Humboldt Bay Shellfish Mariculture Business Survey: Assessing Economic Conditions and Contributions

Bill Rich of Mad River Slough Shellfish Nursery operating his work vessel with his dog Opal, heading north on Mad River Slough beneath water transmission pipelines, Humboldt Bay, California, March 16, 2026

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Executive Summary

Humboldt Bay occupies a key position in the California and West Coast shellfish mariculture industry because of its longstanding high-health status, uniquely strong tidal exchange, and stable, healthy ecosystems. Its shellfish industry has produced more than half of California's market-sized oysters annually since 2015 and more than half of all farmed shellfish in 2024. That same year, it supplied at least 177 businesses with market-sized shellfish, and 136 farms with shellfish seed. Because no other California bay currently possesses the same high-health status allowing it to export seed to other states, Humboldt Bay serves a unique role in the U.S. West Coast shellfish industry. The seed produced in Humboldt Bay is grown to market size in bays along the U.S. West Coast, including California, Oregon, Washington, and Alaska. This report estimates Humboldt Bay supplies seed to 66% of all U.S. West Coast shellfish farms and may account for roughly 46% of these Pacific oysters, Kumamoto oysters or Manila clams market-size production, which was equal to $88.9 million in sales revenue in 2023. As a result, shellfish seed produced in Humboldt Bay helps sustain an estimated $155.5 million in annual economic activity and over 1,500 jobs across the U.S. West Coast.

This report assesses the economic conditions and contributions of Humboldt Bay's shellfish mariculture industry based primarily on survey results from seven of the eight businesses operating in Humboldt Bay in 2024. All values are reported in 2026 dollars unless stated otherwise. The survey was adapted from a study by Cal Poly Humboldt researchers in 2018, [1] allowing for a comparison with 2016 industry conditions while integrating new questions on shellfish seed production, supply chain geography, and emerging threats and opportunities.

[1] Richmond, L., Fisher, W., Smith, W., Hackett, S., Tyburczy, J. (2018). Humboldt Bay shellfish mariculture business survey: Assessing economic conditions and impact. Humboldt State University; California Sea Grant. https://fisheries.legislature.ca.gov/sites/fisheries.legislature.ca.gov/files/u8/2018-11-9%20Humboldt%20Bay%20Shellfish%20Mariculture%20Business_FINAL_REPORT.pdf (6 of 6 businesses participated at that time)

Economic Contributions

Based on the survey results, in 2024 the shellfish mariculture industry supported 57 full-time equivalent (FTE)[2] direct jobs, $4.8 million in labor income, and an estimated $31.1 million in total economic output. The industry produced 9 million market-sized oysters (Kumamoto oysters and Pacific oysters), and 459 million individual shellfish seed (Kumamoto oysters, Pacific oysters, and Manila clams). In addition, the industry contributed a minimum of $65,000 in volunteer hours towards research and projects in collaboration with community organizations, while also bringing in significant cultural and monetary value through events such as the annual Arcata Oyster Festival.

Table 1. Economic contributions of the Humboldt Bay shellfish mariculture industry in 2024 based on survey results (7 of 8 businesses reporting) (2026 dollars)

Economic Indicators	2024
Businesses[3]	8
Jobs (FTEs)	57
Payroll	$4,758,559
Taxes	$187,208
Net business income	$4,712,884
Value Added[4]	**$9,658,651**
Intermediate inputs[5]	**$6,134,371**
Direct Industry Output	**$15,793,022**
Total Economic Output (1.97 multiplier)[6]	**$31,112,254**

[2] A full-time equivalent (FTE) is a measurement of full time jobs supported at a rate of 2080 hrs/year. For this analysis, part-time jobs are considered half-time, or 0.5 FTEs.
[3] The number of businesses is based on publicly available data.
[4] Value added is the industry's own contribution to output, equivalent to the sum of labor income, net business income, and taxes on production.
[5] Intermediate inputs are the goods and services purchased from other industries and consumed in production (e.g., seed, freight, utilities, repairs, professional services), and does not include durable goods (i.e. capital expenditures).
[6] Total economic output is direct industry output plus the indirect and induced activity generated as the industry's spending and wages circulate through the regional economy.

Industry Changes – 2016 versus 2024

Compared to 2016, the industry has shifted toward seed and larvae production, while scaling back on market-sized shellfish (Table 2). Local businesses grew from six to eight, with two new businesses entering. Seed production increased 152%, labor income rose 15%, and revenue increased 17%. During the same period, the industry saw a decline in market-sized shellfish production by 9%, with employment down 43%. The decline in employment was concentrated almost entirely among laborers and farm hands, which fell from 79 to 42 positions, consistent with a 32% decline in acres being cultivated. This reflects the lower labor demand of nursery and hatchery operations relative to the production of market-sized shellfish. The reduction of market-sized shellfish can be at least partially attributable to a reduction in the footprint of Pacific Coast Seafood's shellfish operations (Pacific Shellfish) by nearly 1/3 in 2017, which is the largest shellfish business by grow-out area in the Bay. [7]

Table 2. Summary of reported key economic indicators for the Humboldt Bay shellfish mariculture industry, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting) (2026 dollars).

