A Group Project

PERCEPTIONS OF SEAWEED AQUACULTURE IN SANTA BARBARA AND VENTURA COUNTIES

by

Janelle Gaun
Madeline McEwen
Sydney Rilum
Laurel Wee

Advisors

Hunter S. Lenihan, PhD
Sarah E. Anderson, PhD
Kevin M. Johnson, PhD

Client

Ocean Rainforest, Inc.

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IN SANTA BARBARA AND VENTURA COUNTIES

As authors of this Group Project report, we archive this report on the Bren School's website such that the results of our research are available for all to read. Our signatures on the document signify our joint responsibility to fulfill the archiving standards set by the Bren School of Environmental Science & Management.

X _____
Janelle Gaun

X _____
Madeline McEwen

X _____
Sydney Rilum

X _____
Laurel Wee

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The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

X _____
Hunter S. Lenihan

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Faculty Advisor:

Hunter S. Lenihan, PhD – Bren School, Professor

External Advisors:

Sarah E. Anderson, PhD – Bren School, Professor

Kevin M. Johnson, PhD – California Sea Grant, Extension Specialist

Client:

Ocean Rainforest, Inc.

Eliza Harrison – Program Manager

Javier Infante – MacroSystems Primary Investigator

Courtney Schatzman – Environmental Scientist and Data Manager

External Funder:

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UCSB Bren School Faculty:

Heather Hodges, PhD

Allison Horst, PhD

Chris Jerde, PhD

Casey O'Hara, PhD Candidate

Interviewees:

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Acronyms

AOA	Aquaculture Opportunity Area
ACS	American Community Survey
CCC	California Coastal Commission
CDFW	California Department of Fish and Wildlife
DOD	Department of Defense
ENGO	Environmental Non-Governmental Organization
MPA	Marine Protected Area
NOAA	National Ocean and Atmospheric Administration
SLO	Social License to Operate
USACE	United States Army Corps of Engineers
VSE	Ventura Shellfish Enterprise

Abstract

Marine seaweed aquaculture provides sustainable forms of food, fertilizers, and pharmaceuticals while potentially contributing to nutrient mitigation, habitat creation, and short-term carbon sequestration. The industry in the United States is underdeveloped due to a combination of economic, social, and regulatory constraints. These constraints exist in California where there is an insufficient understanding of how the public and key stakeholder groups perceive seaweed aquaculture, which appears to limit political support for or against further developing the industry. Our study conducted a public survey and semi-structured interviews with key stakeholder groups to determine perceptions of seaweed aquaculture and whether it has a Social License to Operate (SLO) in Santa Barbara and Ventura counties. Survey results indicate less public opposition to seaweed aquaculture than described in the scientific literature and by stakeholders associated with the industry, with a majority (56.8%) of residents in support of seaweed aquaculture expansion and relatively few (8.8%) in opposition. Many residents are unfamiliar with the implications, benefits, and impacts of the industry. Communication strategies to inform stakeholder groups should provide clear and accessible information to stakeholders so they will be more likely to form positive perceptions of seaweed aquaculture and support future projects. Interview analysis suggests that offshore seaweed aquaculture in southern California has a conditional SLO. Despite widespread support from the scientific community and public, and general acceptance from federal agencies, the industry has not shown accountability to environmental non-governmental organizations (ENGOs) and state agencies. Pilot projects can build interactional trust with influential ENGOs and the fishing industry.

Introduction

Project Significance

Seaweed farming is a key component in developing the blue economy.[1,2] The blue economy describes the sustainable development and use of ocean resources to support economic growth while preserving marine ecosystems and health.[3] Farmed seaweed has many uses, including human consumption, animal feed,[4] biofuel,[4,5] and is an additive in cosmetics and pharmaceuticals.[5] Macroalgae aquaculture facilities may also generate multiple ecosystem services, including nutrient management, habitat creation, and carbon sequestration.[6] Global seaweed production tripled between 2000 and 2018, with industry growth concentrated in China and other Asian countries.[7]

Macroalgal aquaculture is not widely implemented in North America and Europe due to a combination of economic,[8] social, and regulatory[9] constraints. Kelp aquaculture, in specific, has historically been limited to nearshore waters,[8] typically areas of high use conflict,[10] which has constrained the size of farms in many western countries. Pursuing offshore operations is one strategy to capture economies of scale and overcome high costs from technical and regulatory challenges;[8] however, stakeholder resistance has been cited as a major barrier to developing offshore facilities in the United States.[9–11]

Since their arrival to Santa Barbara in 2020, Ocean Rainforest, a seaweed cultivation company founded almost a decade prior in the Faroe Islands, has faced pushback from local stakeholders regarding their proposed commercial aquaculture operations. The company considers widespread misunderstanding of sustainable aquaculture practices as a significant obstacle to expanding their operations in Santa Barbara, and elsewhere along the coast of western North America. Clarifying stakeholder perceptions can help Ocean Rainforest address major social constraints early on, improve regulation and policy development, and build trust between the public and industry.

Project Aim and Objectives

Despite claims that stakeholder resistance hinders offshore development, there have been few studies on local perceptions of either coastal or offshore seaweed aquaculture in southern California. The aim of this project was to gain an understanding of stakeholder resistance to or support for seaweed aquaculture development in Santa Barbara and Ventura counties, and to develop a foundation and framework for social licensing campaigns for aquaculture in the United States.

Objectives:

- Identify stakeholder perceptions of seaweed aquaculture in Santa Barbara and Ventura counties using a public survey and semi-structured interviews with key stakeholder groups
- Determine the influence of stakeholder perceptions on seaweed aquaculture development
- Examine whether seaweed aquaculture has a social license to operate

Background

Project Client

Ocean Rainforest's mission is to create a "rainforest" in the ocean. Ocean Rainforest grows, harvests, and processes seaweed in the Faroe Islands for commercial use, such as food additives and cosmetic products. The company prides itself on the quality of its seaweed and sustainability of aquaculture cultivation processes. Ocean Rainforest has developed a system for open ocean seaweed cultivation and has maintained a robust operation in the Faroe Islands since 2010. The company aims to expand operations into the United States. In January 2020, Ocean Rainforest, Inc. (ORI), a subsidiary of Ocean Rainforest, began pilot operations in Santa Barbara, California under a government contract with the Advanced Research Projects Agency - Energy (ARPA-E) Department for the MacroSystems initiative. Within that funding framework, ORI planned to establish a local hatchery, deploy the open-ocean cultivation infrastructure, develop highly efficient harvesting technologies, and collect data on the environmental conditions and ecological impacts of offshore giant kelp (*Macrocystis pyrifera*) cultivation.

Aquaculture

Growth of Aquaculture Industry

Global aquaculture production tripled between 1997 and 2017[12] and will be an increasingly important industry as global agriculture intensifies.[13] Despite accounting for a small proportion of global aquaculture products, seaweed aquaculture is growing faster than any other aquaculture industry.[14] Algal aquaculture production has tripled since 2000 and composed 28% of global live-weight production in 2017.[12] China and other Asian countries produce 99% of farmed seaweed, including kelp species.[4] Expanding algal cultivation has the potential to meet increasing global demand for algal products use in food, feed, biofuel, and the cosmetics and pharmaceuticals industries.[15]

Aquaculture in California

California consumes more seafood than any other state, but heavily relies on imported products from international markets.[16] Growth trends in global aquaculture production since 2000[12] are not reflected in California, where little to no growth occurred during a similar period.[16] In 2017, marine aquaculture contributed 19% ($57M) of California's seafood production.[16] In 2018, twenty-one farms leased a total of 8,354 acres of marine space in California.[16] Between 1990 and 2019, total employment in fisheries and aquaculture declined in all sectors.[16]

Offshore Aquaculture

Offshore seaweed aquaculture has been constrained in the United States by poor governance and regulatory structure,[9] as well as the technical challenges of developing cost-effective technology that can withstand the harsh open-ocean environment.[8] The U.S. Department of Energy ARPA-E awarded $22 million in grants through the MARINER project[4] to scale commercial kelp farming in the U.S. The program's technological approach intends to "achieve the efficiency and production costs"[17] of macroalgal mariculture while expanding the range of the industry further offshore.[4] Siting facilities offshore may reduce coastal water use conflicts,[10] but also presents unique socio-cultural challenges. Most offshore aquaculture sites are in public waters and can create resource competition and access concerns among existing stakeholders.[13]

Seaweed Aquaculture Ecosystem Services

Although seaweed aquaculture farms create artificial ecosystems, made up of cultivation lines, buoys, and anchors, they provide many of the same ecosystem functions as natural kelp forests and seaweed beds. They serve as a source for food, raw materials,[18] and biofuel,[19] provide potential carbon sequestration,[2,20] eutrophication mitigation,[2,14,21,22] habitat,[21] wave attenuation,[23] and coastal protection,[24] as well as nursery ground for a biodiverse range of species.[25,26] Seaweed aquaculture is also globally recognized as an environmentally responsible and sustainable form of biomass production.[1,27] Farming of seaweeds provides cultural ecosystem services by supporting many types of recreational activities, such as fishing, snorkeling, diving, and kayaking, as well as educational opportunities.[28]

Kelp cultivation involves a suspended infrastructure that is not attached to the seafloor, which increases exposure to surface water motion and the rate of nutrient uptake.[29] Seaweed farming uses no arable land or freshwater and, in most cases, requires no additional fertilizers.[23] Seaweeds remove inorganic nutrients from the marine environment as they grow.[30,31] Large-scale coastal seaweed cultivation is argued to substantially remediate excess nitrogen and phosphorus from anthropogenic runoff.[27,32] Continuing trends toward seaweed aquaculture expansion could lead to a substantial contribution to short-term climate change

mitigation, as seaweed cultivation contributes to the removal of carbon dioxide from the atmosphere.[14,27] However, in comparison to biomass sediment deposition,[33] the amount of carbon sequestered for long-term storage is uncertain, due to the end of life harvest of seaweed in commercial seaweed aquaculture.

Kelp also has indirect benefits that contribute to marine biodiversity, including providing vital habitat for invertebrates and fish species.[15,33] Biodiversity ensures not only an ecosystem's ability to recover from disturbance, but is also an integral part of maintaining ecosystem benefits to humans.[34] Artificial reefs in the Santa Barbara Channel have been shown to provide services to ecosystems similar to those provided by natural habitats.[35] Further research is needed to discern whether offshore kelp aquaculture operations provide similar ecosystem benefits.

Seaweed Aquaculture Environmental Concerns

The intensification of global aquaculture has had significant impacts on aquatic and terrestrial ecosystems in the last three decades.[36] Though seaweed farming has fewer environmental impacts than fish aquaculture does,[37] scientists continue to advocate for ecologically and socially sustainable growth as the industry expands.[12,15] Environmental stakeholders have raised concerns over offshore aquaculture, including the potential for marine mammal entanglement, marine debris, noise pollution, and pathogen outbreaks due to monoculture cultivation.[19,24] Monoculture cultivation reduces genetic diversity, allowing for increased susceptibility to abiotic stressors, disease, and parasites.[24] Kelp cultivation sites may also alter the benthic community through the release and deposition of particulate organic matter from wave action and decomposition.[10]

Large-scale seaweed cultivation requires the addition of artificial materials, such as moorings, lines, and floats, that serve as a structural substrate for seaweed growth.[15] Lines are typically composed of synthetic polymer rope (e.g., polypropylene) to resist degradation in the marine environment, and if lost due to storm surges or improper management, contribute to marine pollution and artificial habitat creation.[24] Loss of aquaculture infrastructure can also result in entanglement and mortality of marine mammals, though the extent of entanglement risk is poorly understood.[15] Well-designed and regulated infrastructure may reduce entanglement risk.[15]

Another concern with aquaculture is the increase in vessel traffic required for installation, maintenance, and harvesting of kelp farm operations. Aquaculture activities will likely increase anthropogenic noise, proportionate to the scale of operations, and may lead to a shift in behavioral responses of surrounding marine life.[15]

Social License to Operate

Social license to operate (SLO) is a conceptual framework that describes stakeholders' acceptance of some entity, activity, or industry.[38] The framework is used to assess socio-political risk and develop communication and conflict-reduction strategies with stakeholder communities.[39] SLO framework that originated in the mining industry is now utilized by industrial, governmental, and non-governmental organizations to consider how to move forward with a project. Several competing theoretical frameworks have been created to understand the components of a SLO, but all are based on the interplay of socio-political, economic, and interactional components.[40] Boutilier and Thomson's (2011) arrowhead model (Fig. 1) depicts ascending levels of SLO as a company moves from purely transactional interactions to interactions with the community grounded in trust.

Boutilier and Thomson (2011) theorized that four key factors contribute to gaining SLO: economic legitimacy, socio-political legitimacy, interactional trust, and institutionalized trust (Fig 1).[38] The following definitions and concepts are derived from Boutilier and Thompson (2011). Economic legitimacy describes "the perception that the project/company offers a benefit to the perceiver," and is often the first level of acceptance from stakeholders. Benefits from economic legitimacy can include environmental and economic benefits. Following economic legitimacy, the company then gains interactional trust and socio-political legitimacy. Socio-political legitimacy is the sense that the company understands and follows the community's sense of fairness and way of life, while interactional legitimacy is thoughtful and consistent engagement with the stakeholders and the broader community. A conditional SLO can be earned by gaining a combination of economic legitimacy, socio-political legitimacy, and interactional trust. Institutionalized trust, a mutualistic relationship between stakeholders and the company based in respect, is not necessary in order to be granted a SLO, but Boutilier and Thomson theorize that it is unlikely a company will achieve this level of social acceptance without one of the other three components.[38] Unlike previous models by Boutilier and Thompson, the arrowhead model acknowledges that an organization can have a combination of the traits and can be granted a conditional SLO without achieving all of the components (Fig 1).[38]

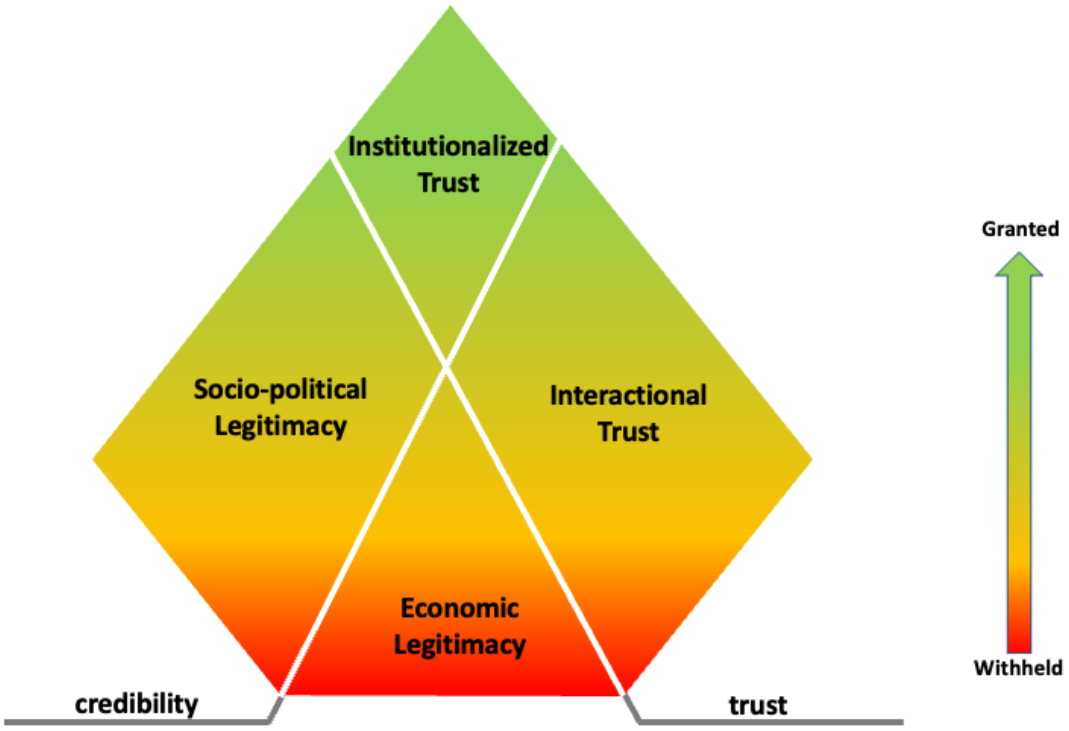

Figure 1: The arrowhead model from Boutilier and Thompson (2011) describes four key components to attaining a social license to operate. The two white lines represent credibility and trust. As a company builds interactional trust and social legitimacy, they move from purely transactional relationships to institutional relationships based in mature regard.[38] Color indicates the risk of the SLO, with red representing withheld, yellow representing conditional, and green representing granted. Figure adapted from Boutilier and Thompson (2011).

SLOs are difficult to quantify due to the challenge of accurately measuring trust and acceptance. However, a stakeholder's quality of contact with the company is the strongest positive predictor of SLO across industries.[41,42] In a study of an Australian mining company, procedural fairness and the stakeholder's perception of being heard and listened to, even if the ultimate decision negatively affected them, was found to be a significant positive predictor of the company's attainment of a SLO.[41] An assessment of the SLO for the aquaculture industry in New Zealand also identified that SLO was positively correlated with the perceived "fairness" of the economic benefits of the entire industry, although it was not a factor in predicting company-level measure of SLO.[42] Although there was a negative correlation between trust and perceived negative impacts in the Australian mining community study,[41] perceived negative impacts were not a strong predictor of SLO in either the mining industry or aquaculture.[41,42]

Perceptions of Aquaculture

Global

The aquaculture industry is developing rapidly at a global scale, along with the growing amount of public interest in the industry. Not all types of aquaculture have been perceived similarly, especially in regards to sustainable sources of food. Some poorly managed nearshore aquaculture projects – cited for depletion of water quality, introduction of invasive species, and transferring of diseases to wild populations – have resulted in public caution to support aquaculture expansion.[13,43,44] Development of sustainable management practices are, however, improving the reputation of aquaculture.

Froehlich *et al.*'s (2017) study compiled global newspaper headlines and revealed a trend of positive increase of general "aquaculture" coverage, while noting "marine" and "offshore" terms have received more negative press.[45] Offshore farming, typically conducted in deeper waters with faster currents, is argued to support more ecologically sustainable aquacultured products.[46,47] The distinction between offshore and nearshore aquaculture types may not yet be apparent to the public. In the United States and New Zealand, concerns over environmental impacts of aquaculture tended to be more generalized, compared to targeted issues.[45] These generalized concerns are theorized to be due to a lack of knowledge surrounding offshore aquaculture, which highlights the need for better communication of real versus perceived impacts of aquaculture.[45]

United States

Few studies have examined the general public's perceptions of aquaculture in the United States[33] Of those studies, consistently low levels of awareness and knowledge of aquaculture processes and products were found across the nation.[45,48] One nationally representative survey of U.S. residents found that when presented with a series of fact-based true-or-false statements regarding seafood production and aquaculture, more than 50% of respondents selected "don't know."[49] The general public tend to associate aquaculture with economic benefits and environmental risk.[50,51] A review of media coverage of aquaculture found that although associations with aquaculture was generally positive, the term "offshore aquaculture" is increasingly associated with negative coverage.[45]

Local perceptions of seaweed farming are important to the growth of the kelp farming industry. Lack of knowledge among stakeholders may impede informed discussions about offshore aquaculture.[45] Billing *et al.* (2021) indicated that lack of clear information specific to a local area about seaweed cultivation can create misinformation and trust issues.[52] This study found that trust between the local community and industries is vital in expanding

seaweed cultivation – interpersonal relationships built between local small-scale operators and stakeholders allowed for an easier path to gaining a social license.[52]

America's historic negative perception of both marine and offshore aquaculture has stunted the growth of the industry.[9,45] However, the success of kelp aquaculture in the Northeast is partially attributed to strong support from coastal managers, stakeholders, and the public, due to the environmental benefits kelp aquaculture provides.[4] The social impacts of kelp farming must be addressed to maintain a sustainable industry as kelp aquaculture continues to expand in the United States.

California

Spatial conflicts and public perceptions will continue to be an important part of whether seaweed aquaculture progresses in the United States.[16] As aquaculture sites are explored, it is important that the spatial conflict scenarios, even if minimal, are explored with commercial fishers – a key stakeholder group who has been shown to have concerns over the potential impact on their use of fishing space.[53]

Aquaculture Siting in the Santa Barbara Channel

Offshore siting analyses prioritize farm development in nutrient-rich waters, typically upwelling sites.[46,47] These areas, however, also support local fisheries and marine mammal habitat, which increases the chance of conflict among stakeholders. In 2020, President Trump signed Executive Order 13921, "Promoting American Seafood Competitiveness and Economic Growth," which directed the National Oceanic and Atmospheric Administration (NOAA) to improve federal permitting and regulatory oversight and site Aquaculture Opportunity Areas (AOAs) in federal waters, including the Southern California Bight, a region extending from the U.S.-Mexico Border to Point Conception in Santa Barbara County.[54] In 2021, NOAA released the Atlas of AOAs, which identified locations between 500 and 2,000 acres with suitable conditions for offshore aquaculture that minimized spatial conflicts with other users.[55] Of the ten locations identified in the Southern California Bight, eight are located in the Santa Barbara Channel (Fig. 2).

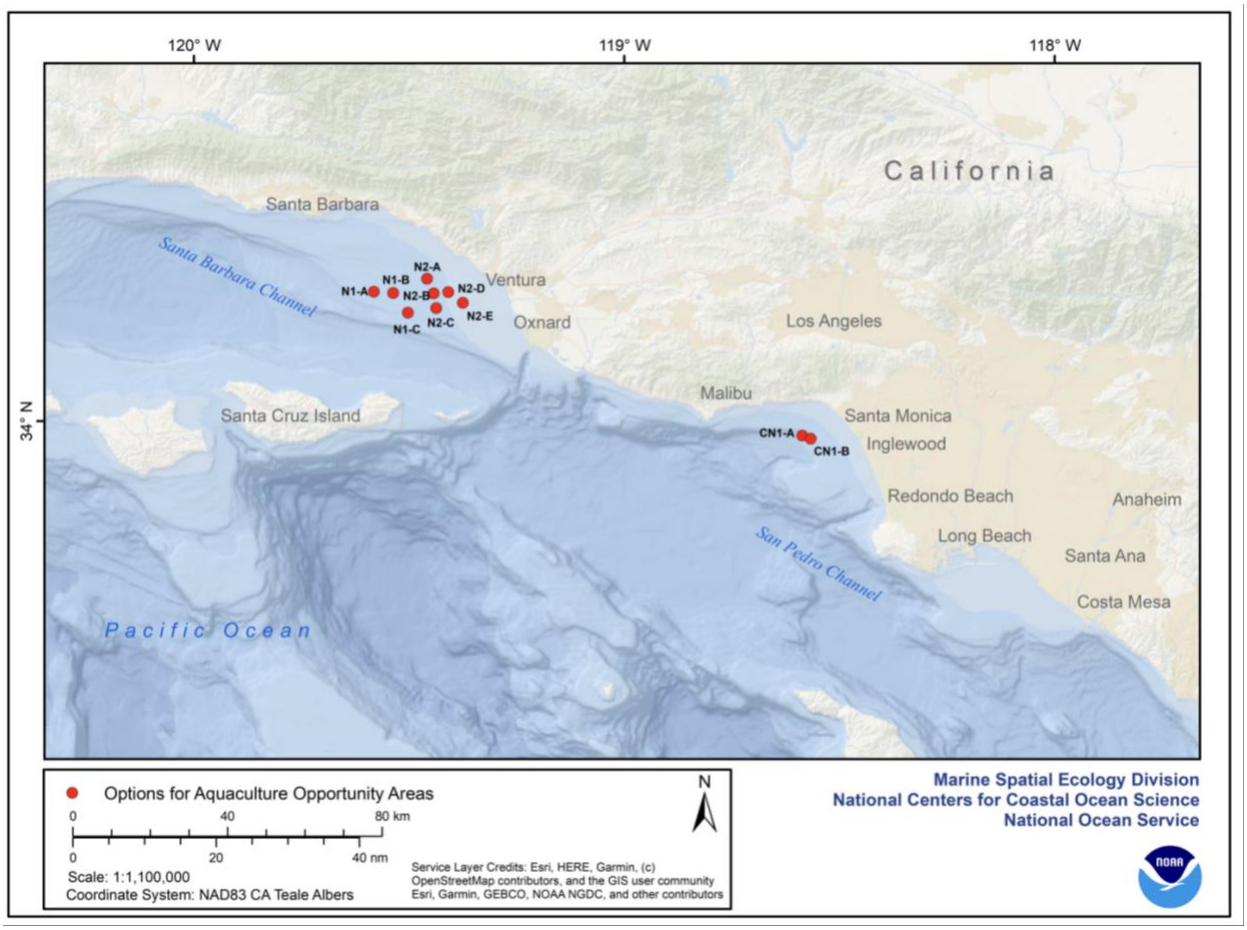

Figure 2: Distribution of options for Aquaculture Opportunity Areas in U.S. federal waters of the Southern California Bight. Red circles represent the options, but do not reflect the size of the options. Image from NOAA's Aquaculture Opportunity Area Atlas.

