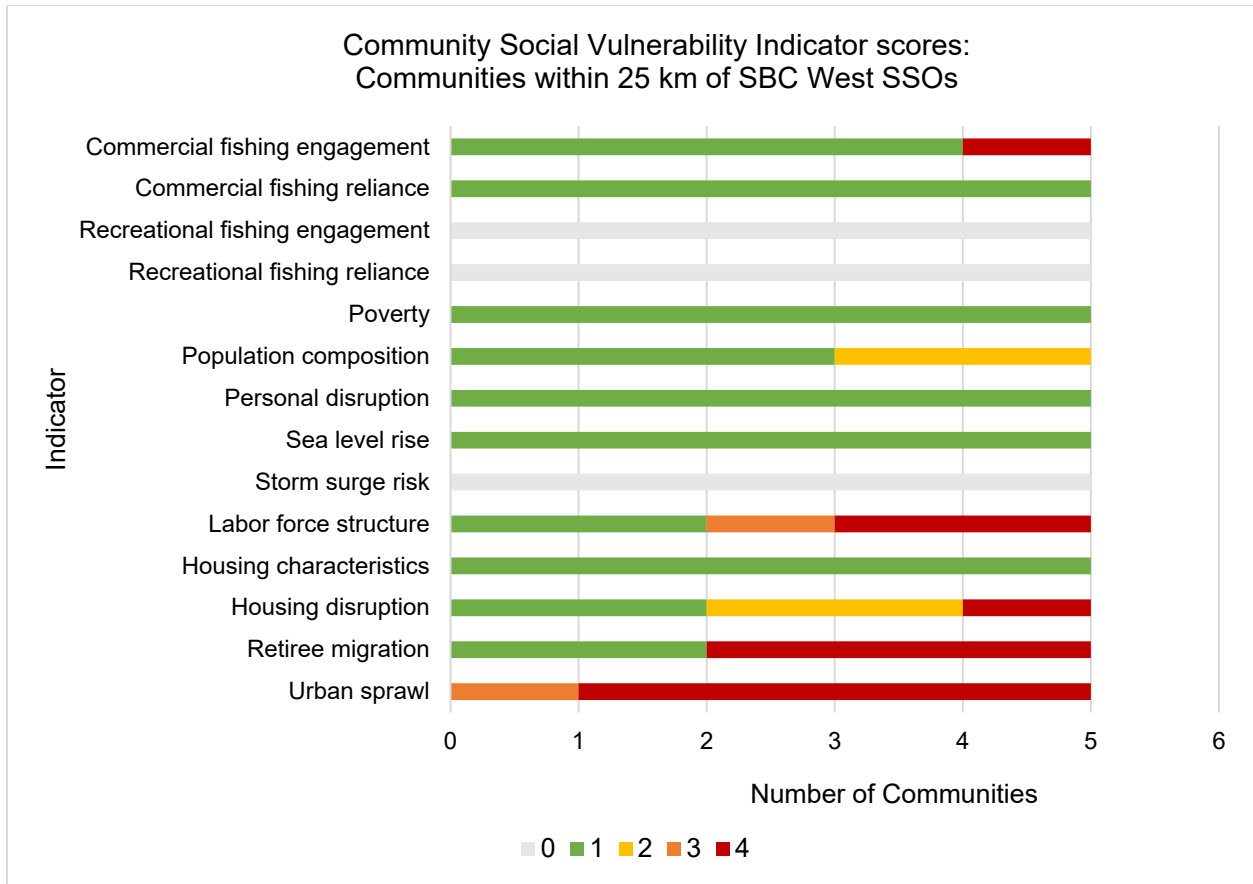


Figure 4. Community Social Vulnerability Indicator scores: Communities within 25 km of SBC West. Categorical indicator rankings are presented by indicator for 5 communities identified to be within 25 kilometers of SBC West SSOs. The number of communities possessing each score is indicated by x-axis values, with color used to distinguish how many communities within the group of 15 possessed each score. Indicator scores of 0 represent no data and are plotted in gray. Other scores range from 1 to 4 with higher scores corresponding to greater vulnerability. Scores of 1 are shown in green, 2 in yellow, 3 in orange, and 4 in red.