Economic Indicators	2016	2024	Change
Businesses [8]	6	8	2
Acres under cultivation	386	264	-32%
Jobs (FTEs)	100	57	-43%
Payroll	$4,138,296	$4,758,559	15%
Market-size oysters	9,955,732	9,054,192	-9%
Shellfish seed	182,209,000	459,029,000	152%
Sales revenue	$13,495,424	$15,793,022	17%
Total expenditures	$16,035,715	$11,508,103	-28%
Value added	$5,403,412	$9,658,651	79%
Total economic output	$26,585,985	$31,112,254	17%

During this time, the composition of expenditures and revenue shifted. Labor became the single largest cost category at 41.5% of total expenditures, up from 25.8% in 2016, while

[7] California Coastal Commission. (2017). Staff report: Application No. 9-17-0646 (Coast Seafoods Company). https://documents.coastal.ca.gov/reports/2017/9/w22b/w22b-9-2017-report.pdf

[8] Number of business on publicly available data, not survey results

combined seed and larvae expenditures fell by 46%. On the revenue side, seed sales rose from $4.6 million to $6.95 million and now account for 44% of total industry revenue, up from 34.3%. These changes across both expenditures and revenue are consistent with the local industry's pull back in market-sized production and increase in seed production.

Regional importance through shellfish seed production

In 2024 Humboldt Bay produced approximately 9 million market-sized oysters and 459 million individual shellfish seed. Approximately 95% of total production was exported to Washington, Oregon, and Alaska, making Humboldt Bay a key contributor to shellfish production in the U.S.. Based on the survey results, data from U.S. Department of Agriculture's census production figures from 2023, and species-specific mortality rates from literature, this report estimates that Humboldt Bay may account for roughly 46% of U.S. market-size production of the three species it seeds. In turn, this seed is the primary supply input to an estimated 38% of the region's overall shellfish industry by sales revenue – or $88.9 million in 2023 – supporting approximately $155.5 million in economic output across the U.S. West Coast region. Because this contribution flows through forward linkages to farms across the region, a disruption to Humboldt Bay's seed supply could carry economic impacts beyond effects to the local industry's direct economic output. This disruption could be analogous to the economic impacts that the ocean acidification events between 2007 and 2009 had on seed supply, estimated to have cost the Pacific Northwest shellfish industry nearly $110 million, while jeopardizing 3,200 jobs. [9]

This regional role through seed production is also the source of some of the industry's key concerns. Survey participants identified biosecurity as a key concern, describing the introduction of Ostreid herpesvirus-1 (OsHV-1) as the single greatest existential threat to the bay's nurseries, which could cause 50% mortality of organisms and halt seed export

[9] Ekstrom, J. A., Suatoni, L., Cooley, S. R., Pendleton, L. H., Waldbusser, G. G., Cinner, J. E., Ritter, J., Langdon, C., van Hooidonk, R., Gledhill, D., Wellman, K., Beck, M. W., Brander, L. M., Rittschof, D., Doherty, C., Edwards, P. E. T., & Portela, R. (2015). Vulnerability and adaptation of US shellfisheries to ocean acidification. Nature Climate Change, 5(3), 207–214. https://doi.org/10.1038/nclimate2508

that is dependent on the Humboldt Bay's high-health status. Introduction of this disease into Humboldt Bay could close local operations and businesses to close, and have cascading effects across the U.S. West Coast shellfish industry.

This concern is often tied directly to the proposed Humboldt Bay Offshore Wind Heavy Lift Marine Terminal [10], which would increase vessel traffic into the bay and the associated risk of disease transmission. The Humboldt Bay Offshore Wind Heavy Lift Marine Terminal is a proposed port facility on the Samoa Peninsula, led by the Humboldt Bay Harbor, Recreation and Conservation District, intended to support floating offshore wind development for the state of California. Humboldt Bay is one of three ports identified in California as a good candidate for the type of facility proposed; which would utilize existing coastal dependent industrial zoned upland areas and the existing deep water federal navigation channel. At the same time, Humboldt Bay is the only bay in California which can currently export shellfish seed out of state; the nurseries for which are also all currently located on the Samoa Peninsula in close proximity to the proposed terminal project. This seeming conflict of uses has been a source of tension for the industry.