Environmental Communication

The field of environmental communication is multidisciplinary and plays an important role in framing environmental issues.[56] The primary function of environmental communication is to help solve environmental problems and/or shape perceptions of environmental topics through message framing and construction.[57] Within the environmental field, successful persuasion strategies are necessary to encourage ideological agreement and acquire social and economic support.[58] Due to their persuasive abilities, documentary films have become a useful strategy in environmental communication and education.[59,60]

The definition of a documentary is linked to objectivity and the neutral representation of a topic.[61] Documentaries are used by businesses, teachers, activists, and governments[58] and can successfully influence behaviors, raise awareness,[62] and bring about change.[63 64] Film is also considered a critical teaching instrument for engaging learners.[65] An investigative study of

short documentary films demonstrates the medium's ability to increase learners' memorization and comprehension of a subject when used for education.[60]

Stakeholder Communication and Engagement

To develop a successful project, an industry or business must effectively manage and engage the project's stakeholder community.[66] Effective engagement is ongoing and incorporates the changing attitudes and interests of each person or group, particularly those with the most influence.[66,67] This includes identification and prioritization of stakeholders, a targeted communication strategy, and dynamic collaboration that will continue throughout the project's lifespan.[68]

Communication strategies are plans for communicating specific information with an audience.[69] A strategy should identify stakeholders, outline the project's goals, select preferred methods of communication, and create a plan to obtain feedback.[69]

Research Questions

To understand the climate surrounding seaweed aquaculture in California, our study addressed the following research questions:

- Does seaweed aquaculture have a social license to operate in California?
- What are the perceptions of seaweed aquaculture and how do those perceptions influence its expansion in California?
- What are the uncertainties facing seaweed aquaculture in California?

Methods

Overview

Our project focus was narrowed to Santa Barbara and Ventura Counties in the Santa Barbara Channel. This location was chosen due to client interest and because it is where multiple aquaculture projects have been proposed in the last decade. The region contains 80% of the Southern California Bight AOAs identified by NOAA which could drive future aquaculture projects in the region.[55] Our study design includes a survey of the general population of the counties and semi-structured interviews from experts in different stakeholder groups to gather information and understand current stakeholder perceptions of the aquaculture industry.

Stakeholder Identification

Stakeholders were identified through review of the gray literature, a mapping exercise with our client, and snowball sampling. The term stakeholder was used in this project because it was the standard at the time the research took place. The term “stakeholder” encompasses government agencies, organizations, and community groups that may be impacted or have interest in the project. We decided not to engage with Indigenous communities for this project due to our project's short timeframe and the history of extractivism of Indigenous knowledge. However, Indigenous knowledge and perspectives are essential to sustainable marine spatial planning. Our client will continue to engage these Indigenous communities outside of this project.

Literature Review

Stakeholders engage with aquaculture through the regulatory and permitting processes. Stakeholders were identified through a gray literature review of public comments on all proposed aquaculture projects between 2015 and 2021 in the Southern California Bight, which extends from Point Conception to San Diego. Public comments for proposals in state waters were submitted to the California Coastal Commission, while proposals in federal waters were sent to the US Army Corps of Engineers. Comments for federal projects were secured under the Freedom of Information Act.

Stakeholder Mapping

The team developed a stakeholder map by synthesizing information from past aquaculture proposals in California and stakeholders identified by the client. The relative level of acceptance of various stakeholder groups were discussed along with their roles and magnitude of influence surrounding the permitting process for aquaculture. Stakeholders with the most leverage were targeted for individual interview sampling.

Snowball Sampling

Snowball sampling was used to enrich the sample population and identify latent stakeholders. This strategy utilizes participants' social knowledge to identify crucial and influential people within and among stakeholder groups.[70] Participants in semi-structured interviews were asked for recommendations of individuals or organizations we should consider speaking with.

Data Collection

Survey

Objective

Survey analytics were used to identify whether Santa Barbara and Ventura County residents are supportive of or opposed to seaweed aquaculture, how familiar they are with the industry, what knowledge they have about seaweed aquaculture, and what benefits and risks they perceive the industry will pose to the environment and economy. Analytics were also used to develop a community engagement and outreach strategy for commercial kelp producer, Ocean Rainforest, to utilize as a framework for aquaculture expansion along the California coastline.

Research Question

> **What knowledge do Santa Barbara and Ventura County residents have regarding seaweed aquaculture, and what are their perceived benefits and/or risks about aquaculture expansion?**

Hypothesis

> *The majority of the general public have not been exposed to the idea of seaweed aquaculture; some are interested in the potentially beneficial and harmful effects of it; however, most will likely not feel familiar with the topic. Those who are well versed in the trade-offs of aquaculture will have more polarized opinions.*

Respondents

The public perception survey targeted respondents from Santa Barbara and Ventura counties. Based on the Qualtrics sample size calculator,[71] 385 respondents were needed to sample a representative population of the ~1.3 million (1,292,505)[72] people that reside in Santa Barbara and Ventura counties, using a 95% confidence interval and a 5% margin of error. Response weighting was used to adjust survey responses to reflect target demographic proportions of Santa Barbara and Ventura counties more accurately.

Distribution

The survey was distributed through two channels. The first was through a paid survey contract with Qualtrics for 305 responses from Santa Barbara and Ventura County residents, funded by the UCSB Bren School and a Sustainable Ocean Alliance microgrant. The second was a non-paid self-distributed survey, open to the public and distributed through social media, listservs, and stakeholder groups. Survey advertisements consisted of a QR code with a link to take the survey on the Qualtrics survey platform (Appendix B1). This dual survey

distribution method reduced costs while ensuring a more representative sample population was obtained. The cost of acquiring 385 responses using Qualtrics paid services was not feasible with the financial resources of this project. Thus, the self-distributed survey responses were intended to supplement paid survey responses.

The paid survey was launched by Qualtrics on Tuesday, December 21, 2021, and collected 305 responses in one week. Qualtrics replaced 15% (n = 45) of the survey responses for inadequate or insufficient responses (e.g., respondents took the survey in less than three minutes, did not answer all the questions, or had incomplete demographics answers). In total, we received 365 responses from the paid survey released through Qualtrics (including five extra responses).

The self-distributed survey was open for one month, from Thursday, December 9, 2021, until Sunday, January 9, 2021. A total of 146 responses were received, with 110 of those responses being complete (i.e., the respondent made it to the end of survey). After combining responses from both survey distribution methods, a total of 511 survey responses were collected.

Survey Design

The public survey was developed to understand stakeholder perceptions and support for expanding aquaculture (Appendix B2). The creation of the survey utilized similar questions, concerns, and themes mentioned in previous surveys of public interest and aquaculture projects on the east coast of the US and in other countries.[49,73,74] The survey questionnaire was created using Qualtrics' web-based survey interface and consisted of 22 questions (all closed-ended except for one open-ended) and 11 demographic questions (Appendix B2). The survey took an average of eight minutes to complete. Protocol required all survey questions be optional and thus we could not force a response to any question in the survey. An anonymous online consent form required the participant to select whether they accept or decline participation before beginning the survey. The statement included our survey's purpose, confidentiality, and anonymity. For the Qualtrics paid survey, two screener questions were added to ensure respondents reside in either Santa Barbara or Ventura County and are 18 years or older.

A wording experiment was used to determine whether word choice influenced an individual's support for expanding aquaculture. Each respondent was randomly assigned one of four following terms used to describe aquaculture – seaweed farming, kelp farming, seaweed aquaculture, or kelp aquaculture – resulting in roughly equal distribution among the terms.

The questions asked were:

"Are you supportive of or opposed to expanding _____ off the California coast?"

- Answer choices: Strongly opposed, Somewhat opposed, Neither opposed nor in support, Somewhat agree, Strongly agree

"When you think of_____, what word comes to mind?"

- Open-ended answer (one word only)

The remainder of the survey was the same for all respondents, involving a mix of question formats such as ranked answer choices, Likert scale, and some open-ended demographic questions. Likert scale questions asked respondents to rank their level of agreement with each statement from "strongly disagree" to "strongly agree," as well as an option to select "don't know." Survey participants were each asked about their familiarity with aquaculture and to rank a list of eight terms used to refer to aquaculture based on which they viewed most positively. The terms included: ocean-, seaweed-, and kelp- farming; ocean-, seaweed-, and kelp- aquaculture; regenerative aquaculture, and seaweed mariculture. Terms were presented in a random order to reduce order-effect biases.

After the terminology questions, respondents were provided a definition of aquaculture, so that each respondent would have the same baseline understanding of the term before being asked about their perception of aquaculture from "very negative" to "very positive." Each respondent was also asked about their exposure to aquaculture, perceptions of seaweed aquaculture's impact on the environment and the economy, general benefits and risks, and perceptions and trust in science, the industry, and permitting process. Participants were later asked about their desire to learn more about aquaculture, including ranking aquaculture topics of interest as well as forms of communication they would prefer to learn by. The survey ended with the following demographic questions: year of birth, gender identity, race/ethnicity, highest level of education, annual household income and number of people in their household, zip code, political affiliation, occupation sector, and relationship to aquaculture industry.

Respondents who took the survey via our own distribution, were sent to a google forms page where they had the option of providing their email address to be sent the results of this study. They were ensured that their emails would not be associated or linked with their survey responses.

Semi-Structured Interviews

Objective

Semi-structured interviews are a research method that combines pre-developed questions from an interview guide with open-ended probing questions. Semi-structured interviews

allow researchers to explore deeper themes and explore variation within the stakeholder groups by asking probing questions in a dialogue with the interviewee.[75] Our interview guide included key guiding questions but gave researchers the flexibility to explore topics introduced by the interviewee and ask for clarification, explanation, or examples (Appendix C1). Interviews were conducted with subject matter experts in five key stakeholder groups: government agencies, environmental non-governmental organizations (ENGOs), commercial and recreational fishers, aquaculturists, and the scientific community.

Research Question

Does seaweed aquaculture have a social license to operate from key stakeholder groups?

Hypothesis

Seaweed aquaculture will not have a SLO from commercial and recreational fishers, environmental non-governmental organizations, regulators, and the scientific community. Negative experiences with recent aquaculture projects in Southern California have eroded trust in the aquaculture industry and created suspicion of new aquaculture permits. Concerns about marine mammal entanglement will be a primary concern for environmental groups and drive their engagement with regulators. Commercial and recreational fishers will be primarily concerned with latent spatial conflicts that will limit their current fishing grounds.

Interviewee Identification and Outreach

Representatives from the five key stakeholder groups were identified in the stakeholder mapping exercise and literature review. Interviewees were prioritized by level of stakeholder group influence and their expertise and familiarity with the California aquaculture industry. Interviewees were sent interview requests with one follow-up email if there was no response.

Conducting Semi-Structured Interviews

Interviews were conducted over Zoom, a video teleconferencing software program. Each interview lasted 30 to 60 minutes and were attended by two to four researchers. Participants signed consent forms indicating their voluntary participation and willingness to be recorded (Appendix C3). At the beginning of each interview, researchers verbally confirmed the participants' voluntary participation and consent to be recorded. Researchers did not take extensive notes during the interview to focus on the conversation and follow-up questions. Interview audio and video recordings were stored in a secure cloud-based Box folder until transcribed.

Interviewers followed an interview guide (Appendix C1) but were encouraged to tailor questions to each subject's expertise or background. Each interview concluded with

researchers asking if the subject had recommendations on who else researchers should speak (i.e., snowball sampling).

Data Analysis

Survey Analysis

Survey responses from the paid and self-distributed surveys were compiled into an Excel (.csv) spreadsheet and analyzed in R using RStudio version 4.1.2. Analysis was coded and created reproducibly in R using RStudio and stored on an open-source GitHub repository. All data files and R markdown documents (.Rmd) are publicly available at our team's GitHub repository (Appendix B3).

Filtering Responses

In total, we received 511 survey responses via the two survey distribution methods. The 146 survey responses from the self-distributed survey were filtered by county, via zip code. Survey responses from respondents that did not reside in Santa Barbara and Ventura counties were removed from analysis (n = 96). A total of 400 responses were collected from Santa Barbara and Ventura County residents. These responses were then filtered for "speeders" – respondents that took less than three minutes to complete the survey. A total of 36 "speeder" responses were removed from analysis, due to the risk of inclusion of inadequate responses, leaving 364 survey responses to use for data analysis.

Response Weighting

Response weighting was used to adjust sampled population responses to reflect target population demographics of Santa Barbara and Ventura counties more accurately. Demographic data for Santa Barbara and Ventura counties were obtained from U.S. Census Bureau's American Community Survey (ACS) 2019 county estimates, as 2020 census data was not publicly available at the time of project completion.[72]

The sample data was weighted using the rake weighting method to separate respondents into groups based on sex and age. The survey asked respondents to select their gender identity (as opposed to sex), with the options of man, woman, non-binary, not listed, and prefer not to state. ACS data only provided binary sex ratio proportions, not gender identity proportions. Consequently, gender identity was used as a proxy for sex (i.e., man = male and woman = female). Responses from respondents who identify as non-binary (n = 3) were removed from analysis for weighting purposes. Limitations of this analysis are explored in the discussion. An additional 11 responses were removed from weighted analysis as they did not indicate either their gender identity or year of birth (or both). Total survey responses used for weighting was 350.

ACS 2019 estimates for female and male populations of Santa Barbara and Ventura County were summed by sex to determine the sex ratio for the two counties combined. The combined population of Santa Barbara and Ventura counties (N = 1,292,505) was estimated to be 49.7% male and 50.3% female in 2019. Our survey sample population (n = 350) was 44.0% male and 56.0% female.

Age groups were used in combination with sex to break respondents into further categories and weight responses by two demographics. The age groups used for weighting correspond with the U.S. Census Bureau estimates from ACS 2019. Population proportions were adjusted to account for our sample population age range of 19 to 96, which included removing age groups "0 to 4," "5 to 9," and "10 to 14" and merging the "80 to 84" and "85+" age groups to "80+." Since we only obtained responses from 19-year-old Santa Barbara and Ventura County residents, we assumed uniform distribution across the "15 to 19" age group and used 1/5th of the age group population to represent the 19-year-old population and create the age and sex group proportions and weights. In total the respondents were broken into 28 weighted groups. Weights were calculated by dividing the population proportion by the sample proportion for each age and sex group. For weights assigned to each age and sex group refer to Appendix A, Table A1.

Research Questions and Hypotheses

Survey analysis addressed the following series of research questions and hypotheses:

1. **<u>Wording Experiment</u>: Does terminology influence a residents' support for seaweed aquaculture?**
    - **Hypothesis:** *Residents will be more supportive of the term "kelp farming", than of the terms "kelp aquaculture," "seaweed aquaculture," and "seaweed farming," because of its associations with an important native species and since farming is a more familiar term.*
    - **Statistical Test:** A Chi-square test of independence was conducted on proportions of answer choices to the question "Are you supportive of or opposed to expanding <u>(random term)</u> off the California coast?" for each of the four randomly assigned terms (seaweed farming, kelp farming, seaweed aquaculture, or kelp aquaculture).
2. **<u>Support</u>: Are Santa Barbara and Ventura County residents supportive of or opposed to expanding seaweed aquaculture off the California coast?**
    - **Hypothesis:** *Those who are well versed in the trade-offs of (or familiar with) aquaculture will have more polarized opinions (either strongly supportive or strongly opposed). Those who are relatively unfamiliar with aquaculture will have more positive views of it.*

3. **<u>Perception</u>**: **Does perception of aquaculture change when specifying seaweed aquaculture?**
    - **Hypothesis:** *Yes, people will view seaweed aquaculture more positively than aquaculture in general.*
    - **Statistical Test:** A Chi-square test of independence was conducted to determine whether there was a statistically significant difference between the proportion of positive and negative perceptions of aquaculture versus seaweed aquaculture.
4. **<u>Knowledge</u>: Are residents familiar with aquaculture?**
    - **Hypothesis:** *Most of the public have not been exposed to the idea of aquaculture and are unfamiliar with it.*
    - **Statistical Test:** A Fisher's exact test was conducted to determine whether there was a statistically significant association between familiarity and perception variables.
5. **<u>Relationship Between Perception and Support</u>: Is support related to more positive perceptions of seaweed aquaculture?**
    - **Hypothesis:** *Those who view seaweed aquaculture more positively will be more likely to be in support of seaweed aquaculture expansion.*
    - **Statistical Test:** An ordered logistic regression was run to predict a respondent's level of support (dependent variable) based on their perception of seaweed aquaculture (independent variable).
6. **<u>Relationship Between Familiarity and Support</u>: Is support related to a higher level of familiarity with aquaculture?**
    - **Hypothesis:** *Those who are familiar with aquaculture will have more polarized opinions on seaweed aquaculture, whereas those less familiar will have more positive views of kelp aquaculture.*
    - **Statistical Test:** An ordered logistic regression was run to predict a respondent's level of support (dependent variable) based on their level of familiarity with aquaculture (independent variable).
7. **<u>Relationship Between Perception and Familiarity</u>: Is perception of seaweed aquaculture related to familiarity with aquaculture?**
    - **Hypothesis:** *Residents more familiar with aquaculture will view seaweed aquaculture more positively compared to those less familiar with aquaculture.*
    - **Statistical Test:** An ordered logistic regression was run to predict a respondent's perception of seaweed aquaculture (dependent variable) based on their level of familiarity with aquaculture (independent variable).

Likert Question Analysis Approach

Each closed-ended, categorical question had a number assigned to the Likert style response category (e.g., 1- strongly agree, 2- agree, 3- neutral, 4- disagree, 5- strongly disagree). The

mean response and standard deviation were calculated for each question, as well as the weighted proportion of each answer choice selected. The mean rank score and standard deviation was determined for each ranking response question.

Statistical Tests

The following statistical tests were utilized in survey analyses:

- Pearson's Chi-square test for independence
- Fisher's exact test (used when the assumptions for chi-square were violated)
- Ordered logistic regression

Semi-Structured Interview Thematic Analysis

Thematic analysis is a method of qualitative data analysis that looks for trends or patterns. Inductive thematic analysis builds codes and themes from the data rather than applying an existing theoretical framework to the data. Thematic analysis of the interviews was conducted following the general process outlined by Braun and Clarke (2006) and explained by Maguire and Delahunt (2017).[76]

1. Become familiar with the data
   We read through the transcripts two to three times before beginning the coding process, to get an understanding of the interviewee's perspective.

2. Generate initial codes
   Codes are a method of grouping and organizing qualitative data by tagging evidence or lines of text. We developed an initial set of codes (codebook) to answer the central question of whether kelp aquaculture has a social license to operate. Codes highlighted perceptions, concerns, and relationships noted by interviewees. The codebook (Appendix C2) was used to consolidate codes moving forward. Transcripts were coded using NVivo 12 Mac.

3. Search for themes
   Once all the transcripts were coded, researchers searched for themes. Themes include overarching patterns between and among cases (interviews) that helped us determine whether each sector has granted a SLO to aquaculture. Several codes feed into a larger theme.

4. Review themes
   We reviewed and refined the themes. We revisited the codes and reread transcripts to ensure our coding strategy was consistent among transcripts. During this time, we also consolidated codes that had overlapping meaning.

Transcriptions and Notes

Qualitative data from semi-structured interviews were recorded and transcribed verbatim using the word-to-text program Descript 29.1.2 by a researcher. Filler words, such as "uh" and "um" were removed. Transcribed interviews were checked by another team member for accuracy.

One of the twelve participants declined to be recorded during their interview but consented to handwritten notes. Four researchers attended the interview so two could take notes while the other two focused on conducting the interview. Notes from the interview were coded and used in lieu of interview transcripts.

Coding

There are four key threshold components of a social license to operate; economic legitimacy occurs when stakeholders perceive the industry will have economic value for them; socio-political legitimacy relates to fitting into the community and following the community's sense of fairness; interactional trust is built through consistent follow-through in the companies actions and promises as well as their availability to talk about challenges; and finally, institutional trust in which the organization is embedded in the society and there is psychological identification.[38] Codes were developed to identify components of the SLO within the transcripts. Categories of codes included impacts, relationships among and between stakeholders, other types of aquaculture, and specific projects.

Several codes contained nested subcodes within the category. For example, the code "Negative Impacts" included codes for "entanglement" and "marine debris". Codes were added to accurately capture patterns in the data. The final codebook can be found in Appendix C2.

Results

Survey Results

Survey Response Demographics

Survey sample age and sex group demographics were mostly representative of the target population of Santa Barbara and Ventura counties (Fig. 3). Our 350 survey respondent demographics revealed a slight over sampling of certain sex and age groupings, including females ages 20 to 34 and males ages 30 to 34 and 70 to 74, and under sampling of males ages 19 to 24 and females ages 75+ (Fig. 3). To avoid skewing the perceptions of Santa Barbara and Ventura County residents, survey responses were weighted by the respondent's

sex and age group to ensure our analysis reflected a representative sample of our target population (Table A1). Our weighted sample population (n = 350) represents the target population of Santa Barbara and Ventura counties (N = 1,292,505) with a 95% confidence interval and a 5.2% margin of error and was used to conduct the following analyses.

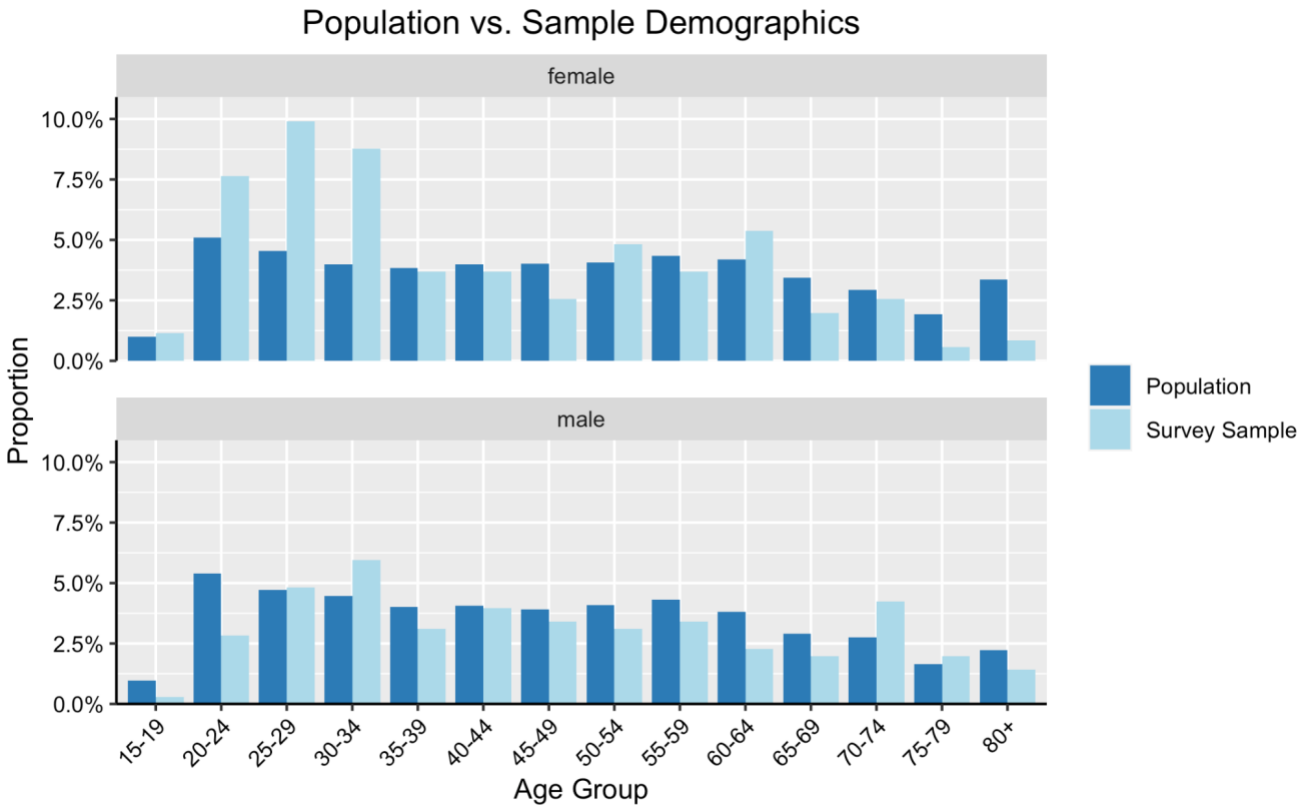

Figure 3: Demographic comparison between our survey sample population and combined Santa Barbara and Ventura populations. Note ages 0-18 were removed from proportion, and thus age group 15-19 only includes 19-year-olds.

Wording Experiment- Influence of Terminology on Support

Does terminology influence a residents' support for seaweed aquaculture?

We hypothesized that residents will be more supportive of the term "kelp farming," than of the terms "kelp aquaculture," "seaweed aquaculture," and "seaweed farming," because of its associations with an important native species and since farming is a more familiar term. To determine whether word choice had any impact on a resident's support or opposition to seaweed aquaculture, a Chi-square test of independence was conducted on proportions of answer choices to the question "Are you supportive of or opposed to expanding _(random term)_ off the California coast?" for each of the four randomly assigned terms (seaweed farming, kelp farming, seaweed aquaculture, or kelp aquaculture). The data satisfied all assumptions of the Chi-square test.

Answer choice proportions were calculated and appeared similar in magnitude for each of the four terms, with the majority of respondents being in support and the minority in opposition of their "choice term" (Fig. 4A). Respondents were most strongly/somewhat supportive of expanding kelp aquaculture (55.7%) and most strongly/somewhat opposed to expanding seaweed aquaculture (11.0%) (Fig. 4A). A large proportion of respondents were neither opposed nor in support, with seaweed farming receiving the largest number of neutral responses (55.4%) (Fig. 4A). A Chi-square test revealed a significant association between word choice and support for or opposition to "choice term" off the California coast (X^2 (12, n = 350) = 22.47, p = .03). Therefore, we reject the null hypothesis and accept the alternative hypothesis that there is an association between word choice and whether a Santa Barbara or Ventura County resident is supportive/opposed to "choice term."