Commercial fishing engagement and reliance. Of the five communities within 25 kilometers of SBC West SSOs, only one possessed a high indicator score relative to fishing engagement and reliance. Santa Barbara had a commercial fishing engagement indicator of 4, reflective of a relatively high number of permit-holders, dealers, and vessel landings and high vulnerability potential relative to a fishing industry disturbance. As noted for several of the high fishing engagement communities near the SBC East SSOs, relative to offshore aquaculture development, this could mean that these communities are particularly vulnerable to negative disruptions such as competition over space or markets but could

also represent areas with high potential for collaborative development due to the presence of existing industry and infrastructure.

Environmental justice. Scores for environmental justice indicators (poverty, population composition, and personal disruption) were relatively low for all communities (at 2 or lower).

Climate change. For all communities, the only climate change indicator data available relates to sea level rise risk and communities had a relatively low score of 1. Refer to Table 8 below for additional coastal hazard discussion using NRI data.

Economic. Three out of the five communities had relatively high labor force structure scores of 3 (Toro Canyon) or 4 (Montecito and Summerland), while all communities had low housing characteristics indicator scores. Few employment opportunities associated with high labor force structure scores suggest a benefit that an expanding aquaculture industry could provide with accessible jobs, but housing vulnerability exacerbated through gentrification pressure (see below) could limit options for local residency.

Gentrification pressure. One community had a high vulnerability score related to housing disruption (Summerland) while three had high scores related to retiree migration into the community (Montecito, Summerland, and Toro Canyon). All five communities' data suggested they are vulnerable due to urban sprawl. Combined, these indicators suggest housing affordability challenges for residents, which could also be a challenge for available workforce needs for a growing industry like offshore aquaculture.

Overall social vulnerability. Collectively, the communities within 25 kilometers of the SBC West SSOs possess similar vulnerability characteristics to those near the SBC East SSOs. Santa Barbara is potentially vulnerable to aquaculture impacts from a commercial fishing engagement standpoint. Thus, aquaculture expansion should involve effort to understand specific interactions with these fisheries and the commercial fishing community. The vulnerability characteristics highlighted here may also suggest existing infrastructure is present to support a growing seafood industry, however, processing capacity continues to be a noted challenge.¹¹ High vulnerability related to labor force is paired with high gentrification pressure in SBC West, suggesting that aquaculture could bring desired employment opportunities, but housing options for that workforce may be limited.

Natural Hazard Risk. The SBC West SSOs are within 25 kilometers of NOAA-identified fishing communities in Santa Barbara County. As noted for SBC East, the overall risk index

¹¹ Culver, C. S., Richards, J. B., & Pomeroy, C. M. 2007. Commercial fisheries of the Santa Barbara channel and associated infrastructure needs. CA Sea Grant Technical Report. CASG-T-07-001. [Available at <https://repository.library.noaa.gov/view/noaa/42127>]

for Santa Barbara County was categorized as relatively high, with a national score of 99.4 and a state score of 84 (in that 84% of counties in California have a lower risk index Score). This high relative risk is driven by multiple hazards (Table 5). FEMA described social vulnerability was very high while community resilience was relatively moderate. As with SBC East, Santa Barbara County's relatively high risk associated with a number of hazards could pose concern for the aquaculture industry as well as local communities through direct hazard impacts.

Table 6. SBC West indicator scores by community. Categorical ranked scores are presented for five communities where indicator data were available. Data were not available for three indicators (recreational fishing engagement, recreational fishing reliance, and storm surge risk). Refer to Table 1 for indicator definitions. High vulnerability scores of 3 or 4 are emphasized in red.

Community	Fishing Engagement and Reliance		Environmental Justice			Climate Change	Economic		Gentrification Pressure		
	Comm. Eng.	Comm. Rel.	Poverty	Pop. Comp.	Personal Disruption	Sea Level Rise Risk	Labor Force	Housing Char.	Housing Disruption	Retiree Migration	Urban Sprawl
Carpinteria	1	1	1	2	1	1	1	1	1	1	3
Montecito	1	1	1	1	1	1	4	1	1	4	4
Santa Barbara	4	1	1	2	1	1	1	1	2	1	4
Summerland	1	1	1	1	1	1	4	1	4	4	4
Toro Canyon	1	1	1	1	1	1	3	1	2	4	4

Santa Monica Bay

Twenty-one communities from the CSVI dataset were located within 25 kilometers of Santa Monica Bay SSOs (Figure 5).

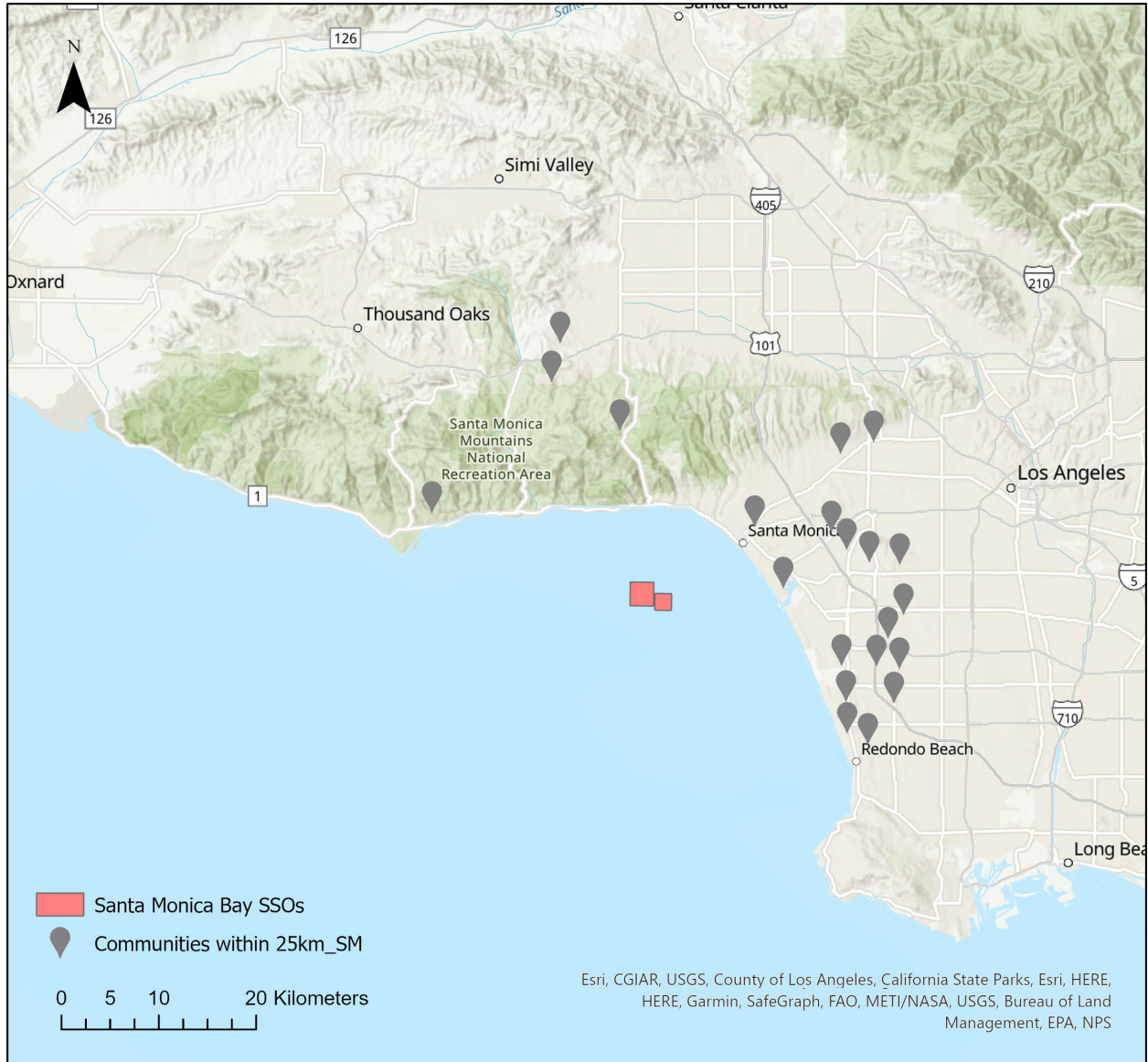


Figure 5. Communities within 25 km of Santa Monica Bay SSOs. SSOs are shown in red polygons; NOAA-identified fishing communities within 25 kilometers of SSOs are indicated by gray pins/balloons.