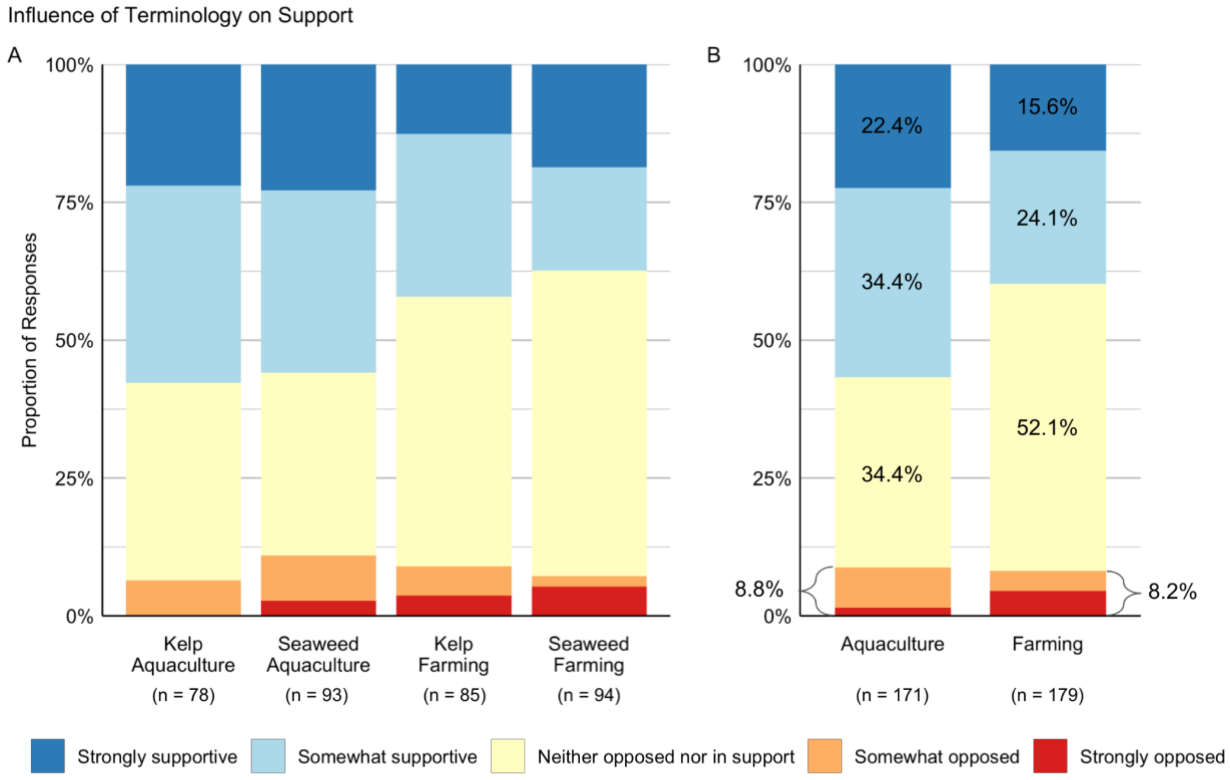

Figure 4: (A) A percent stacked bar graph depicting the weighted proportion of Santa Barbara and Ventura County residents that are strongly supportive, somewhat supportive, neither opposed nor in support, somewhat opposed, and strongly opposed to expanding kelp aquaculture, kelp farming, seaweed aquaculture or seaweed farming off the California coast. Chi-square test for independence between answer count proportions for each term revealed a significant association between word choice and a resident's support or opposition to expanding "choice term" off the coast of California (X^2 (12, n = 350) = 22.47, p = .03). **(B)** Percent stacked bar graph showing the combined proportions of support for kelp and seaweed aquaculture responses in the "aquaculture" column and combined proportions of support for kelp and seaweed farming responses in the "farming" column.

The second part of the embedded wording experiment was qualitative and asked respondents "When you think of _(random term)_ , what word comes to mind?" The responses for each of the four randomly assigned terms (kelp farming, kelp aquaculture, seaweed farming, seaweed aquaculture) was visualized using word clouds (Fig. A1). For both kelp farming and kelp aquaculture, the word "seaweed" was most frequently listed (n = 12, n = 16, respectively), suggesting that Santa Barbara and Ventura County residents associate the term kelp with seaweed (Fig. A1). The word "sustainable," or some version of the term (e.g., sustainability), was listed for each of the four terms, and was the most frequently listed word for seaweed farming (n = 12) (Fig. A1). Many of the terms listed by respondents had positive connotations, such as preservation, innovative, renewable, restorative, beautiful, growth, forward-thinking, natural, health, and beneficial. Conversely, some words mentioned had negative connotations, such as unnatural, destruction, gross, smelly, and unprofitable.

Aquaculture is referred to by many names. Respondents were asked to rank eight terms based on which they viewed most positively, with 1 being the most positive and 8 being least positive. The average score assigned to each term was calculated to determine whether Santa Barbara and Ventura County residents prefer the usage of one term over others (Table A2). The term "regenerative aquaculture" was ranked highest (mean score of 3.95) while "seaweed mariculture" was ranked lowest (mean score of 5.59) (Table A2). The other six terms, which consisted of interchangeable words, had similar average scores (ranging from 4.22 - 4.63) that fell in between the mean scores for "regenerative aquaculture" and "seaweed mariculture" (Table A2).

Support

Are Ventura and Santa Barbara residents supportive of or opposed to expanding seaweed aquaculture off the California coast?

Since the Chi-square test revealed a significant association between word choice (aquaculture vs. farming) and support for or opposition to the assigned term, answers to each of the four versions of the survey question were combined for further analyses (Fig. 4B). We assumed that the combined data set reflected residents' support for or opposition to the synonymous terms of kelp/seaweed aquaculture and kelp/seaweed farming. Grouped proportions revealed that a greater proportion of Santa Barbara and Ventura County residents are supportive of kelp/seaweed "aquaculture" (56.8%) than of kelp/seaweed "farming" (39.7%) (Fig. 4B). The majority (52.1% of residents are neither opposed nor in support of expanding kelp/seaweed farming, while 34.4% are neither opposed nor in support of expanding kelp/seaweed aquaculture (Fig. 4B). A small proportion of residents are opposed to kelp/seaweed aquaculture or farming (8.8% and 8.2%, respectively) (Fig. 4B).

Perception

Does perception of aquaculture change when specifying seaweed aquaculture?

Respondents were provided with the definition of aquaculture before being asked how positive or negative their view of aquaculture was, on a scale from "very positive" to "very negative." Respondents were then given the definition of seaweed aquaculture and then asked about their perception of seaweed aquaculture. As hypothesized, Santa Barbara and Ventura County residents had a slightly greater proportion of positive perceptions of seaweed aquaculture (72.0%) than of aquaculture in general (65.1%) (Fig. 5). However, a Chi-square test revealed no statistically significant difference between the proportion of positive and negative perceptions of aquaculture versus seaweed aquaculture, and thus no significant association was found between the perception and type of aquaculture stated (X^2 (5, n = 350) = 4.41, p = .49). Thus, we accept the null hypothesis that there is no difference in perception between aquaculture and seaweed aquaculture.

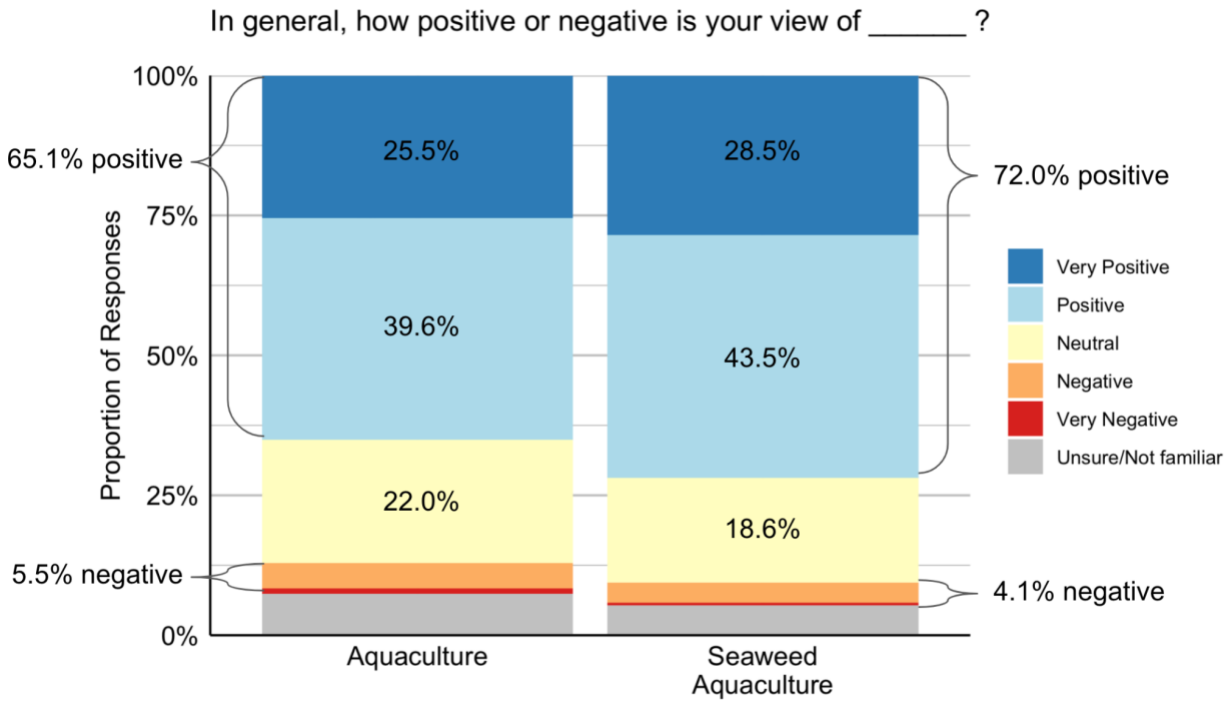

Figure 5: A percent stacked bar plot displaying the weighted proportion of Santa Barbara and Ventura County residents that have a very positive, positive, neutral, negative, and very negative perception of "aquaculture" compared to that of "seaweed aquaculture" (n = 350). No significant association was found between the perception and type of aquaculture stated (general aquaculture vs. seaweed aquaculture) (X^2 (5, n = 350) = 4.41, p = .49).

Knowledge

Are residents familiar with aquaculture?

Our hypothesis that most of the public have not been exposed to the idea of aquaculture, was contradicted from the responses received to the survey question "How familiar are you with aquaculture?" (Fig. 6). A majority of Santa Barbara and Ventura County residents have a basic understanding of aquaculture, but lack specific knowledge or details, while few residents (7.9%) are very familiar with it (Fig. 6). In addition, few residents (14.5%) have never heard of aquaculture before (Fig. 6).

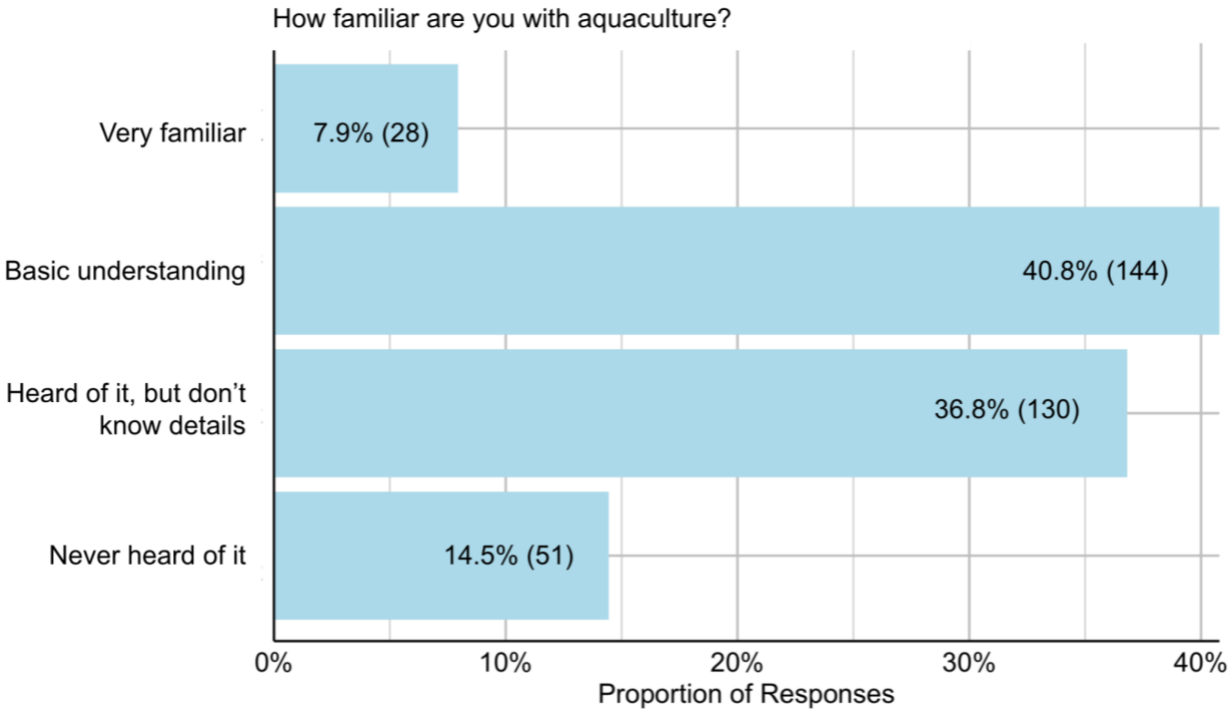

Figure 6: Weighted proportion (and counts) of Santa Barbara and Ventura County residents' responses to the survey question "How familiar are you with aquaculture?," ranging from very familiar (very knowledgeable) to never heard of it (no knowledge) (n = 350).

Residents' level of familiarity with aquaculture was compared against their perception of seaweed aquaculture (Fig. 7). A Fisher's exact test was used to determine whether there was an association between these two categorical variables, since the data did not satisfy the assumptions of a Chi-square test. A significant association between familiarity with aquaculture and perception of seaweed aquaculture was found (p = .0004), indicating that familiarity and perception are dependent variables.

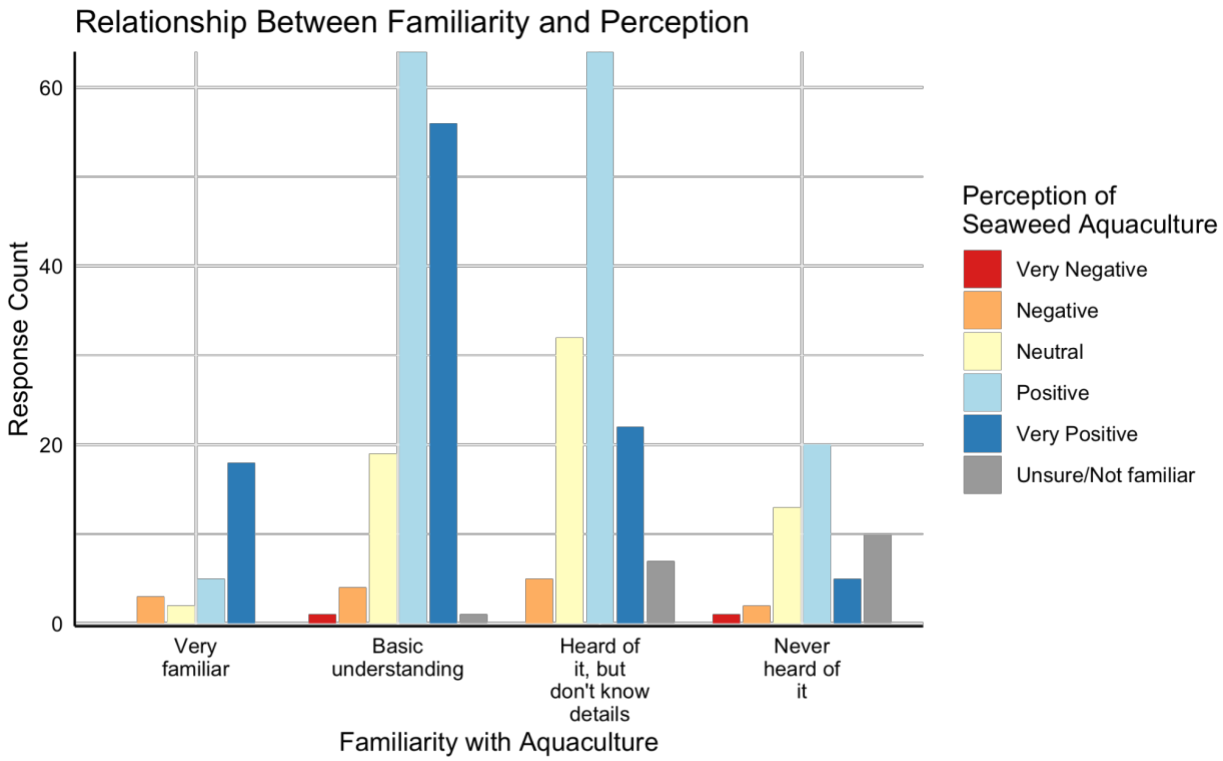

Figure 7: Relationship between perception of seaweed aquaculture (Very Negative to Very Positive) and familiarity with aquaculture (n = 350). A significant association was found between the familiarity with aquaculture and perception of seaweed aquaculture (*Fisher's exact test, p* = .0004).

Ordered Logistic Regressions

Ordered logistic regressions (ordered logit models) were used to determine how well an ordinal dependent response variable can be predicted by the responses to other variables or questions. The combined results of the support for the two "farming" terms and the two "aquaculture" terms were grouped to run regression analysis to determine the probability of a resident's support for aquaculture/farming given their level of familiarity with aquaculture or perception of seaweed aquaculture.

5. Relationship Between Perception and Support

Is support related to more positive perceptions of seaweed aquaculture?

We hypothesized that those who view seaweed aquaculture more positively will be more likely to be in support of seaweed aquaculture expansion. An ordered logistic regression was run to predict a respondent's level of support (dependent variable) based on their perception of seaweed aquaculture (independent variable).

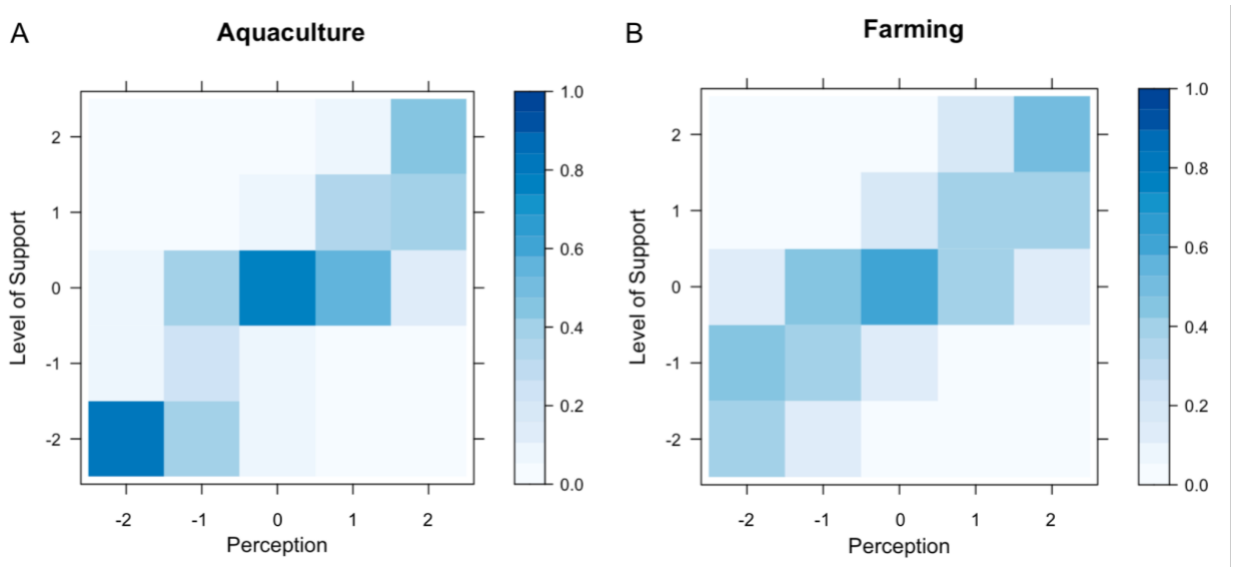

Figure 8: Predicted probabilities results of regression analysis for support v. perception - The heatmaps illustrate the predictive probabilities of a resident's level of support for **(A)** kelp/seaweed aquaculture and **(B)** kelp/seaweed farming based on their perception of seaweed aquaculture. Levels of support include strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2). Perceptions of seaweed aquaculture include very negative (-2), negative (-1), neutral (0), positive (1), and very positive (2). Darker shades of blue represent higher probabilities that a resident will have the respective level of support for their respective perception. Note "don't know/unsure" response categories were removed from perception question analyses. (A: n = 169; B: n = 162)

As hypothesized, predicted probabilities from regression results revealed that residents with positive perceptions of seaweed aquaculture were more likely to support kelp/seaweed aquaculture or farming, while those with negative perceptions were more likely to oppose it (Fig. 8, Table A3, Table A5). Similar predicted probabilities were found for regressions run with aquaculture v. farming support terms; however, probabilities for support for aquaculture v. perception were higher for polarized responses than for support for farming v. perception (Fig. 8).

Residents with a very negative perception of seaweed aquaculture had an 82% probability of strongly opposing kelp/seaweed aquaculture, while residents with a very positive perception of seaweed aquaculture had a 44% probability of being strongly supportive of kelp/seaweed aquaculture (Fig. 8A, Table A3). The probability of residents with a neutral perception of seaweed aquaculture to neither oppose nor support kelp/seaweed aquaculture and kelp/seaweed farming was 75% and 59%, respectively (Fig. 8, Table A4, Table A6).

6. Relationship Between Familiarity and Support

Is support related to a higher level of familiarity with aquaculture?

We hypothesized that residents who are familiar with aquaculture will have more polarized opinions on seaweed aquaculture, whereas those less familiar will have more positive views of kelp aquaculture. An ordered logistic regression was run to predict a respondent's level of support (dependent variable) based on their level of familiarity with aquaculture (independent variable).

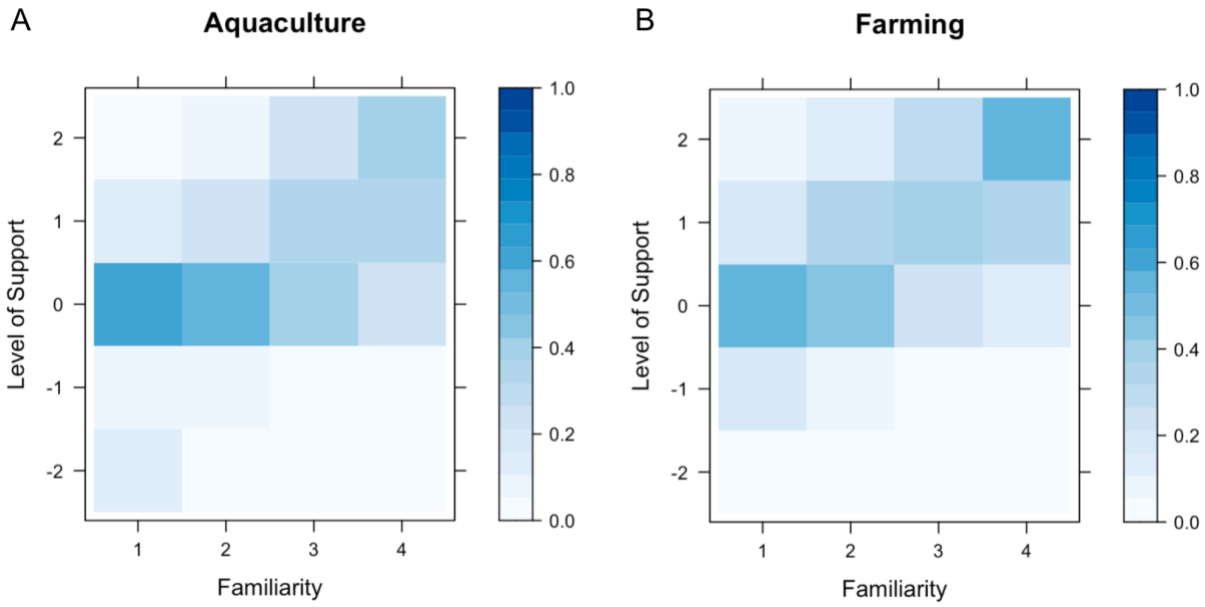

Figure 9: Predicted probabilities results of regression analysis for support v. familiarity - The heatmaps illustrate the predictive probabilities of a resident's level of support for (A) kelp/seaweed aquaculture and (B) kelp/seaweed farming based on their level of familiarity with aquaculture. Levels of support include strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2). Levels of familiarity include: "never heard of it" (1), "heard of it, but don't know details" (2), "basic understanding" (3), and "very familiar (4). Darker shades of blue represent higher probabilities that a resident will have the respective level of support for their respective level of familiarity. (A: n = 175; B: n = 175)

Predicted probabilities from regression results revealed that residents more familiar with aquaculture were more likely to support kelp/seaweed aquaculture or farming than those unfamiliar with it (Fig. 9, Table A7, Table A9). Contradictory to our hypothesis, predicted probabilities did not indicate that those very familiar with aquaculture had polarized opinions, as these individuals had a 39% probability of strongly supporting and 1% probability of strongly opposing aquaculture (56% and 0% respective probabilities for farming) (Fig. 9, Table A8, Table A10). Residents unfamiliar with (never heard of) aquaculture, had the greatest probability (61%, 55%) of being neither opposed nor in support of kelp/seaweed aquaculture and farming (Fig. 9, Table A8, Table A10).

7. Relationship Between Perception and Familiarity

Is perception of seaweed aquaculture related to familiarity with aquaculture?

We hypothesized that residents more familiar with aquaculture will view seaweed aquaculture more positively compared to those less familiar with aquaculture. An ordered logistic regression was run to predict a respondent's perception of seaweed aquaculture (dependent variable) based on their level of familiarity with aquaculture (independent variable).