Community Social Vulnerability. CSVI data for the Santa Monica Bay SSOs are presented below (Figure 6). Recreational fishing reliance and engagement, as well as storm surge data were not available and are shown as scores of zero in the plot. Broadly, the communities within 25 kilometers of the Santa Monica Bay SSOs showed the greatest vulnerabilities related to environmental justice (population composition) and gentrification pressure (housing disruption and urban sprawl). These communities differed from the SBC East and

West SSOs in that retiree migration was not also driving vulnerability related to gentrification.

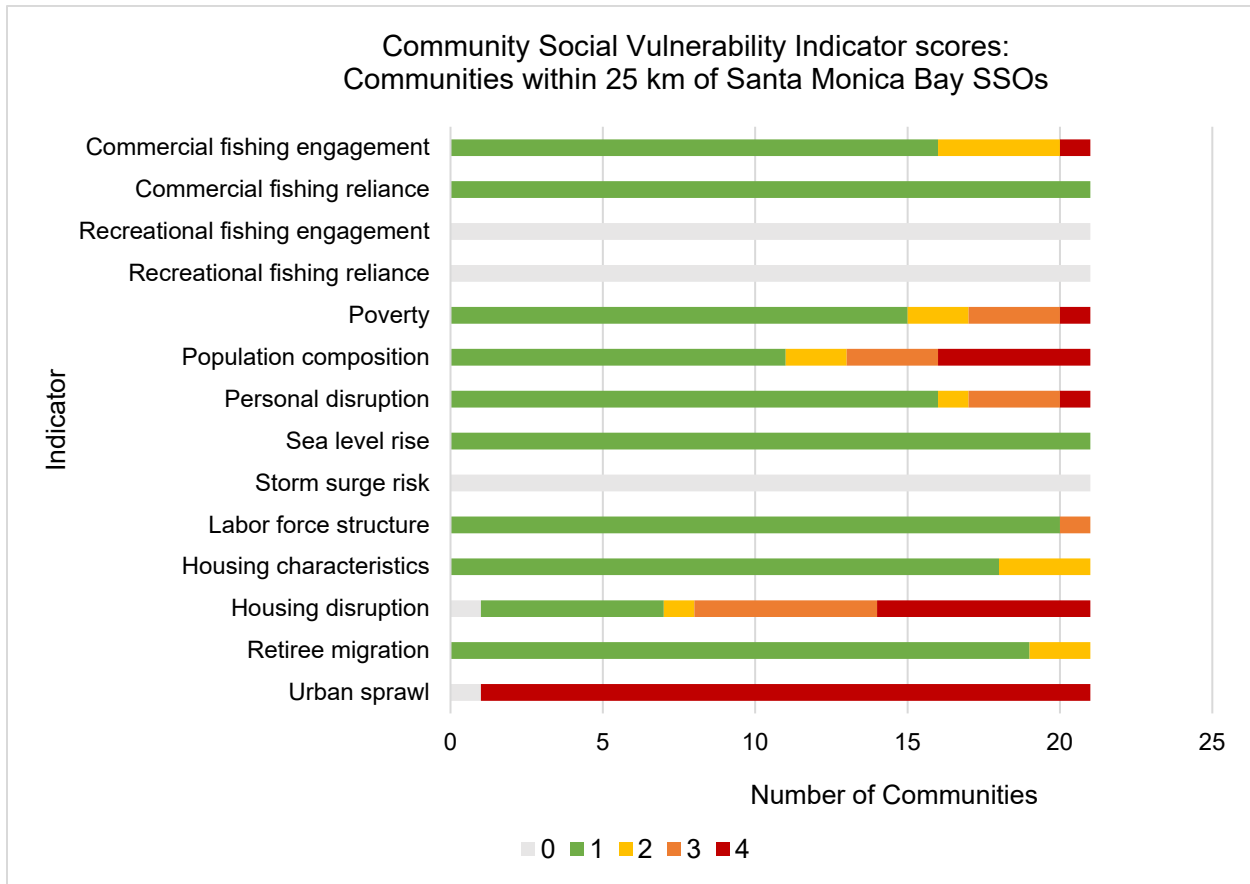


Figure 6. Community Social Vulnerability Indicator scores: Communities within 25 km of Santa Monica Bay SSOs. Categorical indicator rankings are presented by indicator for 5 communities identified to be within 25 kilometers of Santa Monica Bay SSOs. The number of communities possessing each score is indicated by x-axis values, with color used to distinguish how many communities within the group of 5 possessed each score. Indicator scores of 0 represent no data and are plotted in gray. Other scores range from 1 to 4 with higher scores corresponding to greater vulnerability. Scores of 1 are shown in green, 2 in yellow, 3 in orange, and 4 in red.

Commercial fishing engagement and reliance. Only one community possessed a high indicator score related to commercial fishing engagement and reliance (Table 7). Los Angeles, with a commercial engagement score of 4, is more vulnerable to fisheries disruptions. As indicated related to commercial engagement above, this indicator could suggest that competition among space and markets could be particularly problematic for Los Angeles, but could also indicate opportunity for aquaculture interactions via existing infrastructure and industry.

Environmental justice. Several communities possessed high vulnerability indicator scores within the environmental justice indicator group. Hawthorne, Inglewood, Lennox, and Los Angeles all scored high related to poverty; Lennox highest with a score of 4. Relative to

population composition, eight communities were highly vulnerable with scores of 3 (Del Aire, Ladera Heights, View Park-Windsor Hills) and 4 (Hawthorne, Inglewood, Lawndale, Lennox, and Los Angeles). Four communities had high vulnerability scores related to personal disruption (Hawthorne, Inglewood, Lennox, Los Angeles) with Lennox again scoring higher than others. These indicator scores suggest that a large number of households in these communities may be limited by resources in various ways (income, education, English language skills), and could be less able to adapt to changes brought on by a developing new industry such as offshore aquaculture. At the same time, these communities could present opportunity for thoughtful collaboration and equitable engagement by new operations to work with community members to reduce vulnerability.

Climate change. For all communities, the only climate change indicator data available relates to sea level rise risk and communities had a relatively low score of 1. Refer to Table 8 below for additional coastal hazard discussion using NRI data.

Economic. Economic indicators suggest relatively low vulnerability in this category for all communities. Hidden Hills had a score of 3 for labor force structure, but all other scores were 2 or lower.

Gentrification pressure. More than half of the communities within 25 kilometers of SSOs possessed high vulnerability scores related to housing disruption, with 6 communities at a score of 3 (Hermosa Beach, Inglewood, Lennox, Manhattan Beach, Redondo Beach, and View Park-Windsor Hills) and 7 communities at a score of 4 (Culver City, Del Aire, El Segundo, Hawthorne, Lawndale, Los Angeles, and Marina del Rey). All 21 communities had high vulnerability scores of 4 tied to urban sprawl, except Topanga, which had no data for this indicator. These indicator results highlight housing-related pressures that could be influenced positively or negatively depending on how aquaculture advances with these communities in mind. The scores also point to challenges related to housing for the new industry workforce, or the need to compensate employees well to be able to combat such gentrification pressure.

Overall social vulnerability. Though at a larger scale with more communities within the analysis for Santa Monica Bay SSOs (21 vs. 13 and 5 for SBC East and SBC West, respectively), the CSVI indicators for these communities revealed similar vulnerabilities. One community, Los Angeles, may be more vulnerable with regard to commercial fisheries engagement. A number of communities have high vulnerability scores related to environmental justice indicators, with overlap among the three indicators of poverty, population composition, and personal disruption. Some of these communities are also facing gentrification pressure, but in many cases represented two different groups of communities except in the case of urban sprawl, a vulnerability experienced by all communities. Unlike the communities near the Santa Barbara SSOs, labor force structure

was not a high vulnerability for most of the communities in this area. This suggests that job opportunities through aquaculture may not be as sought after here, but a forward-thinking industry should pay attention to environmental justice vulnerabilities and aquaculture pathways that could help enhance resilience and sustainability.

Table 7. Santa Monica Bay indicator scores by community. Categorical ranked scores are presented for 21 communities where indicator data are available. Data were not available for three indicators (recreational engagement, recreational reliance, and storm surge risk). Refer to Table 1 for indicator definitions. High vulnerability scores of 3 or 4 are emphasized in red.