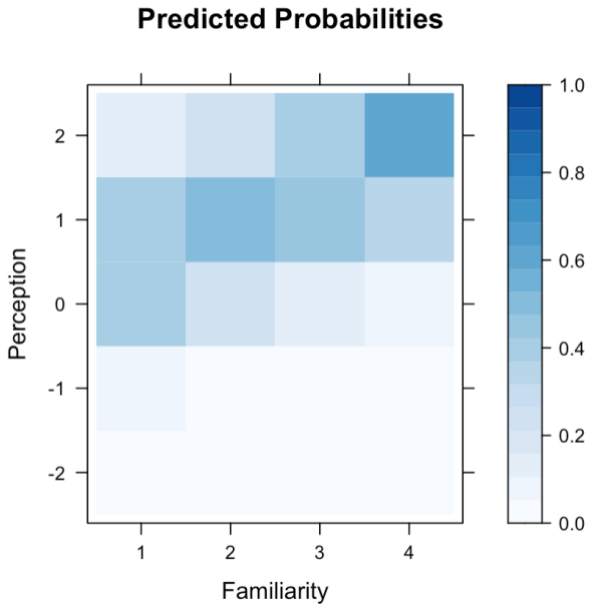

Figure 10: Predicted probabilities result of regression analysis for perception v. familiarity - The heatmap illustrates the predictive probabilities of a resident's perception of seaweed aquaculture based on their level of familiarity with aquaculture. Levels of support include strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2). Perceptions of seaweed aquaculture include very negative (-2), negative (-1), neutral (0), positive (1), and very positive (2). Levels of familiarity include: "never heard of it" (1), "heard of it, but don't know details" (2), "basic understanding" (3), and "very familiar (4). Darker shades of blue represent higher probabilities that a resident will have the respective level of perception for their respective level of familiarity. Note "don't know/unsure" response categories were removed from perception question analyses. (n = 334)

As hypothesized, predicted probabilities from regression results revealed that residents more familiar with aquaculture were more likely to have positive perceptions of seaweed aquaculture than those unfamiliar with it (Fig. 10, Table A11). Residents very familiar with aquaculture, had the greatest probability (58%) of having very positive views and smallest probability (0%) of having very negative views of seaweed aquaculture (Fig. 10, Table A12). Those unfamiliar with (never heard of) aquaculture had the greatest probability of having positive views of seaweed aquaculture (41%), followed by neutral views (39%) (Fig. 10, Table A12).

Environmental and Economic Impacts

Around 25% of respondents answered "don't know" to statements regarding environmental and economic impacts of seaweed aquaculture (Fig. A2). Approximately 40% of respondents disagreed that "seaweed aquaculture has negative impacts on marine ecosystems" and 10% agreed that it would have negative impacts (Fig. A2). Almost half (49%) of Santa Barbara and Ventura County residents agreed that "the benefits of seaweed aquaculture outweigh the potential risks," while only a small proportion (8%) disagreed (Fig. A2).

A majority of residents (59%) agreed that "seaweed aquaculture has a positive impact on the local economy," while only 6% disagreed (Fig. A2). When asked if they agree or disagree that "aquaculture will be an important food supply as climate change progresses," 69% of respondents agreed and 3% disagreed (Fig. A2). A large proportion of residents disagreed that seaweed aquaculture will "interfere with commercial and recreation fishing" and "interfere with tourism and recreation" (Fig. A2).

Demographic Analysis of "Supportive," "Neutral," and "Opposed" Groups

To determine who makes up the "supportive," "neutral," and "opposed" to seaweed aquaculture groups, demographic analyses were conducted for responses to the question "are you supportive of or opposed to expanding seaweed aquaculture off the California coast?"

Sex and Age

Sex and age do not appear to impact an individual's support for expanding aquaculture. Males were slightly more opposed to expanding seaweed aquaculture (11.1%) than females (5.7%) (Fig. A3). However, the proportion of males and females neither in support nor in opposition are similar (39.9% males, 47.9% females) (Fig. A3). A Chi-square test confirmed no significant association between sex and support for seaweed aquaculture expansion (X^2 (4, n = 350) = 5.89, p = .21). Additionally, there is no apparent trend in age and level of support, which was confirmed by a Fisher's exact test (p = .09) (Fig. A4).

County of Residence

Although the proportion of people who oppose expanding aquaculture was similar between Santa Barbara and Ventura counties (7.9% SB; 8.8% Ven), most Ventura County residents are neither supportive nor opposed to seaweed aquaculture (35.2% SB; 49.5% Ven) while the majority of Santa Barbara County residents are supportive (56.8% SB; 41.7% Ven) (Fig. A5). It should be noted that pre-weighting, Santa Barbara County was slightly over sampled constituting 39.2% of responses compared to 34% of the population (ACS 2019). Response weighting did not account for county population ratios. Despite apparent trends in support by county, a Chi-square test revealed no significant association between county of residence and support for seaweed aquaculture expansion (X^2 (4, n = 350) = 9.03, p = .06).

Education Level

A Fisher's exact test revealed a significant association between education and support for seaweed aquaculture (p = .02). As the amount of college education increases, the proportion of individuals that strongly support expanding aquaculture significantly increases (21.1% Bachelors; 28.8% Master's; 49.9% PhD) (Fig. 11).

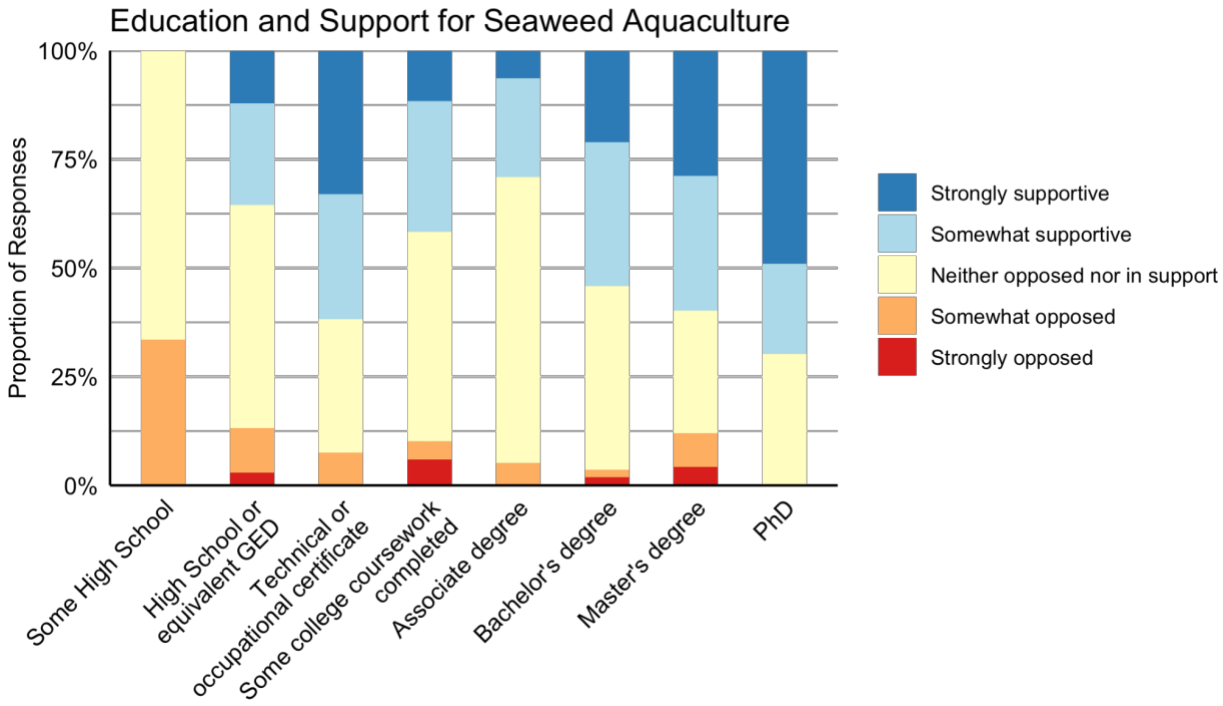

Figure 11: Relationship between education level of respondent and support for expanding seaweed aquaculture. Data did not meet the assumptions of a chi-squared test, instead a Fisher's exact test for count data was run with simulated p-value (based on 2000 replicates) and revealed a significant association between education and support for seaweed aquaculture (p = .02).

Political Affiliation

A resident's political affiliation did not appear to influence an individual's level of support for expanding seaweed aquaculture (Fig. A6). A Chi-square test confirmed this and revealed no significant association between political affiliation and support for seaweed aquaculture expansion (X^2 (6, n = 348) = 7.66, p = .26).

Monthly Ocean Visitation

Support for seaweed aquaculture increased the greater the number of days per month spent at or near the ocean (Fig. A7). However, a Chi-square test did not reveal a significant association between monthly ocean visitation and support for seaweed aquaculture expansion (X^2 (8, n = 350) = 10.53, p = .23).

Household Income, Occupational Sector and Relation to Aquaculture Industry

A resident's household income, sector of occupation, or relation to the aquaculture industry did not appear to have an impact on the level of support for expanding seaweed aquaculture (Fig. A8, Fig. A9, Fig. A10). Response weighting did not include household income demographic proportions and therefore might be an unrepresentative example.

Semi-Structured Interviews

Interviews

Twelve interviews were conducted between November 2021 and January 2022. Interviews ranged between 27 minutes and 88 minutes. Only one of the twelve interviewees (sector = ENGO) declined to be recorded. Four researchers attended this interview–two as interviewers and two as note takers. Notes from the interview were not coded.

Table 1: Total number of interviews, interview requests, percentage of interview requests that resulted in a semi-structured interview (positive response rate), and average interview length (min).
*Includes a fisheries consultant that works closely with fishing interests
**Total percentage may not equal 100 due to rounding

Sector	Interviews (n = 12)**	Interview Requests (n = 23)**	Positive Response Rate	Average Interview Length (min)
Commercial and Recreational Fishing*	2 (16%)	5 (22%)	60%	44
Aquaculture	2 (16%)	3 (13%)	66%	53
Government/ Regulatory	3 (25%)	6 (26%)	50%	64
ENGO	2 (16%)	5 (22%)	40%	56
Scientific	3 (25%)	4 (18%)	66%	44

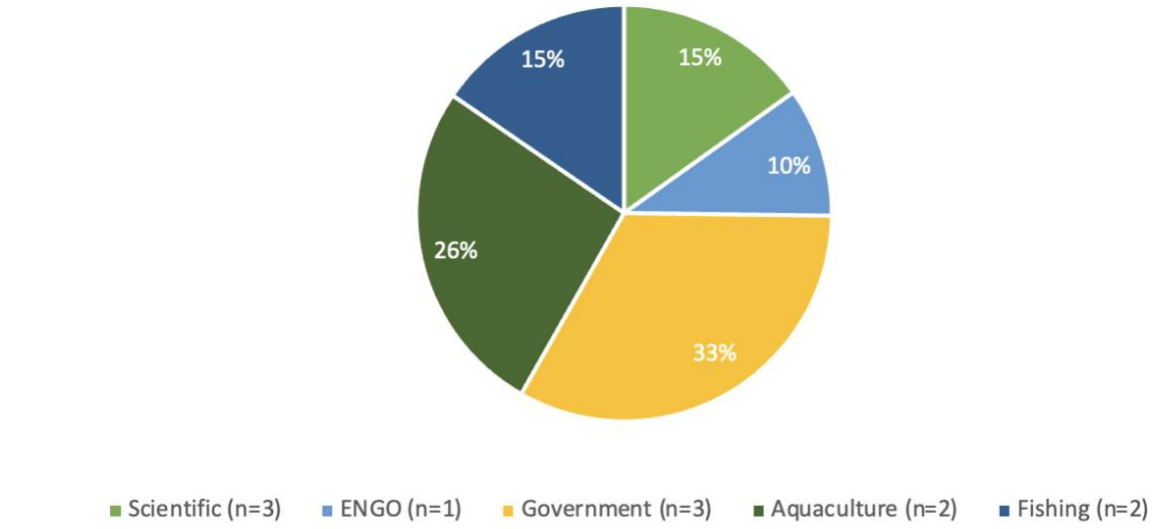

Figure 12: Percent coded references by sector.

The Government sector had the longest average interview time (Table 1) which may have influenced the overall proportion of total recorded references for each sector (Fig 12). The low percentage of codes from the ENGO sector reflect that one interviewee opted out of being recorded and their interview could not be transcribed and coded (Fig 12).

Code Analysis

Eleven of 12 interviews were coded using the predefined coding structure (Appendix C2). One interviewee declined to be recorded (sector = ENGO) resulting in a sample size of n = 1 for the ENGO sector. Trends and thematic analysis results were confirmed through extensive notes of the unrecorded interview.

The top 20 codes represent 55% of all coded references (745 of 1353). “Role and stance”, the most frequently used individual code, indicates references to stakeholders’ position or role in aquaculture (Table 2). It was most frequently coded in conjunction with “authority” (6.3%), “negative impacts” (5.5 %), and “agency judgment” (5.5 %) (Table A13). “Public Perception” and “VSE” (Ventura Shellfish Enterprise) were all among the top five codes which may reflect the study design. The interview guide asked direct questions about both codes (Appendix C1).

Table 2: The top 20 codes from 11 transcribed interviews showing the total number of times the specific code was referenced in the transcripts (No. of References) and the number of times the code or a subcode was referenced in a transcript (Total Coding References). For example, "Spatial" is directly coded 69 times in the transcripts and appears 99 when counting any subcodes like "Fisheries."

Codes	No. of References	Total Coding References (Top Level & Child)
Codes\Relationshipsand stance	71	71
Codes\Spatial	69	99
Codes\Communication	54	54
Codes\Public Perceptions	54	54
Codes\Other Aquaculture	50	50
Codes\Negative Impacts	42	55
Codes\Relationships	40	40
Codes\Relationships-stakeholder	40	40
Codes\Positive Impactsor Community well-being	36	38
Codes\Relationshipsjudgement	36	36
Codes\Feasibility	29	29
Codes\Positive Impactssource	29	29
Codes\Data and informationvalidity	27	27
Codes\Relationships-agency	27	27
Codes\Positive Impacts	24	24
Codes\Location	23	23
Codes\Negative Impacts	23	23
Codes\Data and information	22	22
Codes\Regulator	22	22
Codes\Relationships	22	22

Table 3: Percent of coded references of the top 20 codes used in analysis. Values represent the proportional use of the code among all sectors (rows sum to 100%). For example, 49.3% of "Role and Stance" coded references were from interviews with "Government" officials.

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Role and Stance	5.63%	25.35%	49.3%	16.9%	2.82%	100%
Spatial	20.29%	8.7%	34.78%	14.49%	21.74%	100%
Public Perceptions	21.82%	9.09%	41.82%	18.18%	9.09%	100%
Communication	22.64%	7.55%	37.74%	22.64%	9.43%	100%
VSE	22.64%	9.43%	15.09%	39.62%	13.21%	100%
Competition	15.56%	15.56%	8.89%	40%	20%	100%
Authority	0%	12.5%	50%	35%	2.5%	100%
Inter-stakeholder	25%	5%	22.5%	32.5%	15%	100%
Agency Judgement	18.92%	10.81%	29.73%	37.84%	2.7%	100%
Economic or Co...unity well-being	8.33%	13.89%	16.67%	30.56%	30.56%	100%
Monetary	10.34%	3.45%	17.24%	51.72%	17.24%	100%
Food Source	10.34%	6.9%	31.03%	34.48%	17.24%	100%
Data Validity	3.7%	0%	44.44%	51.85%	0%	100%
Inter-agency	3.7%	3.7%	59.26%	33.33%	0%	100%
Environmental	16.67%	16.67%	8.33%	45.83%	12.5%	100%
Location	8.7%	8.7%	47.83%	17.39%	17.39%	100%
Size	8.7%	0%	47.83%	43.48%	0%	100%
Uncertainty	13.64%	22.73%	27.27%	18.18%	18.18%	100%
CCC	14.29%	4.76%	23.81%	57.14%	0%	100%
Leverage	4.76%	33.33%	38.1%	23.81%	0%	100%
Total	**13.96%**	**11.28%**	**32.89%**	**30.74%**	**11.14%**	100%

Impacts from Aquaculture

Negative impacts from aquaculture accounted for 15.2% of the total coded references (n = 1353). Spatial impacts and indirect and direct economic competition are primary concerns identified through coding references (Table 3). "Spatial" and spatial subcodes were the most frequently used code family in the analysis accounting for 7.3% of all coded references (Table 2). Concerns over spatial resources were primarily about siting location and conflict with trawl grounds (Table 5).

Indirect and direct economic impacts ("competition", "economic") were also frequently cited concerns. Combined, the two codes were the most frequently referenced codes by both the aquaculture and fishing sectors. Marine mammal entanglement ("Entanglement") and water quality were among the least referenced negative impacts constituting only 5.82% of all negative impact references (Table 4a and 4b).

Table 4a: Percentage of coded references to negative impacts from aquaculture. Value represents the proportional use of the code within each sector (columns sum to 100%). Codes are displayed in descending count order (n = 206).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Spatial	43.75%	31.58%	38.1%	19.23%	37.5%	**33.5%**
Competition	21.88%	36.84%	6.35%	34.62%	22.5%	**21.84%**
Size	6.25%	0%	17.46%	19.23%	0%	**11.17%**
Economic	0%	5.26%	0%	15.38%	17.5%	**7.77%**
Biological effects	15.62%	0%	12.7%	0%	5%	**7.28%**
Marine Debris	9.38%	26.32%	3.17%	0%	2.5%	**5.34%**
Entanglement	0%	0%	12.7%	0%	5%	**4.85%**
Imported	0%	0%	4.76%	11.54%	2.5%	**4.85%**
Disease	3.12%	0%	4.76%	0%	2.5%	**2.43%**
Water Quality	0%	0%	0%	0%	5%	**0.97%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 4b: Percentage of coded references to negative impacts from aquaculture. Value represents the proportional use of the code among each sector (rows sum to 100%). Codes are displayed in descending count order (n = 206).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Spatial	20.29%	8.7%	34.78%	14.49%	21.74%	**100%**
Competition	15.56%	15.56%	8.89%	40%	20%	**100%**
Size	8.7%	0%	47.83%	43.48%	0%	**100%**
Economic	0%	6.25%	0%	50%	43.75%	**100%**
Biological effects	33.33%	0%	53.33%	0%	13.33%	**100%**
Marine Debris	27.27%	45.45%	18.18%	0%	9.09%	**100%**
Entanglement	0%	0%	80%	0%	20%	**100%**
Imported	0%	0%	30%	60%	10%	**100%**
Disease	20%	0%	60%	0%	20%	**100%**
Water Quality	0%	0%	0%	0%	100%	**100%**
Total	**15.53%**	**9.22%**	**30.58%**	**25.24%**	**19.42%**	**100%**

Table 5: Percentage of coded references to "Spatial" codes. Value represents the proportional use of the code within each sector (columns sum to 100%). "Fisheries" was coded if the interviewee referenced spatial conflict with fisheries generally. "Trawl," "Intermittent," and "Salmon" were coded if specifically mentioned. Codes are displayed in descending count order (n = 52).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Location	18.18%	33.33%	68.75%	40%	44.44%	**44.23%**
Trawl	27.27%	0%	18.75%	40%	44.44%	**26.92%**
Fisheries	45.45%	66.67%	12.5%	20%	0%	**25%**
Salmon	9.09%	0%	0%	0%	0%	**1.92%**
Intermittent	0%	0%	0%	0%	11.11%	**1.92%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Positive impacts accounted for 10.7% of the total coded references (n = 1353). The most frequently referenced positive impacts of expanding aquaculture were the "Economic and Community Benefits" which constituted 24% of the total coded positive impacts references (Table 6a and 6b). Positive environmental impacts ("Environmental") included references to habitat creation, ecosystem services, wave attenuation, and the ecological role of kelp.

Table 6a: Percentage of coded references to positive impacts. Value represents the proportional use of the code within each sector (columns sum to 100%). Codes are displayed in descending count order (n = 146).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Economic or Co...unity well-being	15%	45.45%	19.35%	19.64%	39.29%	**24.66%**
Food Source	15%	18.18%	29.03%	17.86%	17.86%	**19.86%**
Environmental	20%	36.36%	6.45%	19.64%	10.71%	**16.44%**
Nutrients and Feed	5%	0%	6.45%	16.07%	0%	**8.22%**
Domestic	0%	0%	16.13%	7.14%	0%	**6.16%**
Carbon Sequestration	10%	0%	3.23%	7.14%	3.57%	**5.48%**
Nursery and Refuge	5%	0%	6.45%	0%	14.29%	**4.79%**
Biological Effects	10%	0%	0%	7.14%	0%	**4.11%**
Size	0%	0%	6.45%	5.36%	0%	**3.42%**
Biofuel	15%	0%	0%	0%	3.57%	**2.74%**
Harbor Infastructure	0%	0%	6.45%	0%	3.57%	**2.05%**
Intrinsic value of ocean	5%	0%	0%	0%	7.14%	**2.05%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 6b: Percentage of coded references to positive impacts. Value represents the proportional use of the code among all sectors (rows sum to 100%). Codes are displayed in descending count order (n = 146).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Economic or Co...unity well-being	8.33%	13.89%	16.67%	30.56%	30.56%	**100%**
Food Source	10.34%	6.9%	31.03%	34.48%	17.24%	**100%**
Environmental	16.67%	16.67%	8.33%	45.83%	12.5%	**100%**
Nutrients and Feed	8.33%	0%	16.67%	75%	0%	**100%**
Domestic	0%	0%	55.56%	44.44%	0%	**100%**
Carbon Sequestration	25%	0%	12.5%	50%	12.5%	**100%**
Nursery and Refuge	14.29%	0%	28.57%	0%	57.14%	**100%**
Biological Effects	33.33%	0%	0%	66.67%	0%	**100%**
Size	0%	0%	40%	60%	0%	**100%**
Biofuel	75%	0%	0%	0%	25%	**100%**
Harbor Infastructure	0%	0%	66.67%	0%	33.33%	**100%**
Intrinsic value of ocean	33.33%	0%	0%	0%	66.67%	**100%**
Total	**13.7%**	**7.53%**	**21.23%**	**38.36%**	**19.18%**	**100%**

Other Aquaculture and Other Projects

References to other forms of marine aquaculture constituted 2% of the total coded references (n = 1353). The fishing sector referenced finfish aquaculture more frequently than any other

sectors (Table 7). Only 16% of the coded references to “finfish” or “shellfish” were cross coded with specific projects or permits (e.g., VSE) indicating that perceptions of other aquaculture types are not necessarily tied to specific companies or projects but industry-wide perceptions (Table A14).

Table 7: Percentage of coded references to other types of marine aquaculture. Value represents the proportional use of the code among all sectors (rows sum to 100%). Codes are displayed in descending count order (n = 30).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
shellfish	0%	6.67%	46.67%	33.33%	13.33%	**100%**
finfish	0%	20%	6.67%	6.67%	66.67%	**100%**
Total	**0%**	**13.33%**	**26.67%**	**20%**	**40%**	**100%**

Other marine planning actions constituted 1.9% of the total coded references. Marine protected areas (MPA) were the most frequently coded reference to other projects (Table 8a). Coded references in the fishing sector were equally split between MPAs, AOAs, and wind farming (Table 8a). “Wind farming” was only identified by the government and fishing sectors, stakeholders that are actively engaged in siting new wind farms off the coast of California (Table 8b).

Table 8a: Percentage of coded references to other types of marine spatial planning concerns. Value represents the proportional use of the code within each sector (columns sum to 100%). Codes are displayed in descending count order (n = 26).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
MPA	80%	100%	16.67%	0%	28.57%	**38.46%**
AOA	0%	0%	50%	0%	28.57%	**30.77%**
Wind Farming	0%	0%	33.33%	0%	28.57%	**23.08%**
Oil Rigs	20%	0%	0%	0%	14.29%	**7.69%**
Total	**100%**	**100%**	**100%**	**0%**	**100%**	**100%**

Table 8b: Percentage of coded references to other types of marine planning or cultivation. Value represents the proportional use of the code among all sectors (rows sum to 100%). Codes are displayed in descending count order (n = 26).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
MPA	40%	20%	20%	0%	20%	**100%**
AOA	0%	0%	75%	0%	25%	**100%**
Wind Farming	0%	0%	66.67%	0%	33.33%	**100%**
Oil Rigs	50%	0%	0%	0%	50%	**100%**
Total	**19.23%**	**7.69%**	**46.15%**	**0%**	**26.92%**	**100%**

Expertise and Trust

Codes about aquaculture operators accounted for 2.2% of the total coded references. The government had the greatest proportion of total references to operator characteristics constituting 48.7% of the total coded references followed by ENGOs at 30% (Table 9a). Relational trust among parties constituted 3.9% of the total number of coded references (Table 10). Relational trust references were most commonly cross coded with the "California Coastal Commission" (11.3%) and "Agency Judgment" (7.8%) with a focus on fairness which accounted for 50% and 54.5% of the cross coded reference for each (Table A15). Fairness was also closely tied to addressing marine spatial conflicts. Of the 30 coded references to fairness, 36% were cross coded with spatial concerns (Table A16).