Community			Environmental Justice			Sea Level Rise Risk	Economic				
	Comm. Eng.	Comm. Rel.	Poverty	Pop. Comp.	Personal Disruption		Labor Force	Housing Char.	Housing Disruption	Retiree Migration	Urban Sprawl
Beverly Hills	1	1	1	1	1	1	1	1	1	1	4
Calabasas	1	1	1	1	1	1	1	1	2	1	4
Culver City	1	1	1	2	1	1	1	1	4	1	4
Del Aire	1	1	1	3	1	1	1	1	4	1	4
El Segundo	1	1	1	2	1	1	1	1	4	1	4
Hawthorne	1	1	3	4	3	1	1	2	4	1	4
Hermosa Beach	2	1	1	1	1	1	1	1	3	1	4
Hidden Hills	1	1	1	1	1	1	3	1	1	1	4
Inglewood	1	1	3	4	3	1	1	2	3	1	4
Ladera Heights	1	1	1	3	1	1	1	1	1	2	4
Lawndale	1	1	2	4	2	1	1	1	4	1	4
Lennox	1	1	4	4	4	1	1	2	3	1	4
Los Angeles	4	1	3	4	3	1	1	1	4	1	4
Malibu	1	1	1	1	1	1	1	1	1	1	4
Manhattan Beach	1	1	1	1	1	1	1	1	3	1	4
Marina del Rey	2	1	2	1	1	1	1	1	4	1	4
Redondo Beach	2	1	1	1	1	1	1	1	3	1	4
Santa Monica	2	1	1	1	1	1	1	1	1	1	4
Topanga	1	1	1	1	1	1	1	1	0	1	0
View Park-Windsor Hills	1	1	1	3	1	1	1	1	3	2	4
West Hollywood	1	1	1	1	1	1	1	1	1	1	4

Natural Hazard Risk. The Santa Monica Bay SSOs are within 25 kilometers of communities in Los Angeles County. The overall risk index for Los Angeles County is categorized as relatively high, with a score of 100. This reflects the national percentile score, in that 100% of US counties have a lower risk index than Los Angeles County. This high relative risk is driven by multiple hazards (e.g., earthquake, wildfire, heat wave, tornado, lightning, and riverine flooding; Table 8), and poses concern for the aquaculture industry directly as well as local communities through direct hazard impacts. These risks are highlighted here to draw attention to amplified vulnerability beyond that identified in the CSVIs for communities with this county. For Los Angeles County, FEMA described social vulnerability is very high and community resilience is very low.

Table 8. Hazard type risk index: Los Angeles County. Hazard type risk index scores are shown by hazard type and reflect a community's Expected Annual Loss (EAL) value and community risk factors. Hazard types are listed in order of highest to lowest EAL.

Hazard Type	Risk Index Score
Earthquake	100
Wildfire	99.9
Tornado	97.6
Heat wave	98.4
Riverine flooding	90.8
Lightning	95
Strong wind	73.5
Landslide	96.3
Drought	73.8
Hail	48.1
Avalanche	33.7
Winter weather	48.6
Coastal flooding	43.3
Tsunami	63.5
Cold wave	0
Hurricane	-
Ice storm	-
Volcanic activity	-

Conclusion:

The analysis provided an overview of social vulnerability and natural hazard risk for communities that might be affected by offshore aquaculture development in the Southern California Bight. Communities featured are all within 25 kilometers of SSOs in the Santa Barbara Channel and Santa Monica Bay but, lacking operational specifics, it is not possible

at this phase in the AOA identification process to predict with certainty if and how these communities might be impacted. Instead, this analysis highlighted particular vulnerabilities and risks that should be recognized by individuals or operations considering aquaculture siting in the Southern California Bight. Depending on the approach, offshore aquaculture development has the potential to both exacerbate existing vulnerabilities or provide potential solutions.

The findings presented point the way for planners and future operations to consider how new offshore aquaculture activities can be best integrated in a way that is beneficial to nearshore communities. The variability inherent in the data and diversity among communities illustrate that there are likely nuances that cannot be captured by a dataset. Prospective operators and those involved in planning are encouraged to engage communities directly when more operational specifics are available. Social vulnerability and risk can and should be assessed in greater detail as actual offshore operations are looking to be sited.

Finally, the recommendations included within the Results and Discussion that suggest how offshore aquaculture could potentially reduce vulnerability and benefit local communities were not written with naiveté or the expectation that those steps are easy for an individual operator to implement. For example, the recurring theme of creating jobs that are accessible for local residents has much packed into such a goal. Despite possibly lofty charges, it is important to think about these best practices and best-case scenarios early in the planning process, in order to increase the likelihood of success for offshore aquaculture to have the most positive impact on local communities.

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