Table 9a: Percentage of coded references to aquaculture applicants. Value represents the proportional use of the code within each sector (columns sum to 100%). Codes are displayed in descending count order (n = 30).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Accountability	100%	66.67%	50%	33.33%	33.33%	**53.33%**
Experience	0%	33.33%	42.86%	33.33%	66.67%	**40%**
Knowledge	0%	0%	7.14%	33.33%	0%	**6.67%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 9b: Percentage of coded references to aquaculture applicants. Value represents the proportional use of the code among all sectors (rows sum to 100%). Codes are displayed in descending count order (n = 30).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Accountability	6.25%	37.5%	43.75%	6.25%	6.25%	**100%**
Experience	0%	25%	50%	8.33%	16.67%	**100%**
Knowledge	0%	0%	50%	50%	0%	**100%**
Total	**3.33%**	**30%**	**46.67%**	**10%**	**10%**	**100%**

Table 10a: Percentage of coded references to relational trust. Values represent the proportional use of the code within each sector (columns sum to 100%). Codes are displayed in descending count order (n = 54).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Trust	100%	0%	69.23%	21.74%	30.77%	**37.04%**
Fairness	0%	66.67%	15.38%	52.17%	30.77%	**37.04%**
Skepticism	0%	33.33%	7.69%	26.09%	23.08%	**20.37%**
Transparency	0%	0%	7.69%	0%	15.38%	**5.56%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 10b: Percentage of coded references to trust and transparency. Values represent the proportion use of the code among all sectors rows sum to 100%). Codes are displayed in descending count order (n = 54).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Trust	10%	0%	45%	25%	20%	**100%**
Fairness	0%	10%	10%	60%	20%	**100%**
Skepticism	0%	9.09%	9.09%	54.55%	27.27%	**100%**
Transparency	0%	0%	33.33%	0%	66.67%	**100%**
Total	**3.7%**	**5.56%**	**24.07%**	**42.59%**	**24.07%**	**100%**

Data and Information

Codes relating to data and information account for 7.5% of the total number of coded references. “Data Validity” and “Uncertainty” were the two most frequently coded references suggesting that the amount and quality of data to support aquaculture expansion in California is insufficient (Table 11a). Interviewees in the government sector talked about data and information the most, contributing 55.45% of all coded references related to data (Table 11b) which reflects their roles as permitting agencies reliant on data heavy processes.

Table 11a: Percentage of coded references to data and information. Value represents the proportional use of the code within each sector (columns sum to 100%). Codes are displayed in descending count order (n = 101).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Data Validity	11.11%	0%	21.43%	66.67%	0%	**26.73%**
Uncertainty	33.33%	83.33%	10.71%	19.05%	44.44%	**21.78%**
Data Gap	22.22%	16.67%	23.21%	14.29%	0%	**18.81%**
Research	11.11%	0%	14.29%	0%	22.22%	**10.89%**
Expertise	11.11%	0%	14.29%	0%	11.11%	**9.9%**
Amount	11.11%	0%	10.71%	0%	11.11%	**7.92%**
Risk Assessment	0%	0%	5.36%	0%	11.11%	**3.96%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 11b: Percentage of coded references to data and information. Value represents the proportional use of the code among all sectors (rows sum to 100%). Codes are displayed in descending count order (n = 101).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Data Validity	3.7%	0%	44.44%	51.85%	0%	**100%**
Uncertainty	13.64%	22.73%	27.27%	18.18%	18.18%	**100%**
Data Gap	10.53%	5.26%	68.42%	15.79%	0%	**100%**
Research	9.09%	0%	72.73%	0%	18.18%	**100%**
Expertise	10%	0%	80%	0%	10%	**100%**
Amount	12.5%	0%	75%	0%	12.5%	**100%**
Risk Assessment	0%	0%	75%	0%	25%	**100%**
Total	**8.91%**	**5.94%**	**55.45%**	**20.79%**	**8.91%**	**100%**

Public Perception

Public perception constituted 3.9% of the total number of coded references in the transcribed interviews of which 41.8% were from the government sector interviews. Public perception was cross tabulated with negative and positive impacts to understand how informed stakeholders thought the public perceived the impacts of aquaculture (Table 12a and 12b). The size and location of aquaculture facilities were the most frequently coded impacts that influenced public perception constituting 50% of total negatives cross coding (Table 11a). The value of aquaculture as a food source and its potential contributions to local economic development were the most frequently referenced positive impacts (69.3%) (Table 12b).

Table 12a: Matrix of coded references to public perception cross coded with negative impacts.

Codes	Crosscoded with 'Public Perceptions'	Percent of Total (n= 14)
9 : Size	4	28.6%
1 : Location	3	21.4%
2 : Biological effects	2	14.3%
10 : Spatial	2	14.3%
3 : Competition	1	7.1%
5 : Disease	1	7.1%
13 : Salmon	1	7.1%
4 : Economic	0	0.0%
6 : Entanglement	0	0.0%
7 : Imported	0	0.0%
8 : Marine Debris	0	0.0%
11 : Fisheries	0	0.0%
12 : Intermittent	0	0.0%
14 : Trawl	0	0.0%
15 : Urchin	0	0.0%
16 : Water Quality	0	0.0%

Table 12b: Matrix of coded references to public perceptions cross coded with positive impacts.

Codes	Crosscoded with 'Public Perceptions'	Percent of Total (n=13)
7 : Food Source	6	46.2%
5 : Economic or Community well-being	3	23.1%
6 : Environmental	2	15.4%
4 : Domestic	1	7.7%
12 : Size	1	7.7%
1 : Biofuel	0	0.0%
2 : Biological Effects	0	0.0%
3 : Carbon Sequestration	0	0.0%
8 : Harbor Infastructure	0	0.0%
9 : Intrinsic value of ocean	0	0.0%
10 : Nursery and Refuge	0	0.0%
11 : Nutrients and Feed	0	0.0%

Themes and Stakeholder Group Analysis

Although seaweed aquaculture is seen as a legitimate industry that could benefit communities in the Santa Barbara Channel, thematic analysis revealed that stakeholders do not yet trust the industry (Fig. 13). Stakeholders rely on existing regulatory structures to ensure applicant accountability in lieu of well-developed trust. However, there regulatory agencies do have the resources or process to monitor offshore aquaculture, relying instead on onerous self-monitoring which relies on operator accountability. Finally, industry expansion is hampered by spatial competition with fisheries.

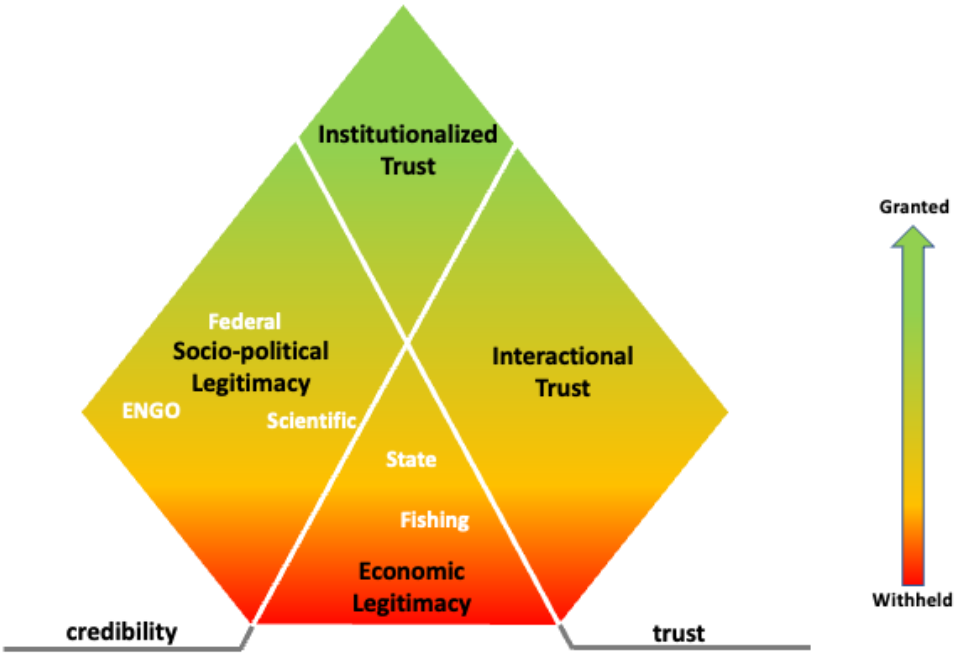

Figure 13: Levels of SLO granted by each stakeholder group for seaweed aquaculture based on information gathered through 12 semi-structured interviews with stakeholders. Color corresponds to the level of risk with red being withheld, yellow as conditional, and green as granted. The state government and fishing sectors have granted high-risk SLO. The industry is perceived as having economic legitimacy by state agencies but lacks socio-political legitimacy or interactional trust which are both essential for attaining a more secure SLO. The industry is perceived as having credibility from the federal government, scientific and ENGO communities which are all "above" the credibility margin; however, there is not yet interactional trust with the industry. Adapted from Boutilier and Thompson (2011).

Commercial and Recreational Fishers

Seaweed aquaculture has not gained economic legitimacy, the first threshold of a social license to operate, from commercial and recreational fishers.[38] The fishing sector is most concerned with direct and indirect economic impacts of expanding aquaculture because of spatial conflicts, particularly in trawl grounds (Table 4; Table 5). Other marine development and governance structures (e.g., MPAs, wind farms) continue to conflict with fisheries which informs the industry's approach to aquaculture expansion (Table 6). Finfish aquaculture operations may be in direct competition with wild-caught fisheries in addition to indirectly through spatial conflicts. Several recent proposals for finfish operations in other parts of California may be shaping the industry's perception of aquaculture as shown by the large proportion of reference to finfish aquaculture (Table 7).

At the same time, the interviewees with the fishing industry recognize the potential economic benefit to local communities and the potential for seaweed aquaculture to serve as nursery or refuge for other species (Table 6).

Environmental Non-Governmental Organizations (ENGOs)

ENGOs rely on a strong regulatory framework in lieu of interactional trust that is necessary to have a social license to operate. Given the potential benefits, ENGOs may be supportive of expanding offshore kelp and shellfish aquaculture. Because there have been very few offshore aquaculture operations to date, the aquaculture industry has not demonstrated interactional trust. ENGOs emphasize the importance of operator accountability (Table 9b) and rely on the substantial regulatory process to ensure applicant accountability.

Scientific and Academic

Although seaweed aquaculture has not gained a social license to operate from the scientific sector, there appears to be general support for expanding pilot projects that could build institutional trust and elevate the industry's sociopolitical legitimacy. More data on this type of project will help increase the scientific understanding of the potential impacts and benefits to the environment and build economic legitimacy. Federal agencies recognize the economic benefits of seaweed aquaculture, while state agencies appear hesitant to support its expansion. A prevalent concern among interviewees was the matter of location (Table 5), size (Table 3; Table 4), and spatial conflict (Table 5; Table 8b). Agencies also place an emphasis on trust (Table 10b), often regarding applicant knowledge, education, and accountability (Table 9b).

Aquaculture

While the aquaculture industry recognizes the economic legitimacy of seaweed aquaculture, plot size is considered a determining factor for both economic and environmental value. (Table 3). Due to associations with past projects like the Ventura Shellfish Enterprise (VSE), regulatory agencies are often seen as a barrier to expanding large scale aquaculture projects. While the interviewees understand the need for a strong regulatory framework, they have concerns with the level of authority given to specific regulatory agencies (i.e., California Coastal Commission (CCC)), particularly in terms of fairness and data validity (Table 3; Table 11b.).

Discussion

Key Findings

Our results indicate that offshore seaweed aquaculture in southern California has a conditional Social License to Operate (SLO) largely because the industry has gained acceptance with federal agencies. There is also widespread support for the industry among the scientific community and the public. The SLO appears conditional because the industry has not been able to build trust or show accountability to ENGOs and state agencies. Two

key state agencies, the California Department of Fish and Wildlife (CDFW) and the California Coastal Commission (CCC), follow a risk-averse approach to decision making. CDFW and the CCC require substantial scientific evidence to prove that there will be minimal or no risk to the environment as the industry grows. This request can be a burden for applicants because it is dependent on monitoring of a project to have already taken place. The lack of projects on the western coast of the U.S. means there are few studies that these agencies feel can be extrapolated to the Santa Barbara Channel. However, the scientific community believes that the existing body of evidence can be applied to the Channel and supports moving forward with small-scale projects.

Seaweed aquaculture has not achieved a SLO from the fishing community, which is withholding their support because of perceived spatial conflicts between aquaculture and a suite of commercial and recreational fisheries. These factors need to be overcome for the full acceptance of kelp aquaculture in Southern California. Nevertheless, there appears to be strong enough support for the seaweed aquaculture industry among a majority of stakeholders and the public for the industry to move forward. Chances of attaining a secure SLO will be substantially increased through execution of pilot projects that build interactional trust with a subset of influential ENGOs and reveal clear benefits to the fishing industry.

In California, stakeholder resistance and permitting processes are frequently cited as hurdles for establishing commercial aquaculture.[11] However, our results indicate there is much less public opposition to seaweed aquaculture than that described in the scientific literature and what Ocean Rainforest has heard from a vocal subsection of stakeholders in public forums held in Santa Barbara and Ventura counties. By contrast, our results indicate that a majority (56.8%) of Santa Barbara County and Ventura County residents support kelp/seaweed aquaculture expansion, while relatively few residents are opposed (8.8%) (Fig. 4B). We also found that terminology is important for gaining support, with a significantly greater proportion of residents in favor of “seaweed aquaculture” and “kelp aquaculture” than of “seaweed farming” and “kelp farming” (Fig. 4A). The significantly smaller proportion of support for “farming” may be due to associations with terrestrial farming or agriculture. Agricultural intensity in Ventura County has increased in the last three decades,[78] which may explain the negative associations with the term in our survey.

Future Research

Our research helped fill information gaps that are vital to understanding the social climate on aquaculture in California, specifically the Santa Barbara Channel. More research is needed to better understand perceptions on expanding projects in Northern California, Oregon, and Washington. Due to the time constraints, this project focused on survey analysis of questions related to support and opposition to kelp aquaculture and on respondent demographics.

Future analyses can be conducted on environmental and economic variables and their relationship to level of support. The 12 interviews conducted provided in-depth information on the various perspectives and industry history surrounding aquaculture in the Santa Barbara Channel. However, a larger sample of interviews from experts in the five stakeholder groups and latent stakeholders not interviewed would increase the diversity of perspectives gathered.

Semi-structured interviews were primarily limited by time, chosen discussion topics, and human interpretation error. Researchers were considerate of participants' time and provided an option for a 30-60-minute interview (the average length was 52 minutes). Proportional coding results may have been influenced by this time frame, as all topics could not be covered in each interview and some interviewees had longer discussions. Results were also influenced by the topics chosen for interview conversations. For instance, a common question asked pertained to Ventura Shellfish Enterprise, likely increasing coding frequency for that category. Lastly, the thematic analysis process is qualitative, creating room for biases and misinterpretations.

Surveys are a more efficient way to gather data from a larger sample size than through focus groups and interviews. Survey analyses may result in biases due to the accessibility of distribution and participation,[79] as well as the number of demographic variables used for weighting responses. Though we found a significant association between terminology and support, additional research is needed to investigate this trend. Our study did not weigh responses based on each county's population proportions. Santa Barbara and Ventura counties have different levels of agricultural activity and history with aquaculture, which may influence respondent's perceptions of the terms "aquaculture" and "farming." Although there was a strong trend, we found no significant association between monthly ocean visitation and support for aquaculture (Fig. A7). Future surveys or studies should collect larger sample sizes to increase the number of respondents in each category of analysis and separate analysis by county to determine if there is a significant trend.

Additionally, surveys may not provide a representative sample of the target population. A larger sample size increases the confidence in the analytical results and decreases the margin of error. In this project, the number of acquired survey responses was limited by time, Qualtrics pools, budget, and data availability. Our survey sample size decreased because of response weighting. Due to the available demographic data, we had to filter out responses from individuals who identified as non-binary or did not include their gender and/or date of birth. As the modern-day spectrum of identity becomes more complex, scientific fields must adjust data-collection methodologies and analyses to include non-binary and gender responses.

Indigenous perspectives were also not included in the study due to the short time frame and our team not being able to foster a long-term relationship with local tribal communities. Due to the history of extractive research with Indigenous knowledge, we did not feel comfortable soliciting interviews where we would not be able to follow through with sustained and meaningful collaborations. Our client will continue to work toward outreach and incorporating Indigenous perspectives.

Major Implications

The seaweed aquaculture industry is flourishing in other countries, providing economic opportunities and ecosystem services. The U.S. is already behind other countries in seafood and seaweed production.[4] In May 2020, President Trump signed Executive Order 13921 directing NOAA to accelerate aquaculture development in the Exclusive Economic Zone (EEZ) to address the seafood trade deficit with other countries.[54]

Stakeholder experts and the Santa Barbara and Ventura communities are largely supportive of seaweed aquaculture in the Santa Barbara Channel. Safe and sustainable aquaculture is dependent on ensuring that environmental standards are met through permitting processes. Subsequently, the length of the permitting process and complicated permitting requirements are significant barriers to aquaculture development in California (Table A17). However, the CCC released the Coastal Development Permit Application Guidance in December 2020 to increase clarity in the aquaculture and restoration permitting process.[80]

Consistent with national studies of public perceptions of aquaculture, a large proportion of Santa Barbara and Ventura County residents are neutral (neither opposed to nor in support of) expanding seaweed aquaculture.[48] Our results imply that the more familiar with aquaculture or more positive the perception, the greater the probability a resident will support aquaculture expansion. This contradicts previous findings from New Zealand, which indicate that individuals who had less engagement with aquaculture had more positive perceptions than those who were less engaged.[42] This may be the result of a robust marine finfish industry in New Zealand, which is generally associated with more environmental impacts and receives lower SLO scores.[42]

Previous research has shown the disproportionate role that active individuals and communities play in creating or withholding a social license to operate.[81] Our findings indicate that much of the population are “neutral” or “don’t know.” These individuals are more likely to develop positive perceptions than individuals with an established unsupportive opinion. At the same time, over 75% of respondents indicated they are “interested in learning more about the issues surrounding seaweed aquaculture” which highlights the importance of an engaging communication strategy that provides information to those who do not currently

have a concrete understanding or solidified opinion on seaweed aquaculture expansion in California (Fig. A11).

Interviews revealed that environmental and economic conditions were the most prevalent concerns among stakeholder groups. However, in the public survey, ~25% of respondents answered "neutral" and over 10% selected "don't know" to many of environmental and economic statements, indicating that many residents are uncertain about aquaculture impacts on the environment and economy (Fig. A2). Consequently, it is essential that a communication strategy provides clear and accessible information to stakeholders so that they will be more likely to form positive perceptions of seaweed aquaculture and support future projects.

Recommendations

Our recommendations provide Ocean Rainforest with ways to engage with the community and communicate their mission to expand commercial seaweed aquaculture in the United States. Film will be the primary method of communication based on survey respondents' educational preference (Fig. A12).

Communication Strategy and Deliverables

Results from our survey and semi-structured interviews will inform a targeted communication strategy for Ocean Rainforest. Because terminology influences public opinion, the terms "seaweed aquaculture" and "kelp aquaculture" will be used throughout all communication deliverables, while "seaweed farming" and "kelp farming" will be avoided. Although the term "regenerative aquaculture" was viewed most positively by respondents, this term will only be used in communication if the project is true to the definition of regenerative. Using the term regenerative can cause distrust if the aquaculture project is not providing a net positive impact. On the other hand, the term "seaweed mariculture" was viewed least positively, most likely because it is not typically used on the west coast of the United States. Communication deliverables will be created as part of a Bren Communication Capstone and will be finalized and disseminated in Spring 2022.

Educational Film

A short documentary film outlining Ocean Rainforest's goals will be created and shown at stakeholder meetings. The film will feature a variety of stakeholders to build a diverse narrative. This includes interviews with scientists, who are seen as a trusted source of information by a majority (74.6% agree) of survey respondents (Fig. A13). The film's main objective is to increase positive perceptions of seaweed aquaculture among stakeholders (Fig. 5). This will be accomplished by highlighting the benefits of seaweed aquaculture and openly discussing sources of hesitation and risk within the industry. Spatial resources and economic

competition will be prioritized to address the predominant stakeholder concerns identified during interviews (Table 3; Table 4). The film will also highlight economic and community benefits, both recognized by all stakeholder groups.

Social Media

Mini "episodes" that utilize footage from the documentary will be posted to Ocean Rainforest's social media. These episodes aim to build support among individuals with no strong opinion on seaweed aquaculture expansion by providing a basic understanding of the industry and increasing familiarity (Fig. 9). Support for seaweed aquaculture was cross analyzed with demographics, and education was the only significant trend found (Fig. 11). However, a greater proportion of individuals that identify as "neither opposed to nor supportive of" seaweed aquaculture lives in Ventura County (Fig. A5). Ocean Rainforest can target people in this area by taking advantage of features like tagging, location, and hashtags.

Infographic/Pamphlet

An infographic will be created to highlight the project's key results and emphasize the environmental and economic value of our oceans. This infographic will help inform groups less likely or unable to watch the films. Interested individuals will be guided to Ocean Rainforest's website and social media channels for more information.

Other Recommendations

- Build coalitions with local and state organizations to obtain a broad diversity of perspectives and interests. Coalitions will support accurate information dissemination to interested communities around Santa Barbara and Ventura counties. Ocean Rainforest should work with these coalitions to help increase awareness and understanding of the trade-offs between the potential benefits and risks of seaweed aquaculture. This can help to empower individuals who are interested in seeking out aquaculture opportunities. In addition, local fishing groups and individual fishers should be a part of the conversation as they may benefit from shared resources concerning offshore kelp aquaculture. Collaborative engagement can be the basis for establishing communication channels with stakeholders, which is a key predictor of SLO.[42]
- Avoid proposing a project that would overlap with trawling grounds. A major concern from government agencies, ENGOs, and the fishing community is the possibility of having a spatial conflict with halibut trawling grounds.
- Target key stakeholders in future expansion projects, such as the fishing and aquaculture communities, academic communities, indigenous communities native to the area, local, state, and federal agencies, and non-governmental organizations. These communities, agencies, and organizations should be targeted if Ocean Rainforest moves to a new location.

Conclusion

Interest in and support for offshore aquaculture is clearly growing in California. Seaweed aquaculture will advance more rapidly with greater access to information about economic and environmental benefits and spatial conflicts for individuals entering the industry and the interested public. Moving forward with aquaculture development is predicated on the rectification of the public's misconceptions and increasing the monitoring and data collection of the growing blue economy to ensure sustainability and gain social acceptance. Our survey indicated support for expanding kelp aquaculture in the Santa Barbara Channel. Unlike other regions where the finfish aquaculture industry is more mature, stakeholder concerns in the Santa Barbara Channel focus on the potential economic impacts to fishing communities and the lack of trust in or accountability of the industry.

Ocean Rainforest has an opportunity to be a leader in coalition building and disseminating educational information to build support in the region. The communication strategy we proposed for Ocean Rainforest utilizes the term “seaweed aquaculture” and focuses on educating the public on both the potential benefits and risks of aquaculture projects. Further research into stakeholder perceptions and sources of positive and negative perceptions would be useful for refining a communication strategy. As more aquaculture projects are introduced and potentially implemented in California, residents will become more exposed to and informed about all forms of marine aquaculture, including seaweed aquaculture. Each project will provide opportunities to learn more about stakeholders’ interests, identify effective communication strategies, and determine how to best engage with the public. Our project can be used as a framework for researching future public perception and stakeholder positioning for future aquaculture siting.

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Appendix

Appendix A - Additional Results

Tables

Table A1: Survey sample and target population demographic proportions grouped by age and sex and assigned weighted values (N = 1,292,505; n = 350). Demographic data for Santa Barbara and Ventura counties were obtained from US Census Bureau's ACS 2019 county estimates.[72]

Age Group	Sex	Population Proportion	Sample Proportion	Sample Count (n)	Assigned Weight
15-19	female	0.00993	0.01133	4	0.87606
15-19	male	0.00973	0.00283	1	3.43575
20-24	female	0.05098	0.07649	27	0.66658
20-24	male	0.05393	0.02833	10	1.90356
25-29	female	0.04547	0.09915	35	0.45864
25-29	male	0.04725	0.04816	17	0.98107
30-34	female	0.03976	0.08782	31	0.45279
30-34	male	0.04469	0.05949	21	0.75115
35-39	female	0.03849	0.03683	13	1.04516
35-39	male	0.04012	0.03116	11	1.28750
40-44	female	0.03993	0.03683	13	1.08428

40-44	male	0.04058	0.03966	14	1.02332
45-49	female	0.04013	0.02550	9	1.57397
45-49	male	0.03917	0.03399	12	1.15237
50-54	female	0.04058	0.04816	17	0.84261
50-54	male	0.04094	0.03116	11	1.31393
55-59	female	0.04341	0.03683	13	1.17872
55-59	male	0.04316	0.03399	12	1.26954
60-64	female	0.04181	0.05382	19	0.77687
60-64	male	0.03817	0.02266	8	1.68439
65-69	female	0.03427	0.01983	7	1.72843
65-69	male	0.02903	0.01983	7	1.46384
70-74	female	0.02933	0.02550	9	1.15030
70-74	male	0.02753	0.04249	15	0.64792
75-79	female	0.01923	0.00567	2	3.39425
75-79	male	0.01645	0.01983	7	0.82934
80+	female	0.03371	0.00850	3	3.96691
80+	male	0.02220	0.01416	5	1.56733

Table A2: Mean rank scores for eight terms used to refer to aquaculture, with 1 indicating the respondent viewed the term most positively and 8 indicating least positive view. Terms were presented in a random order, for each respondent, to reduce order-effect biases. Ranked aquaculture topics by order of interest in learning more. Note mean rank scores were not calculated using weighted responses.

Term	Mean Rank Score (from 1 to 8)	Standard Deviation of Mean Rank Score
regenerative aquaculture	3.95	2.57
ocean aquaculture	4.22	2.24
kelp farming	4.35	2.30
seaweed aquaculture	4.40	2.02
kelp aquaculture	4.43	2.07
seaweed farming	4.44	2.19
ocean farming	4.63	2.56
seaweed mariculture	5.59	1.96

Table A3: Ordered logistic regression results conducted on "support for kelp/seaweed aquaculture" as a function of "perception of seaweed aquaculture." Intercepts refer to level of support: strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2).

```
polr(formula = factor(aquaculture) ~ perception, data = perception_support_aquaculture,
    Hess = TRUE)

Coefficients:
           Value Std. Error t value
perception 2.079     0.2477   8.392

Intercepts:
      Value   Std. Error t value
-2|-1 -2.6139  0.4588    -5.6976
-1|0  -1.5999  0.3311    -4.8321
0|1    2.3829  0.3325     7.1670
1|2    4.3819  0.4469     9.8049

Residual Deviance: 329.9669
AIC: 339.9669
```

Table A4: Predicted probabilities table of "support for kelp/seaweed aquaculture" based on a resident's "perception of seaweed aquaculture." Probabilities were converted from log odds ratios from the ordered logistic regression model. Levels of support: strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2). Perceptions of seaweed aquaculture: very negative (1), negative (2), neutral (3), positive (4), and very positive (5). Note "don't know/unsure" response categories were removed from perception question analyses. *See Fig. 8A for heatmap visualization

Predicted Probabilities of Support for Aquaculture as a Function of Perception

	1	2	3	4	5
-2	0.82	0.37	0.07	0.01	0.00
-1	0.10	0.25	0.10	0.02	0.00
0	0.07	0.37	0.75	0.55	0.14
1	0.00	0.01	0.07	0.33	0.41
2	0.00	0.00	0.01	0.09	0.44

Table A5: Ordered logistic regression results conducted on "support for kelp/seaweed farming" as a function of "perception of seaweed aquaculture." Intercepts refer to level of support: strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2).

```
polr(formula = factor(farming) ~ perception, data = perception_support_farming,
    Hess = TRUE)

Coefficients:
           Value Std. Error t value
perception 1.577     0.2279   6.918

Intercepts:
      Value   Std. Error t value
-2|-1 -3.5642  0.7255    -4.9125
-1|0  -1.4927  0.3330    -4.4829
0|1    1.2430  0.2851     4.3604
1|2    3.1789  0.3687     8.6222

Residual Deviance: 367.1028
AIC: 377.1028
```

Table A6: Predicted probabilities of "support for kelp/seaweed farming" based on a resident's "perception of seaweed aquaculture." Probabilities were converted from log odds ratios from the ordered logistic regression model. Levels of support: strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2). Perceptions of seaweed aquaculture: very negative (1), negative (2), neutral (3), positive (4), and very positive (5). Note "don't know/unsure" response categories were removed from perception question analyses. *See Fig. 8B for heatmap visualization

Predicted Probabilities of Support for Farming as a Function of Perception

	1	2	3	4	5
-2	0.40	0.12	0.03	0.01	0.00
-1	0.44	0.40	0.16	0.04	0.01
0	0.15	0.42	0.59	0.37	0.12
1	0.01	0.05	0.18	0.41	0.38
2	0.00	0.01	0.04	0.17	0.49

Table A7: Ordered logistic regression results conducted on "support for kelp/seaweed aquaculture" as a function of "familiarity with aquaculture." Intercepts refer to level of support: strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2).

```
polr(formula = factor(aquaculture) ~ familiarity, data = familiarity_support_aquaculture,
    Hess = TRUE)

Coefficients:
            Value Std. Error t value
familiarity 0.8711     0.1948   4.472

Intercepts:
      Value   Std. Error t value
-2|-1 -1.2302  0.5678    -2.1665
-1|0  -0.4298  0.4959    -0.8666
0|1    2.4428  0.5095     4.7945
1|2    3.9168  0.5718     6.8503

Residual Deviance: 422.0631
AIC: 432.0631
```

Table A8: Predicted probabilities of "support for kelp/seaweed aquaculture" based on a resident's level of "familiarity with aquaculture." Probabilities were converted from log odds ratios from the ordered logistic regression model. Levels of support: strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2). Levels of familiarity: "never heard of it" (1), "heard of it, but don't know details" (2), "basic understanding" (3), and "very familiar (4). *See Fig. 9A for heatmap visualization

Predicted Probabilities of Support for Aquaculture as a Function of Familiarity

	1	2	3	4
-2	0.11	0.05	0.02	0.01
-1	0.11	0.05	0.02	0.01
0	0.61	0.57	0.41	0.24
1	0.13	0.23	0.33	0.35
2	0.05	0.10	0.21	0.39

Table A9: Ordered logistic regression results conducted on "support for kelp/seaweed farming" as a function of "familiarity with aquaculture." Intercepts refer to level of support: strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2).

```
polr(formula = factor(farming) ~ familiarity, data = familiarity_support_farming,
    Hess = TRUE)

Coefficients:
            Value Std. Error t value
familiarity 1.028     0.1825   5.634

Intercepts:
      Value   Std. Error t value
-2|-1 -2.4030  0.7886    -3.0471
-1|0  -0.3976  0.4409    -0.9018
0|1    2.0986  0.4415     4.7531
1|2    3.8652  0.5158     7.4939

Residual Deviance: 421.5535
AIC: 431.5535
```

Table A10: Predicted probabilities of "support for kelp/seaweed farming" based on a resident's level of "familiarity with aquaculture." Probabilities were converted from log odds ratios from the ordered logistic regression model. Levels of support: strongly opposed (-2), somewhat opposed (-1), neither (0), somewhat supportive (1), and strongly supportive (2). Levels of familiarity: "never heard of it" (1), "heard of it, but don't know details" (2), "basic understanding" (3), and "very familiar (4). *See Fig. 9B for heatmap visualization

Predicted Probabilities of Support for Farming as a Function of Familiarity

	1	2	3	4
-2	0.03	0.01	0.00	0.00
-1	0.16	0.07	0.03	0.01
0	0.55	0.43	0.24	0.11
1	0.20	0.35	0.41	0.32
2	0.06	0.14	0.31	0.56

Table A11: Ordered logistic regression results conducted on "perception of seaweed aquaculture" as a function of "familiarity with aquaculture." Intercepts refer to perceptions of seaweed aquaculture: very negative (-2), negative (-1), neutral (0), positive (1), and very positive (2). Note "don't know/unsure" response categories were removed from perception question analyses.

```
polr(formula = factor(perception) ~ familiarity, data = OLR_perception_familiarity,
    Hess = TRUE)

Coefficients:
             Value Std. Error t value
familiarity 0.8144     0.1344   6.062

Intercepts:
      Value   Std. Error t value
-2|-1 -3.3011  0.7645    -4.3178
-1|0  -1.3949  0.4027    -3.4634
0|1    0.7596  0.3295     2.3052
1|2    2.9382  0.3721     7.8965

Residual Deviance: 754.5987
AIC: 764.5987
```

Table A12: Predicted probabilities of "perception of seaweed aquaculture" based on a resident's level of "familiarity with aquaculture." Probabilities were converted from log odds ratios from the ordered logistic regression model. Perceptions of seaweed aquaculture: very negative (-2), negative (-1), neutral (0), positive (1), and very positive (2). Note "don't know/unsure" response categories were removed from perception question analyses. Levels of familiarity: "never heard of it" (1), "heard of it, but don't know details" (2), "basic understanding" (3), and "very familiar (4). *See Fig. 10 for heatmap visualization

Predicted Probabilities of Perception as a Function of Familiarity

	1	2	3	4
-2	0.02	0.01	0.00	0.00
-1	0.08	0.04	0.02	0.01
0	0.39	0.25	0.14	0.07
1	0.41	0.49	0.46	0.34
2	0.11	0.21	0.38	0.58

Table A13: Matrix of cross coded "Role and Stance" with all other codes.

Codes	Crosscoded with 'Role and stance'	Percent of Total (n=126)
77 : Authority	8	6.3%
23 : Negative Impacts	7	5.6%
76 : Agency Judgement	7	5.6%
58 : Economic or Community well-being	5	4.0%
68 : Regulator	5	4.0%
79 : Inter-stakeholder	5	4.0%
82 : Leverage	5	4.0%
85 : Spatial	5	4.0%
2 : Accountability	4	3.2%
5 : Communication	4	3.2%
25 : Competition	4	3.2%
30 : Marine Debris	4	3.2%
60 : Environmental	4	3.2%
67 : Public Perceptions	4	3.2%
16 : Monetary	3	2.4%
19 : Time	3	2.4%
6 : Data and information	2	1.6%
8 : Data Gap	2	1.6%
22 : Location	2	1.6%
26 : Economic	2	1.6%
31 : Size	2	1.6%
33 : Fisheries	2	1.6%
44 : SB Mariculture	2	1.6%
46 : VSE	2	1.6%
69 : CADFW	2	1.6%
73 : NOAA	2	1.6%
80 : Intra-agency	2	1.6%
81 : Leadership	2	1.6%
86 : Fisheries	2	1.6%
97 : Trust	2	1.6%
99 : Skepticism	2	1.6%
3 : Experience	1	0.8%
9 : Data Validity	1	0.8%
13 : Uncertainty	1	0.8%
14 : Feasibility	1	0.8%
15 : Marketability	1	0.8%
36 : Trawl	1	0.8%
41 : Catalina	1	0.8%
42 : finfish	1	0.8%
45 : shellfish	1	0.8%
49 : MPA	1	0.8%
50 : Oil Rigs	1	0.8%
52 : Wind Farming	1	0.8%
55 : Biological Effects	1	0.8%
61 : Food Source	1	0.8%
70 : CCC	1	0.8%
74 : USACE	1	0.8%
89 : Trawl	1	0.8%
93 : Fishermen	1	0.8%
98 : Fairness	1	0.8%

Table A14: “Finfish” and “Shellfish” coded references cross-referenced with codes for five aquaculture projects in Southern California. Of the 23 coded references to shellfish or finfish aquaculture, only 5 (21.7%) are cross coded with specific projects.

Codes	Finfish	Shellfish
1 : Avalon	0	0
2 : Catalina	0	0
3 : Pacific Aquafarms	3	0
4 : SB Mariculture	0	0
5 : VSE	0	2
6 : finfish (total)	11	0
7 : shellfish (total)	0	12

Table A15: Matrix of cross coded relational trust codes with all codes (n = 141).

Codes	Trust	Fairness	Skepticism	Transparency	Total	Percent of Total (n=141)
70 : CCC	4	8	4	0	16	11.3%
76 : Agency Judgement	3	6	2	0	11	7.8%
77 : Authority	2	7	1	0	10	7.1%
92 : Fairness	5	NA	4	0	9	6.4%
9 : Data Validity	3	5	0	0	8	5.7%
25 : Competition	2	4	1	1	8	5.7%
5 : Communication	4	0	0	2	6	4.3%
36 : Trawl	1	4	1	0	6	4.3%
91 : Trust	NA	5	1	0	6	4.3%
46 : VSE	1	3	1	0	5	3.5%
83 : Role and Stance	2	1	2	0	5	3.5%
93 : Skepticism	1	4	NA	0	5	3.5%
78 : Inter-agency	2	2	0	0	4	2.8%
8 : Data Gap	2	1	0	0	3	2.1%
13 : Uncertainty	0	1	2	0	3	2.1%
42 : finfish	0	0	3	0	3	2.1%
43 : Pacific Aquafarms	0	0	3	0	3	2.1%
58 : Economic or Community well-being	0	2	1	0	3	2.1%
79 : Inter-stakeholder	2	0	1	0	3	2.1%
22 : Location	0	1	1	0	2	1.4%
26 : Economic	1	1	0	0	2	1.4%
32 : Spatial	0	2	0	0	2	1.4%
2 : Accountability	1	0	0	0	1	0.7%
3 : Experience	1	0	0	0	1	0.7%
16 : Monetary	1	0	0	0	1	0.7%
21 : Quality of wild caught	1	0	0	0	1	0.7%
23 : Negative Impacts	0	0	1	0	1	0.7%
31 : Size	1	0	0	0	1	0.7%
33 : Fisheries	0	1	0	0	1	0.7%
41 : Catalina	0	0	1	0	1	0.7%
45 : shellfish	1	0	0	0	1	0.7%
49 : MPA	1	0	0	0	1	0.7%
55 : Biological Effects	0	1	0	0	1	0.7%
60 : Environmental	0	1	0	0	1	0.7%
61 : Food Source	0	0	1	0	1	0.7%
67 : Public Perceptions	0	0	1	0	1	0.7%
69 : CADFW	1	0	0	0	1	0.7%
73 : NOAA	0	1	0	0	1	0.7%
80 : Intra-agency	1	0	0	0	1	0.7%
87 : Fishermen	1	0	0	0	1	0.7%

Table A16: Matrix of relational trust and spatial codes (n = 15).

Codes	Trust	Fairness	Skepticism	Transparency	Total	Percent of Total (n=15)
1 : Spatial	1	6	1	0	8	53.3%
2 : Trawl	1	4	1	0	6	40.0%
3 : Fisheries	0	1	0	0	1	6.7%

Table A17: Percentage of coded references to obstructions to offshore kelp aquaculture development. Values represent the proportional use of the code within each sector (columns sum to 100%). Codes are displayed in descending count order (n = 67).

Codes	Sector = Scientific (n=3)	Sector = ENGO (n=1)	Sector = Government (n=3)	Sector = Aquaculture (n=2)	Sector = Fishing (n=2)	Total (n=11)
Monetary	23.08%	50%	45.45%	57.69%	33.33%	**43.28%**
Regulatory	30.77%	0%	9.09%	0%	60%	**20.9%**
Time	30.77%	50%	36.36%	11.54%	6.67%	**19.4%**
Marketability	0%	0%	9.09%	30.77%	0%	**13.43%**
Technical	15.38%	0%	0%	0%	0%	**2.99%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Figures

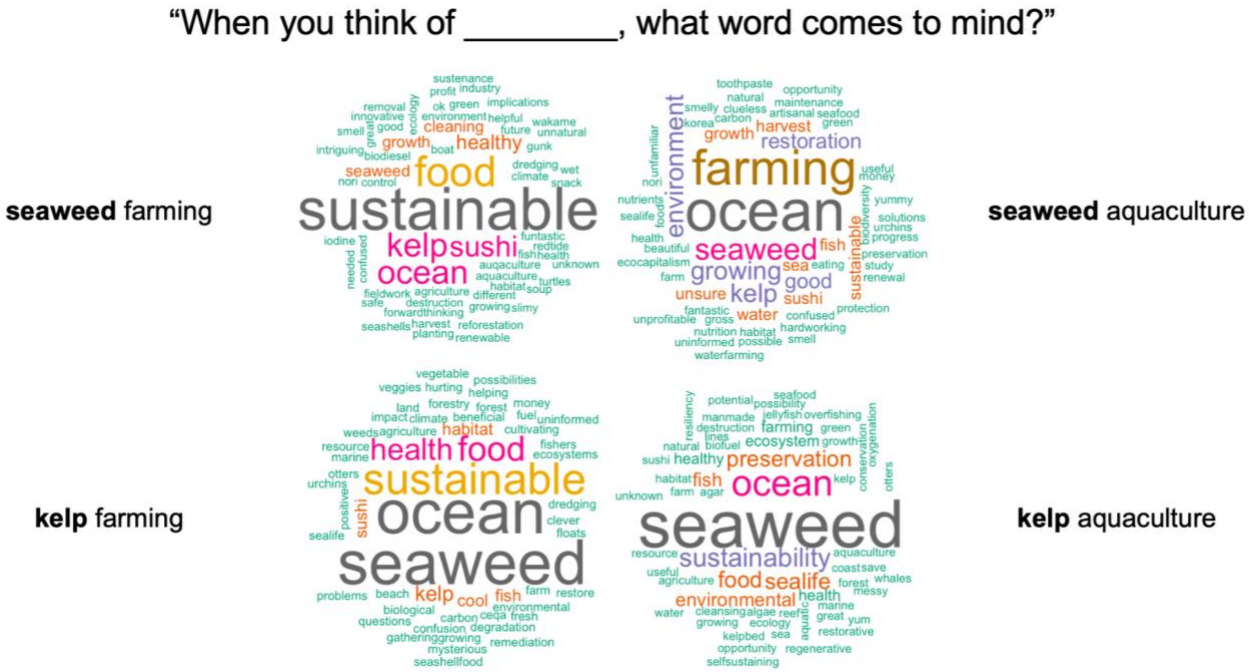


Figure A1: Word clouds of the responses given when respondents were asked what word came to mind when thinking about one of the four randomly assigned terms: kelp farming, kelp aquaculture, seaweed farming, and seaweed aquaculture. Each word cluster displays the frequency in which words were mentioned for each term, as the larger the font size of the word, the greater the frequency in which it was listed.

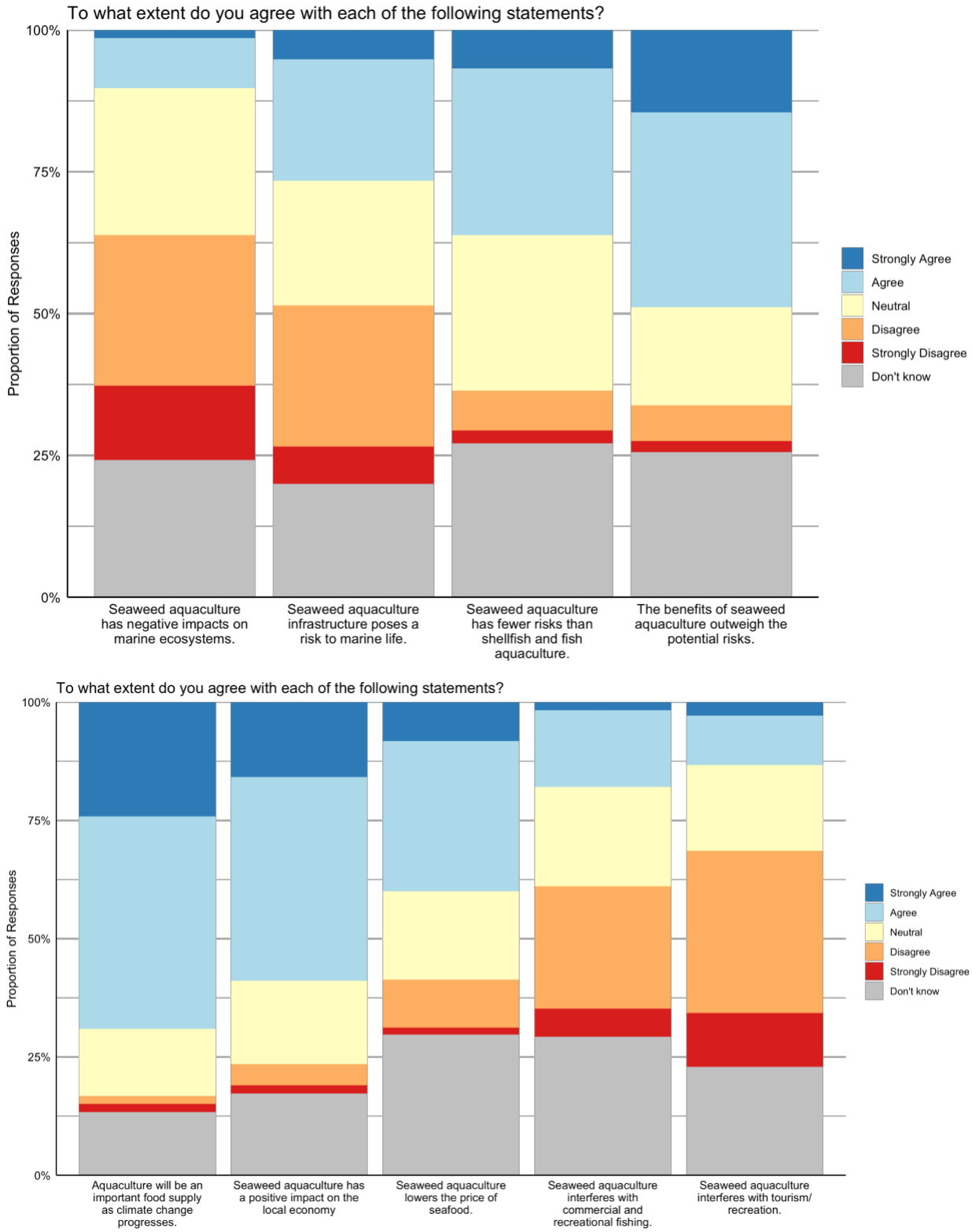


Figure A2: (A) Environmental and **(B)** economic impact statements regarding seaweed aquaculture.

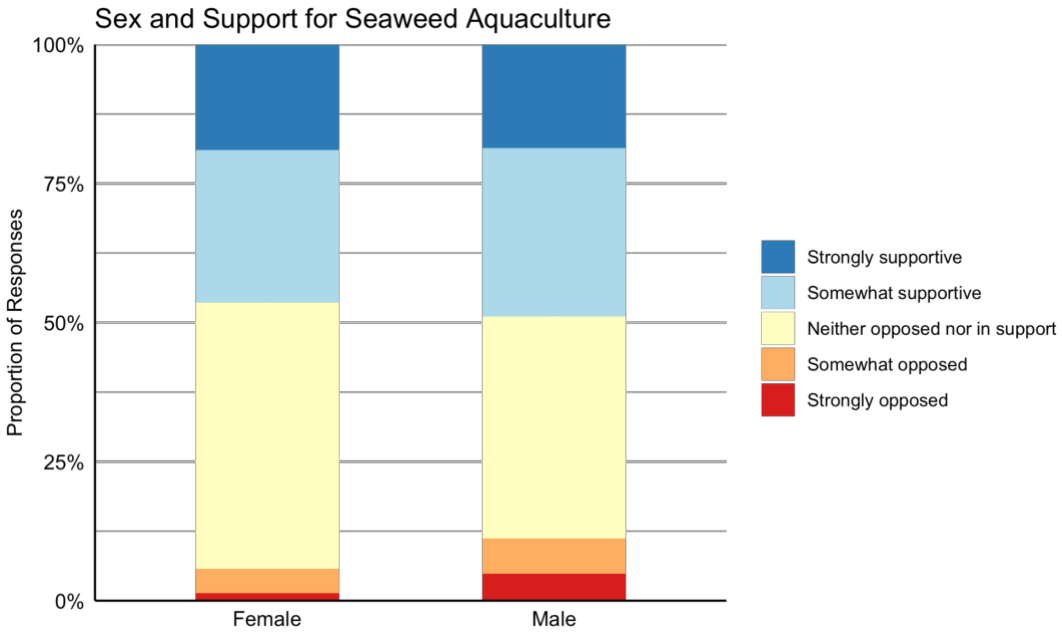


Figure A3: Relationship between sex of respondent and support for expanding seaweed aquaculture. A Chi-square test did not reveal a significant association between sex and support for seaweed aquaculture expansion (X^2 (4, n = 350) = 5.88, p = .21).

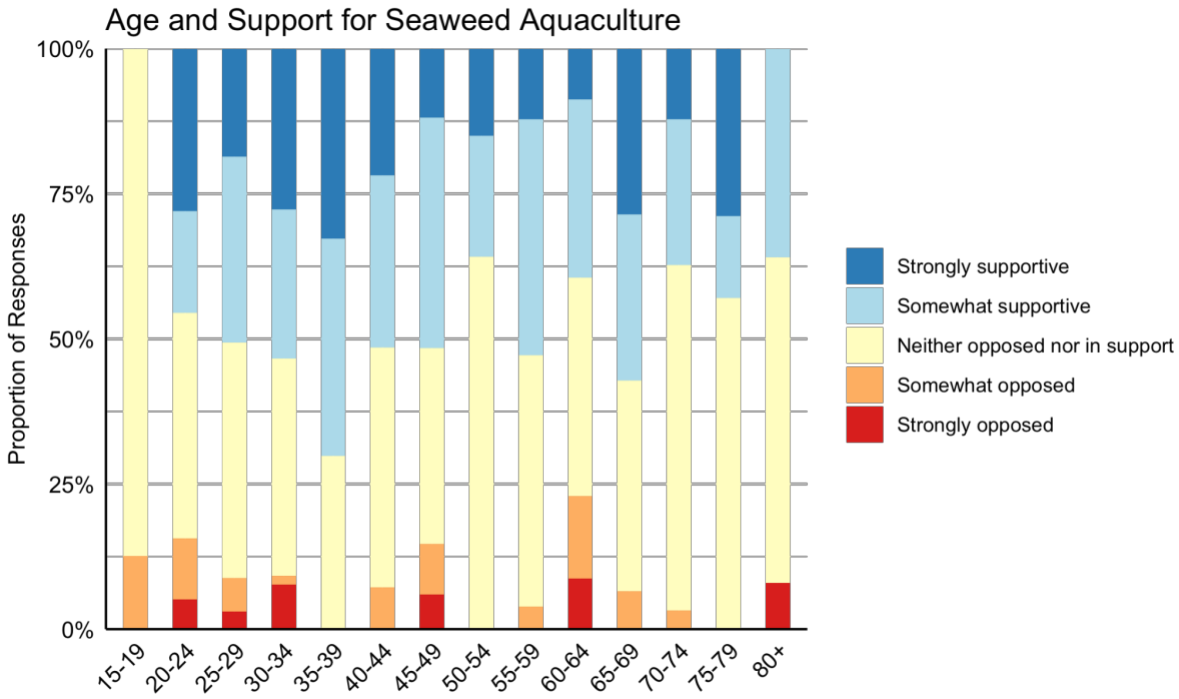


Figure A4: Relationship between age of respondent and support for expanding seaweed aquaculture. Data did not meet the assumptions of a chi-squared test, so a Fisher's exact test for count data was run with simulated p-value (based on 2000 replicates). No significant association was found between age and support for seaweed aquaculture (p = .09).

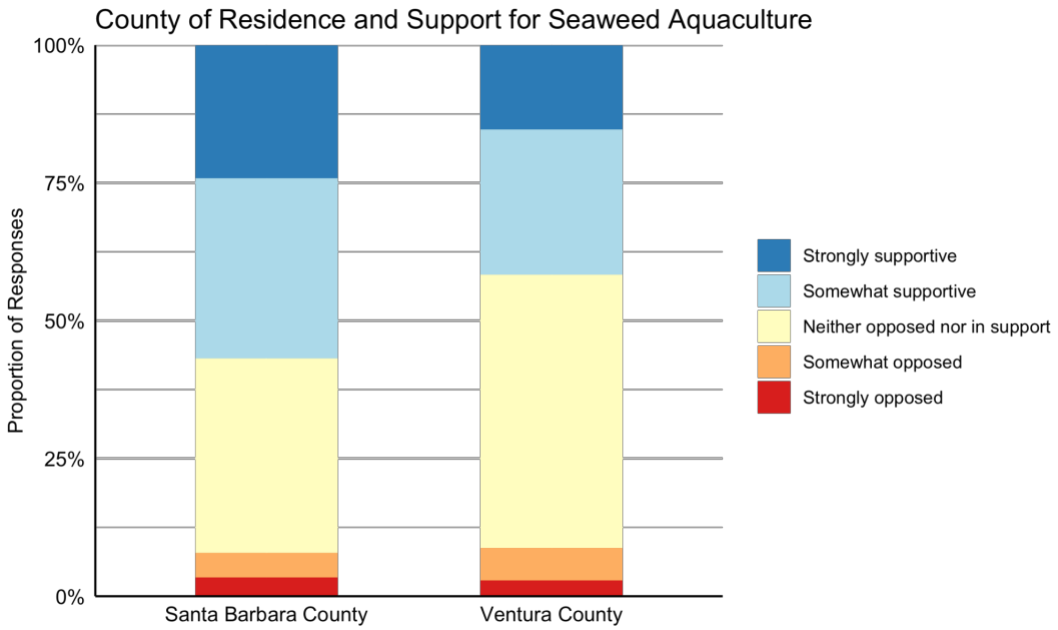


Figure A5: Relationship between county of residence and support for expanding seaweed aquaculture. A Chi-square test revealed no significant association between county of residence and support for seaweed aquaculture expansion (X^2 (4, n = 350) = 9.03, p = .06).

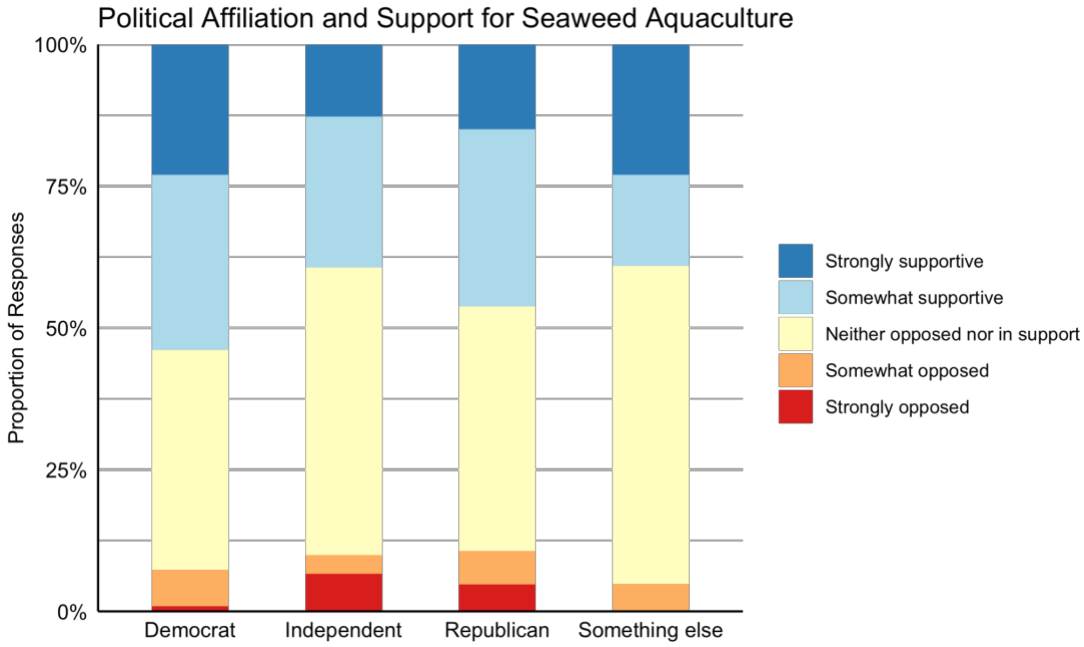


Figure A6: Relationship between political affiliation and support for expanding seaweed aquaculture. Support response categories had to be grouped to meet assumptions of a Chi-square test ("supportive," "neither," and "opposed"). Chi-square test did not reveal a significant association between political affiliation and support for seaweed aquaculture expansion (X2 (6, n = 348) = 7.66, p = .26).

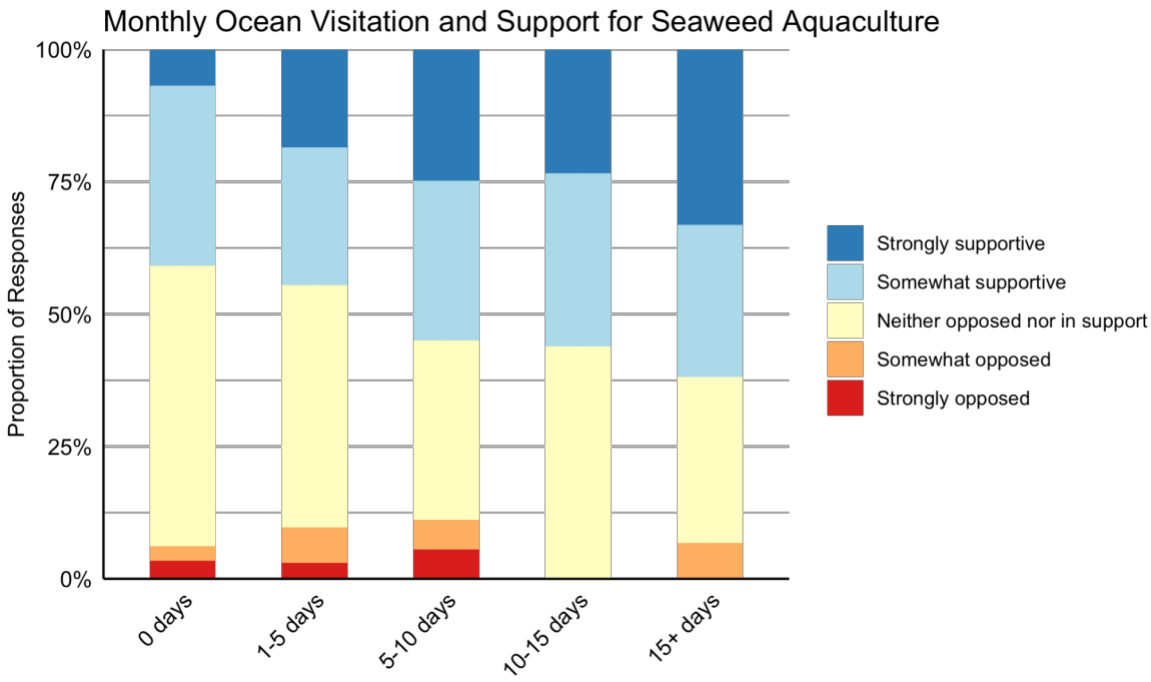


Figure A7: Relationship between number of days per month spent near or at the ocean and support for expanding seaweed aquaculture. Support response categories had to be grouped to meet assumptions of a Chi-square test ("supportive," "neither," and "opposed"). Chi-square test did not reveal a significant association between monthly ocean visitation and support for seaweed aquaculture expansion (X^2 (8, n = 350) = 10.53, p = .23).

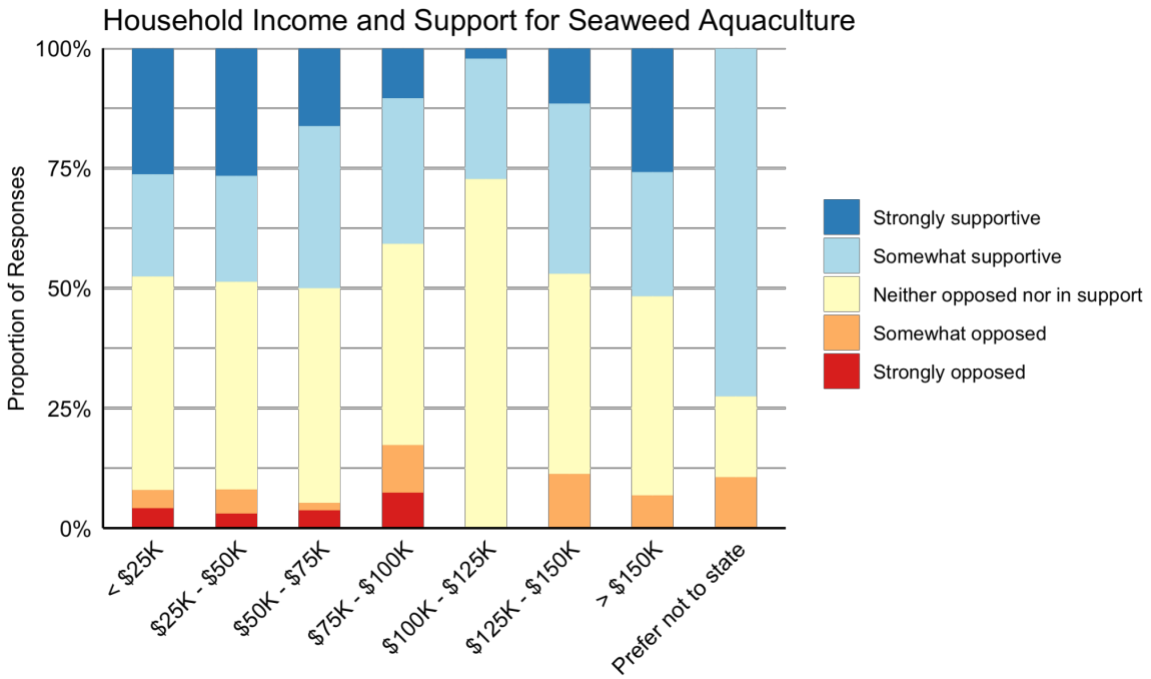


Figure A8: Relationship between household income and support for expanding seaweed aquaculture.

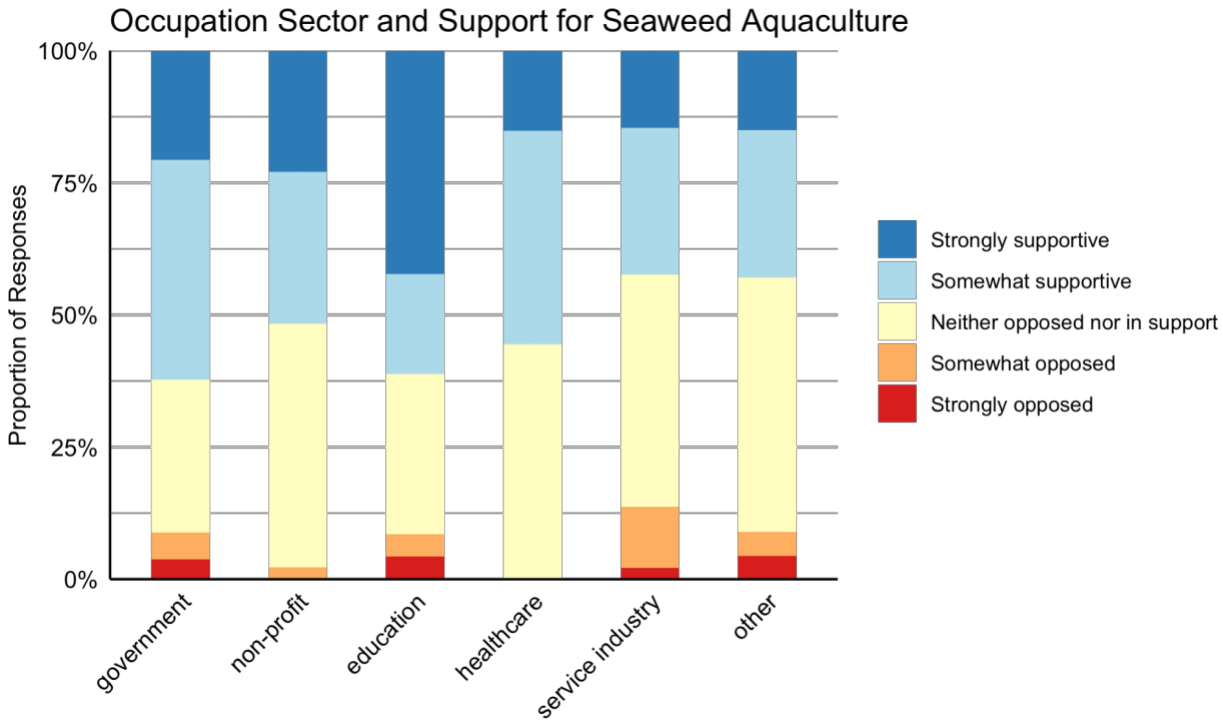


Figure A9: Relationship between occupational sector and support for expanding seaweed aquaculture.

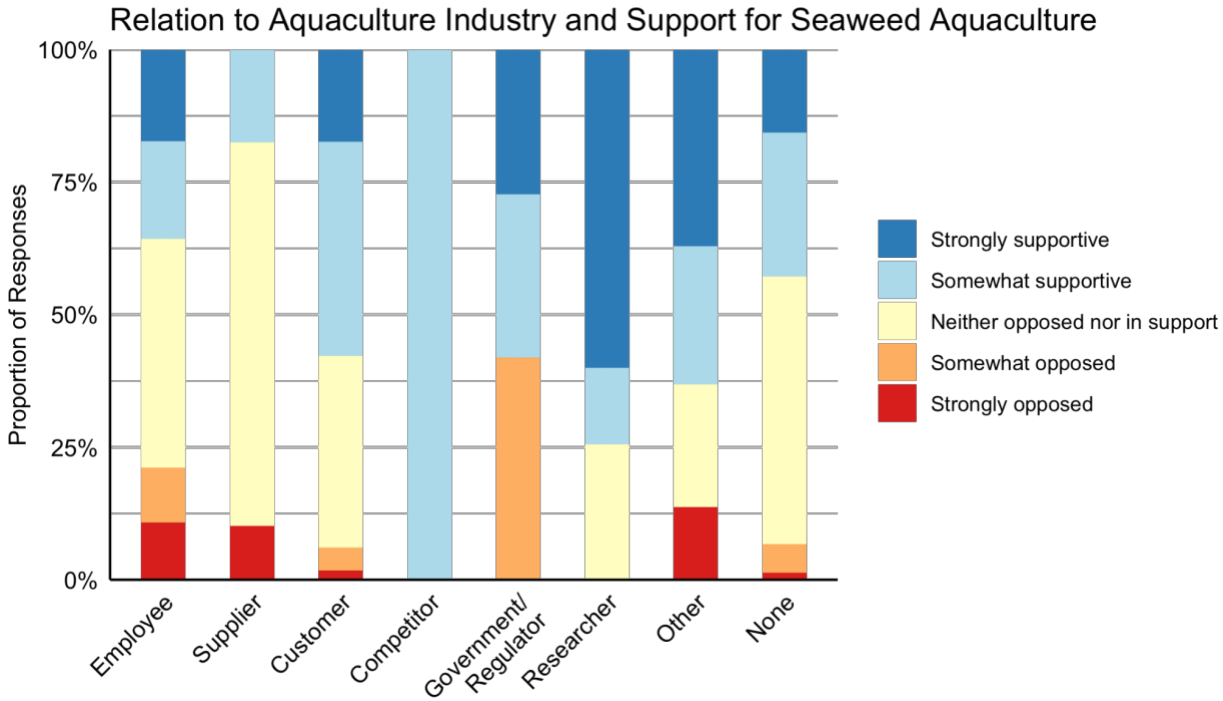


Figure A10: Relationship between relation to aquaculture industry and support for expanding seaweed aquaculture.

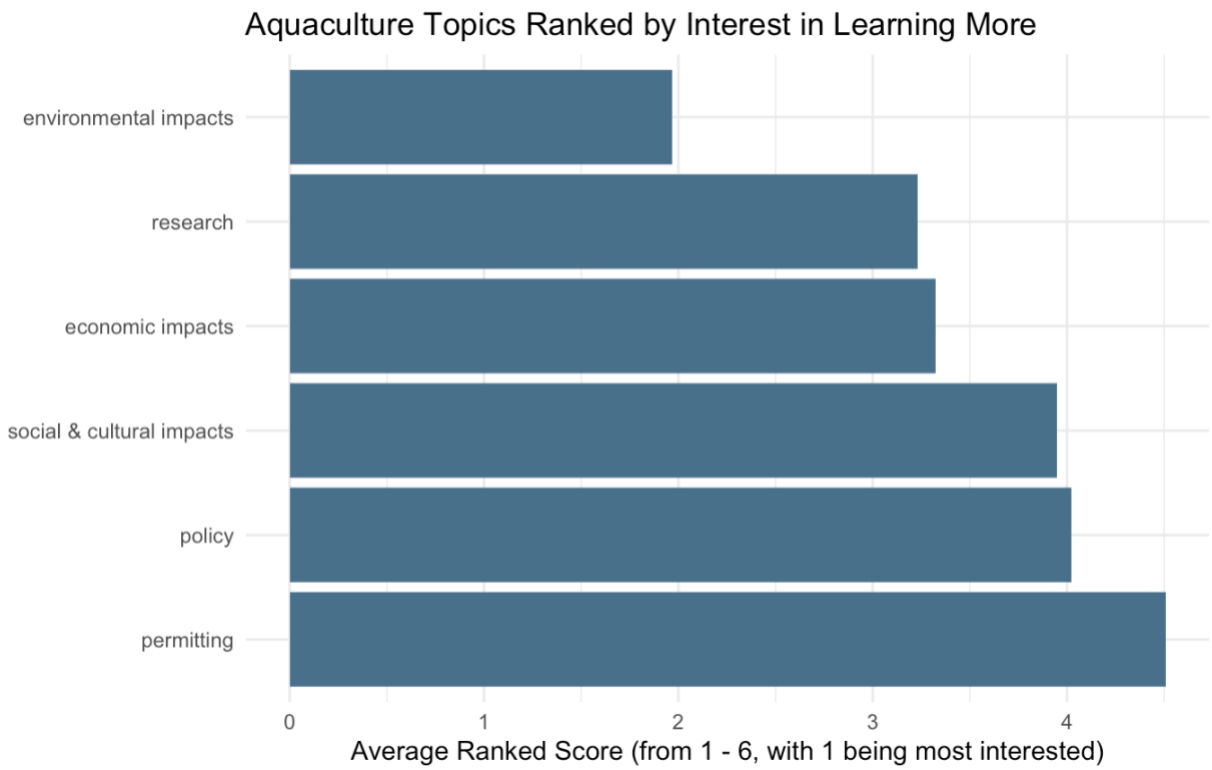


Figure A11: Ranked aquaculture topics by order of interest in learning more. Respondents ranked topics from 1 to 6, with 1 being "most interested." Topic of greatest interest is listed at the top (with the lowest mean score). Note mean rank scores were not calculated using weighted responses.

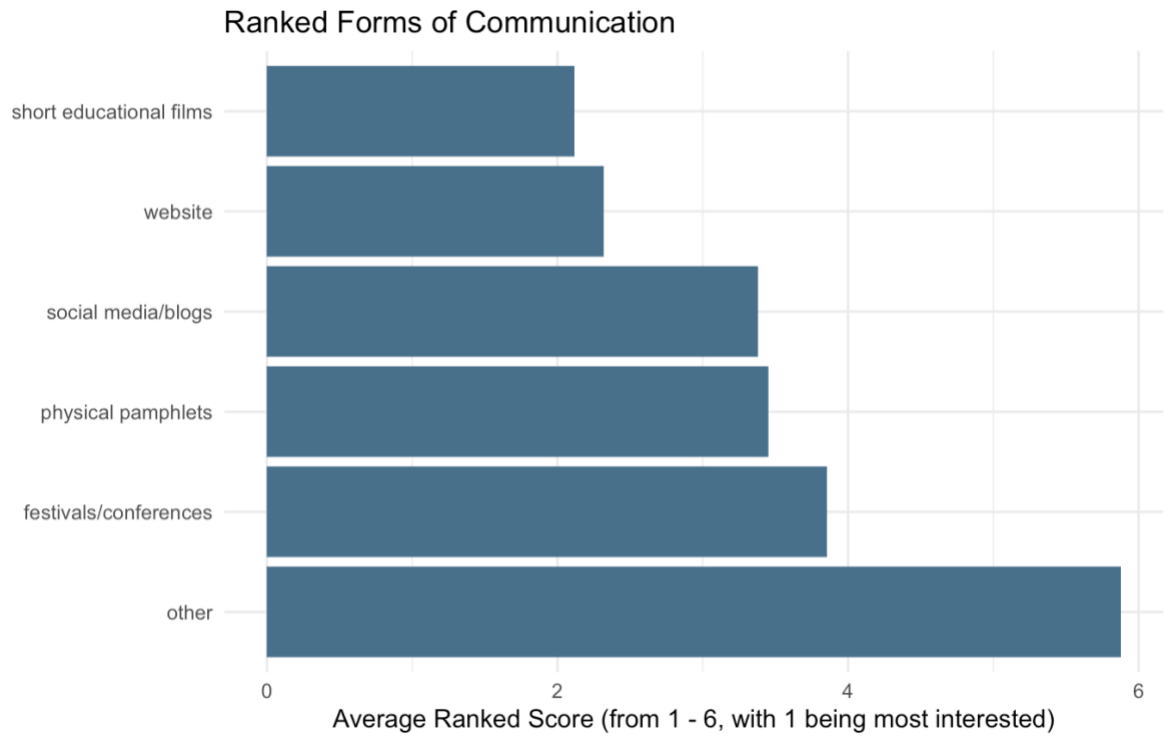


Figure A12: Ranked forms of communication by order of preferred method of learning more about aquaculture. Respondents ranked topics from 1 to 6, with 1 being "most interested." Topic of greatest interest is listed at the top (with the lowest mean score). Note mean rank scores were not calculated using weighted responses.

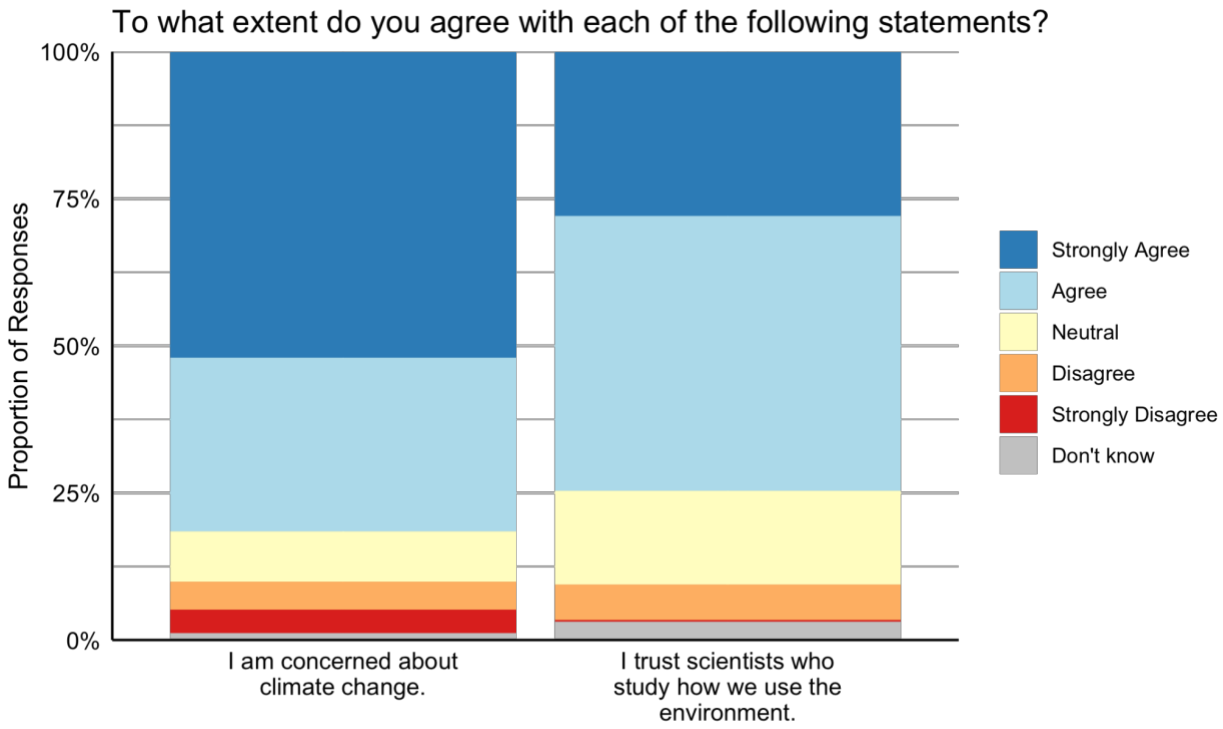
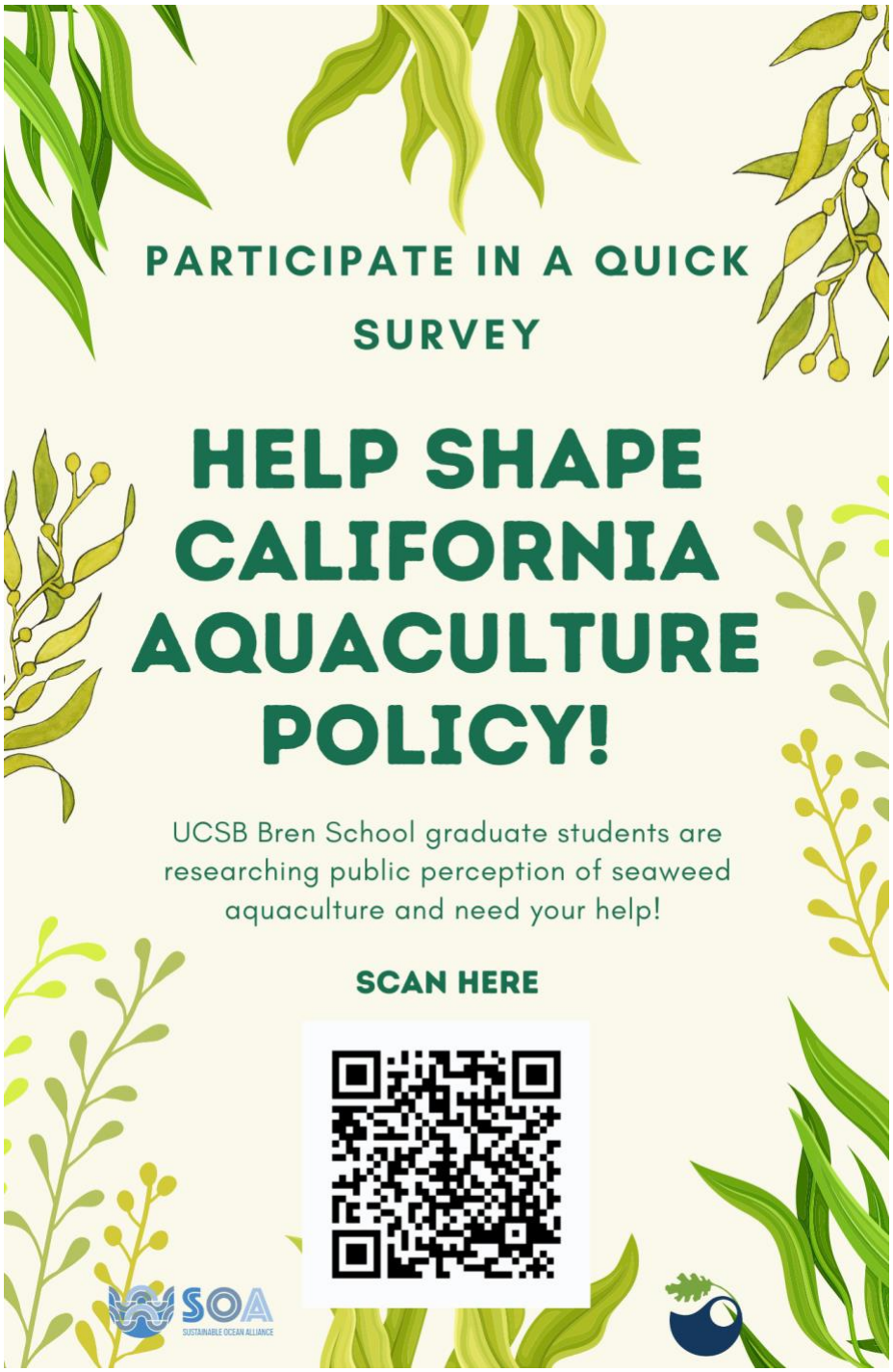


Figure A13: Respondent level of agreeance to statements regarding science.

Appendix B - Survey

B1- Survey Distribution

flier and social media post




PARTICIPATE IN A QUICK SURVEY
HELP SHAPE CALIFORNIA AQUACULTURE POLICY!
LINK IN BIO
SOA
SUSTAINABLE OCEAN ALLIANCE

B2- Survey Matrix

Start of Block: Consent Form

Q1 **Anonymous Online Consent Statement**

Purpose:
You are being asked to participate in a research study being conducted by the Bren School of Environmental Science and Management at the University of California, Santa Barbara. Participation is voluntary. The purpose of this research study is to gain a better understanding of the perception of aquaculture in California.

Procedures:
If you choose to be in the study, you will complete an online survey. The survey will take about 5 to 10 minutes to complete.

You can skip questions that you do not wish to answer or stop the survey at any time. The survey is anonymous and no one will be able to link your responses back to you. Please do not include your name or other information that could be used to identify you in the survey responses.

Contact Information:
If you have questions about the research, you can contact us at gp-kelpwanted@bren.ucsb.edu.

If you have any questions regarding your rights as a research subject, please contact the Human Subjects Committee at (805) 893-3807 or hsc@research.ucsb.edu. Or write to the University of California, Human Subjects Committee, Office of Research, Santa Barbara, CA 93106-2050

Please indicate that you have read the above and consent to participate in this study.

O I have read the above consent statement and AGREE to participate in this study (1)

O I have read the above consent statement and DECLINE participation in this study (2)

Skip To: End of Block If Anonymous Online Consent StatementPurpose: You are being asked to participate in a research stud... = I have read the above consent statement and DECLINE participation in this study

End of Block: Consent Form

Start of Block: Screening Question

Q2 Do you live in Santa Barbara or Ventura County?

O Yes (1)

O No (2)

Skip To: End of Block If Do you live in Santa Barbara or Ventura County? = No

Q46 Are you 18 years or older?

O Yes (1)

O No (2)

Skip To: End of Block If Are you 18 years or older? = No

End of Block: Screening Question

Start of Block: Seaweed farming

Q3 Are you supportive of or opposed to expanding **seaweed farming** off the California coast?

O Strongly opposed (1)

O Somewhat opposed (2)

O Neither opposed nor in support (3)

O Somewhat supportive (4)

O Strongly supportive (5)

Q4 When you think of **seaweed farming**, what word comes to mind?

_____

End of Block: Seaweed farming

Start of Block: Kelp farming

Q5 Are you supportive of or opposed to expanding **kelp farming** off the California coast?

- O Strongly opposed (1)
- O Somewhat opposed (2)
- O Neither opposed nor in support (3)
- O Somewhat supportive (4)
- O Strongly supportive (5)

Q6 When you think of **kelp farming**, what word comes to mind?

_____

End of Block: Kelp farming

Start of Block: Seaweed aquaculture

Q7 Are you supportive of or opposed to expanding **seaweed aquaculture** off the California coast?

- O Strongly opposed (1)
- O Somewhat opposed (2)
- O Neither opposed nor in support (3)
- O Somewhat supportive (4)
- O Strongly supportive (5)

Q8 When you think of **seaweed aquaculture**, what word comes to mind?

_____

End of Block: Seaweed aquaculture

Start of Block: Kelp aquaculture

Q9 Are you supportive of or opposed to expanding **kelp aquaculture** off the California coast?

- O Strongly opposed (1)
- O Somewhat opposed (2)
- O Neither opposed nor in support (3)
- O Somewhat supportive (4)
- O Strongly supportive (5)

Q10 When you think of **kelp aquaculture**, what word comes to mind?

_____

End of Block: Kelp aquaculture

Start of Block: Introduction

Q11 How familiar are you with aquaculture?

- O Very familiar (1)
- O Basic understanding (2)
- O Heard of it, but don't know details (3)
- O Never heard of it (4)

Page Break

Q12 Aquaculture is referred to by many names. Please rank the following names based on which you view most positively, with 1 being most positive. (drag text up or down to change ranking position)

_____ Ocean farming (1)
_____ Seaweed farming (2)
_____ Kelp farming (3)
_____ Ocean aquaculture (4)
_____ Seaweed aquaculture (5)
_____ Kelp aquaculture (6)
_____ Regenerative aquaculture (7)
_____ Seaweed mariculture (8)

End of Block: Introduction

Start of Block: Knowledge

Q13 The previous questions asked about your familiarity with aquaculture. We are now going to provide a definition of aquaculture for you to consider before answering the next question.

<u>Aquaculture</u> is the breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in all types of water environments.

Q14 In general, how positive or negative is your view of **aquaculture**?

- O Very Negative (1)
- O Negative (2)
- O Neutral (3)
- O Positive (4)
- O Very Positive (5)
- O Unsure/Not familiar (6)

Page Break

Q15 **<u>Seaweed aquaculture</u> refers to the breeding, rearing, and harvesting of seaweed in the ocean, such as kelp.**

Q16 In general, how positive or negative is your view of **seaweed aquaculture**?

- O Very Negative (1)
- O Negative (2)
- O Neutral (3)
- O Positive (4)
- O Very Positive (5)
- O Unsure/Not familiar (6)

End of Block: Knowledge

Start of Block: Experience/Exposure Part 1

Q17 Do you spend free time by or in the ocean?

- O Yes (1)
- O No (2)

Display This Question:

If Do you spend free time by or in the ocean? = Yes

Q18 How many days per month do you spend your free time by or in the ocean?

- O 1-5 days (1)
- O 5-10 days (2)
- O 10-15 days (3)
- O 15+ days (4)

End of Block: Experience/Exposure Part 1

Start of Block: Experience/Exposure Part 2

Q19 Note the remaining questions refer to ocean-based aquaculture.

Q20 Have you **heard** of aquaculture farms off the California coast?

- O Yes (1)
- O No (2)
- O Unsure (3)

Q21 Have you **seen** aquaculture farms off the California coast?

- O Yes (1)
- O No (2)
- O Unsure (3)

Display This Question:

If Have you heard of aquaculture farms off the California coast? = Yes

Or Have you seen aquaculture farms off the California coast? = Yes

Q22 Select type(s) of aquaculture that you have heard of or seen off the California coast:

- ☐ Fish (1)
- ☐ Shellfish (2)
- ☐ Seaweed (3)
- ☐ Other (4) _____
- ☐ Don't know type (5)

Page Break

Q23 Do you consume seafood (shellfish, fish, seaweed, etc.)?

O Yes (1)

O No (2)

O Don't know (3)

Display This Question:

If Do you consume seafood (shellfish, fish, seaweed, etc.)? = Yes

Q24 How many times a month do you consume seafood?

O 1-4 (1)

O 4-8 (2)

O 8-12 (3)

O 12+ (4)

Display This Question:

If Do you consume seafood (shellfish, fish, seaweed, etc.)? = Yes

Q25 Do you know the origins of the seafood you purchase or consume (wild caught vs. farmed/aquacultured)?

O Yes (1)

O No (2)

Display This Question:

If Do you consume seafood (shellfish, fish, seaweed, etc.)? = Yes

Q26 Do you have a preference regarding the origins of the seafood you purchase or consume?

- O Wild caught (1)
- O Farmed (2)
- O No preference (3)

End of Block: Experience/Exposure Part 2

Start of Block: Environmental Impacts Part 1

Q27
To what extent do you agree with each of the following statements?

Seaweed aquaculture...

	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Don't know (6)
... has negative impacts on marine ecosystems. (1)	O	O	O	O	O	O
... improves water quality nearby. (4)	O	O	O	O	O	O

... infrastructure poses a risk to marine life. (6)	O	O	O	O	O	O
... infrastructure increases plastic pollution in the ocean. (5)	O	O	O	O	O	O
... has positive impacts on marine ecosystems. (7)	O	O	O	O	O	O
... causes bad smells nearby. (3)	O	O	O	O	O	O
... is visually appealing. (2)	O	O	O	O	O	O

End of Block: Environmental Impacts Part 1

Start of Block: Environmental Impacts Part 2

Page Break

Q28 To what extent do you agree with each of the following statements?

	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Don't know (6)
Aquaculture has the same environmental problems as land-based agriculture. (1)	O	O	O	O	O	O

Farmed seafood is a better for the environment than harvesting wild seafood. (4)	O	O	O	O	O	O
Please select "agree." (6)	O	O	O	O	O	O
Aquaculture will be an important food supply as climate change progresses. (5)	O	O	O	O	O	O

Skip To: End of Block If To what extent do you agree with each of the following statements? != Please select "agree." [Agree]

End of Block: Environmental Impacts Part 2

Start of Block: Economic Impacts

Q29 To what extent do you agree with each of the following statements?

Seaweed aquaculture...

	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Don't know (6)
... has a positive impact on the local economy. (1)	O	O	O	O	O	O
... lowers the price of seafood. (2)	O	O	O	O	O	O

... provides good jobs to those living on the coast. (3)	O	O	O	O	O	O
... interferes with commercial and recreational fishing. (4)	O	O	O	O	O	O
... interferes with tourism/recreation. (5)	O	O	O	O	O	O

End of Block: Economic Impacts

Start of Block: General Benefits vs. Risks

Q30 To what extent do you agree with each of the following statements?

	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Don't know (6)
All types of aquaculture concern me. (3)	O	O	O	O	O	O
Seaweed aquaculture has fewer risks than shellfish and fish aquaculture. (2)	O	O	O	O	O	O
The benefits of seaweed aquaculture outweigh the potential risks. (1)	O	O	O	O	O	O

End of Block: General Benefits vs. Risks

Start of Block: Perceptions/Trust

Q31 To what extent do you agree with each of the following statements?

	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Don't know (6)
I trust existing permitting, monitoring and enforcement processes for ocean aquaculture. (1)	O	O	O	O	O	O
I trust scientists who study how we use the environment. (13)	O	O	O	O	O	O
I am concerned about climate change. (8)	O	O	O	O	O	O
I am concerned that seaweed cultivation sites will be too close to shore. (2)	O	O	O	O	O	O
I am concerned that seaweed cultivation sites will be too big. (5)	O	O	O	O	O	O
I am concerned that seaweed cultivation sites will have an impact on coastal recreation. (3)	O	O	O	O	O	O

I am concerned that seaweed cultivation sites will damage the aesthetic beauty of the California coast. (4)	O	O	O	O	O	O
I am concerned about the environmental impacts of the seaweed aquaculture industry. (14)	O	O	O	O	O	O

End of Block: Perceptions/Trust

Start of Block: Desire to increase aquaculture knowledge/engagement

Q32
To what extent do you agree with each of the following statements?

	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Don't know (6)
I am interested in learning more about the issues surrounding seaweed aquaculture. (1)	O	O	O	O	O	O
I would support policies that fund research on seaweed aquaculture. (4)	O	O	O	O	O	O

I would support policies that expand seaweed aquaculture operations in California. (3)	O	O	O	O	O	O

Page Break

Q33 Rank the aquaculture related topics in order of your interest in learning more, with 1 being most interested. (drag text up or down to change ranking position)

_____ Policy (1)
_____ Permitting (2)
_____ Environmental impacts (3)
_____ Economic impacts (4)
_____ Social & cultural impacts (5)
_____ Research (6)

Page Break

Q34 Rank the forms of communication by which you would prefer to learn about aquaculture, with 1 being most preferred. (drag text up or down to change ranking position)

_____ Short educational film (1)
_____ Physical pamphlets (2)
_____ Festivals/conferences (3)
_____ Website (4)
_____ Social Media/Blogs (5)
_____ Other (6)

End of Block: Desire to increase aquaculture knowledge/engagement

Start of Block: Demographics

Q35 Please tell us a bit about yourself

Q36 In what year were you born?

_____

Q37 Please select your gender identity:

O Man (1)

O Woman (2)

O Non-binary (3)

O Not listed (4) _____

O Prefer not to state (5)

Q38 Please indicate your race/ethnicity: (select all that apply)

- [ ] American Indian (1)
- [ ] Asian American or Asian (2)
- [ ] Black or African American (3)
- [ ] Hispanic or Latinx (4)
- [ ] Middle Eastern or North African (5)
- [ ] Pacific Islander (6)
- [ ] White/Caucasian (7)
- [ ] Prefer not to state (8)

Page Break

Q39 What is your highest level of education?

- O Some High School (1)
- O High School or equivalent GED (2)
- O Associate degree (3)
- O Technical or occupational certificate (4)
- O Some college coursework completed (5)
- O Bachelor's degree (6)
- O Master's degree (7)
- O PhD (8)

Q40 Select your annual household income:

- O < $25K (1)
- O $25K - $50K (2)
- O $50K - $75K (3)
- O $75K - $100K (4)
- O $100K - $125K (5)
- O $125K - $150K (6)

O > $150K (7)

O Prefer not to state (8)

Q41 Enter the number of people in your household (including yourself):

_____

Q42 Enter your zipcode:

_____

Page Break

Q43 In general, do you consider yourself as a Republican, Democrat, Independent, or something else?

O Republican (1)

O Democrat (2)

O Independent (3)

O Something else (4)

Q44 Indicate the sector(s) which your occupation falls under:

- ☐ government (1)
- ☐ non-profit (2)
- ☐ education (3)
- ☐ commercial fisher (4)
- ☐ healthcare (5)
- ☐ service industry (6)
- ☐ other (7) _____

Q45 Which of the following best describes your relationship, if any, to the aquaculture industry?

- ☐ Employee (1)
- ☐ Competitor (2)
- ☐ Supplier (3)
- ☐ Customer (4)
- ☐ Government/Regulator (5)
- ☐ Researcher (6)
- ☐ Shareholder (7)

☐ Other (8) _____

☐ None (9)

End of Block: Demographics

B3- Survey Data Analysis

Analysis was coded and created reproducibly in R using RStudio, and stored on an open source GitHub repository. All data files and R markdown documents (.Rmd) are publicly available at our team's GitHub repository.

Appendix C - Semi-Structured Interviews

C1- Interview Guide

Purpose: The interview guide outlines the planned topics and order in which they will be introduced. It guides the interviewer through the relevant components of a semi-structured interview.[82] The semi-structured interview format provides room for the interviewer to ask for more clarification or follow-up questions to the interviewee's questions. Interviews should last 30-60 minutes and should not exceed 90 minutes.

Introduction

Hi, thank you for meeting with me today. My name is [insert name]. As I noted in the email, I am a master's student at the UCSB Bren School of Environmental Science and Management. I am working with Ocean Rainforest to study stakeholder perceptions of kelp aquaculture in California. We are interviewing experts in the aquaculture industry, permitting, and scientific communities. The information gathered during this interview will help us understand the current status of aquaculture in California and identify challenges moving forward. I expect the interview to take between 30-60 minutes.

Everything you share with us will be confidential. Quotes from our conversation will only refer to you by your stakeholder category- for example: government, NGO, industry, academic, etc.

Although you already signed the consent form, I would like to confirm that you are voluntarily participating in this research and I have your consent to record this conversation. The recording will only be used to transcribe our interview so our research team can look for themes and other responses. Once the audio has been transcribed the video will be deleted.

Do you consent to a recording of our session?

Thank you!

Warm-up Questions

How long have you worked for [organization]?

Can you describe your current roles and responsibilities?

How does your role at [insert organization] relate to aquaculture?

Can you describe the most recent project you engaged with involving aquaculture?

If they mention a specific aquaculture project either transition to specific project questions or mention that you'd like to come back to that.

Organizational Character- Placing in Space

In your own words, what is the mission of [organization]?

How does aquaculture fit into that picture?

Describe your organization's current approach to ocean aquaculture in California.

Challenges + Concerns

What are the ecological implications of kelp aquaculture (onshore and offshore)?

What are the biggest uncertainties in kelp aquaculture in California?

Have these uncertainties influenced your support of kelp aquaculture?

If concerned: What do(es) your organization need to resolve these concerns or how could these concerns be resolved?

How have these concerns shaped your view of aquaculture or kelp aquaculture?

What are the bottlenecks for aquaculture in California?

How has your organization addressed these bottlenecks?

What do you view as the biggest challenges to expanding seaweed aquaculture in California?

Public perceptions of aquaculture

How has the public's perception of aquaculture impacted farm development in California?

Who have been the most vocal supporters of [ocean aquaculture in California or the project they are discussing]?

If referencing a specific aquaculture project: What were their primary concerns?

Who have been the most vocal opponents of [ocean aquaculture in California or the project they are discussing]?

If referencing a specific aquaculture project: What were their primary concerns?

How does your approach to aquaculture address stakeholder concerns?

Experience with Specific Aquaculture Projects (as applicable)

If you want to ask about a specific permit, farm or project they've mentioned or you know they've been a part of.

You mentioned the [project name] farm earlier. Could you briefly describe the project?

If they're talking about a permit application

Was the application successful?

What do you think contributed most to its [success/failure]?
If failure: How could this application have been successful?

Describe some challenges you encountered as you worked on/considered the project.
For regulators: What are the most important decision making considerations for you?

What lessons did you learn from that experience?

How did the community respond to this [application, program, farm]?

If the application wasn't for seaweed cultivation:

Conclusion
Given everything we've talked about, should kelp aquaculture be expanded in California?

C2- Codebook

Name	Files	References
Aquaculturist and applicant	0	0
Accountability	8	16
Experience	7	12
Knowledge	2	2
Communication	11	54
Data and information	6	12
Amount	4	8
Data Gap	9	19
Data Validity	6	27
Expertise	5	10
Research	4	11
Risk Assessment	2	4
Uncertainty	8	22
Feasibility	5	9
Marketability	2	9
Monetary	9	29
Regulatory	3	13
Technical	1	2
Time	6	13
Frames	0	0
Quality of wild caught	1	1
Location	9	23
Negative Impacts	5	17
Biological effects	6	15

Competition	9	42
Economic	5	13
Disease	4	5
Entanglement	4	10
Imported	3	10
Marine Debris	5	11
Size	8	23
Spatial	9	19
Fisheries	7	13
Intermittent	1	1
Salmon	1	1
Trawl	6	14
Urchin	1	1
Water Quality	1	2
Other Aquaculture	4	12
Avalon	1	1
Catalina	5	8
finfish	4	11
Pacific Aquafarms	2	5
SB Mariculture	3	6
shellfish	5	12
VSE	7	50
Other Projects	2	4
AOA	4	8
MPA	4	10
Oil Rigs	2	2

Terrestrial Ag	1	2
Wind Farming	3	6
Positive Impacts	3	7
Biofuel	2	4
Biological Effects	4	6
Carbon Sequestration	5	8
Domestic	3	9
Economic or Community well-being	7	36
sense of duty	1	2
Environmental	8	24
Food Source	9	29
Harbor Infrastructure	2	3
Intrinsic value of ocean	2	3
Nursery and Refuge	3	7
Nutrients and Feed	4	12
Size	3	5
Public Perceptions	12	54
Regulator	6	12
CADFW	2	4
CCC	6	22
DOD	1	1
Fish and Wildlife	4	7
NOAA	6	13
USACE	6	9
Relationships	0	0
Agency Judgment	9	36

Authority	8	40
Inter-agency	7	27
Inter-stakeholder	11	40
Intra-agency	5	9
Leadership	6	7
Leverage	6	22
Role and Stance	11	71
Shared Values	3	5
Spatial	12	69
Fisheries	7	13
Intermittent	1	1
Salmon	1	1
Trawl	6	14
Urchin	1	1
Stakeholders	1	1
ENGO	1	2
Fishers	6	17
Ports	1	1
Scientific	0	0
Tribes	1	2
Trust	9	20
Fairness	4	20
Skepticism	4	11
Transparency	2	3

C3- Interview Consent Form

***Exempt Interview with Audio/Video Recording* Consent Form**

Purpose:
You are being asked to participate in a research study being conducted by the Bren School of Environmental Science and Management at the University of California, Santa Barbara. Participation is voluntary. The purpose of this research study is to gain a better understanding of the view/perception of kelp aquaculture by California's regulatory agencies, non-profits, commercial fishers, and recreational ocean users.

Procedures:
If you choose to be in the study, we will audio and/or video record an interview with you to learn more about your involvement with kelp aquaculture in California. This includes, but is not limited to, questions about your profession/ organization, your background and experience in aquaculture, and your influence in the expansion of seaweed aquaculture in California. The interview will last about 30 to 60 minutes.

You can skip questions that you do not wish to answer or stop the interview at any time.

Confidentiality:
The results of this research may be presented at a conference, published in a scientific journal, and shared with other researchers. Identities will not be disclosed, and individual privacy will be maintained. Your identity will not be made known in written materials resulting from this study. If you consent to associating your name with your comments, unique identifiers will be used to match your data to you (such as a being assigned a number) for storage purposes. The audio/video recordings will be kept for 2 years maximum and deleted after this time. Interview recordings will be transcribed for data analysis.

Third party platforms used to record the interview, such as Zoom, may have access to the recordings under their privacy policy.

Do you consent to being audiovisual recording for purposes of transcription and analysis?
- ☐ Yes
- ☐ No

Do you consent to interviewers taking typed or handwritten notes for purposes of analysis?
- ☐ Yes
- ☐ No

Contact Information:
If you have questions about the research, you can reach us at gp-kelpwanted@bren.ucsb.edu.

If you have any questions regarding your rights as a research subject, please contact the Human Subjects Committee at (805) 893-3807 or hsc@research.ucsb.edu. Or write to the University of California, Human Subjects Committee, Office of Research, Santa Barbara, CA 93106-2050

Do you consent to the use of a unique identifier that will associate you with your comments?
- ☐ Yes
- ☐ No

Appendix D - Glossary of Terms

Economic legitimacy: A foundational component of attaining a social license to operate in which the stakeholder perceives that the company/project offers a benefit.[38]

Institutional trust: The final component of gaining a social license to operate in which "the relations between the stakeholders' institutions (e.g., the community's representative organizations) and the project/company are based on an enduring regard for each other's interests". A social license can be granted without gaining institutional trust.[38]

Interactional trust: A component of gaining a social license to operate. It is "the perception that the company and its management listens, responds, keeps promises, engages in mutual dialogue, and exhibits reciprocity in its interactions."[38]

Sociopolitical legitimacy: A component of gaining a social license to operate in which the company or project is seen to "contribute to the well-being of the region, respects the local way of life, meets expectations about its role in society, and acts according to stakeholders' views of fairness."[38]