Table 3. Humboldt Bay (HB) seed production as an estimated proportion of market-size shellfish production

Species	HB reported seed production 2024 [11]	Estimated mortality rate	Estimated survival to market size	US Market size production 2023	Estimated market share supplied
Oysters	163,060,000	22 - 46% [12]	89,691,600	271,054,000	33%
Manila clams	295,969,000	~50% [13]	147,984,500	246,906,000	60%
Total	**459,029,000**		**237,676,100**	**517,960,000**	**46%**

[10] More information on the Humboldt Bay Offshore Wind Heavy Lift Marine Terminal can be found on the Humboldt Bay Harbor, Recreation, and Conservation District's dedicated project webpage: https://humboldtbay.org/humboldt-bay-offshore-wind-heavy-lift-marine-terminal-project-3

[11] One business which has a permitted nursery did not report their seed production.

[12] On the mortality rate of Pacific Oysters, see Evans and Langdon (2006); Burge et al. (2007); de Melo, Durland, and Langdon (2016); de Melo et al. (2018); and Hollarsmith et al. (2020). The highest observed mortality rate of 46% was used for this analysis. On the mortality rate of Kumamoto oysters, see Langdon et al. (2025). The reported mortality rate of 34% was used for this analysis.

[13] On the mortality rate of Manila clams see, Dethier et al. 2019. A mortality rate 50% was used for this analysis.

Figure 1. Map of reported Humboldt Bay shellfish seed distribution, 2024 (7 of 8 businesses reporting)

Outlook

Looking ahead, most respondents plan to expand operations, projecting employment to grow by 75% over the next five years. However, that optimism is conditional. Respondents cited the following concerns: regulatory changes, followed by permitting costs and water quality, then changing ocean conditions and seed availability. Plans to expand were widely described as contingent on continued access to clean water, adequate tideland availability, protection from biosecurity threats, and control of rising operating costs. Several operators emphasized that Humboldt Bay is the only viable location in California for their operations because of its high-health status, regulatory status for interstate seed exports, and unique environmental conditions. Many of these family-owned businesses framed their future around building something durable across generations. The industry's concerns about future threats coexist with substantial, long-term investments in the bay, underscoring the importance of how these threats are managed going forward.

1.0 Introduction

Shellfish are an important piece of Humboldt County's social, cultural, and economic fabric. [14] Clams, cockles, and other shellfish have been harvested by the Wiyot people of Humboldt Bay (Wiyot: *Wigi*) since time immemorial [15]. The Wiyot people continue these practices today, and with the return of ancestral lands such as Digawututklh (on the Samoa Peninsula), traditional harvesting of clams and other shellfish can resume. [16]

Commercial shellfish farming has been substantially present in Humboldt Bay since 1955, though attempts to build an industry in the Bay date back as early as 1896. [17] In the early 1980s, the development of U.S.-based shellfish hatcheries and the adoption of remote setting restructured the West Coast oyster industry, separating larval production from on-farm grow out, and eliminating dependence on Japanese seed imports; the final shipment arrived in California in 1989. The advancement in hatchery technology drove significant industry growth through in the mid-1990s. Hatcheries supply nurseries with young seed, which is grown to a larger size before passing to producers who raise them to market-size. By 2008, all oysters produced in California were grown from domestic hatchery seed sourced entirely out of state, concentrated in Washington, Oregon, and Hawaii, [18] allowing nurseries to further develop in California. When Hog Island Oyster Co. established their hatchery in Humboldt Bay, circa 2014, it became the first in-state source for hatchery seed. [19]

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[14] Lisa Wise Consulting, Inc., & Humboldt State University. (2019). Eureka, CA fishing community sustainability plan (Final draft). Saltonstall-Kennedy Program, NOAA Fisheries. https://digitalcommons.humboldt.edu/hsuslri_local/64/

[15] Tushingham, S., Eidsness, J. P., Fulkerson, T., Hopt, J., Christiansen, C., Arpaia, A., & Chang, J. (2016). Late Holocene coastal intensification, mass harvest fishing, and the historical ecology of marine estuaries: The view from the Manila site (CA-HUM-321), Humboldt Bay, northwestern Alta California. California Archaeology. https://doi.org/10.1080/1947461X.2016.1176359

[16] Wiyot Tribe. (n.d.). Landback. Retrieved July 31, 2026, from https://www.wiyot.us/466/Landback

[17] Barrett, E. M. (1963). *The California oyster industry* (Fish Bulletin No. 123). California Department of Fish and Game. University of California.

[18] Moore, T. O., & Moore, J. D. (2008). Culture of oysters. In California Department of Fish and Game status of the fisheries report (pp. 21-1–21-14). California Department of Fish and Game.

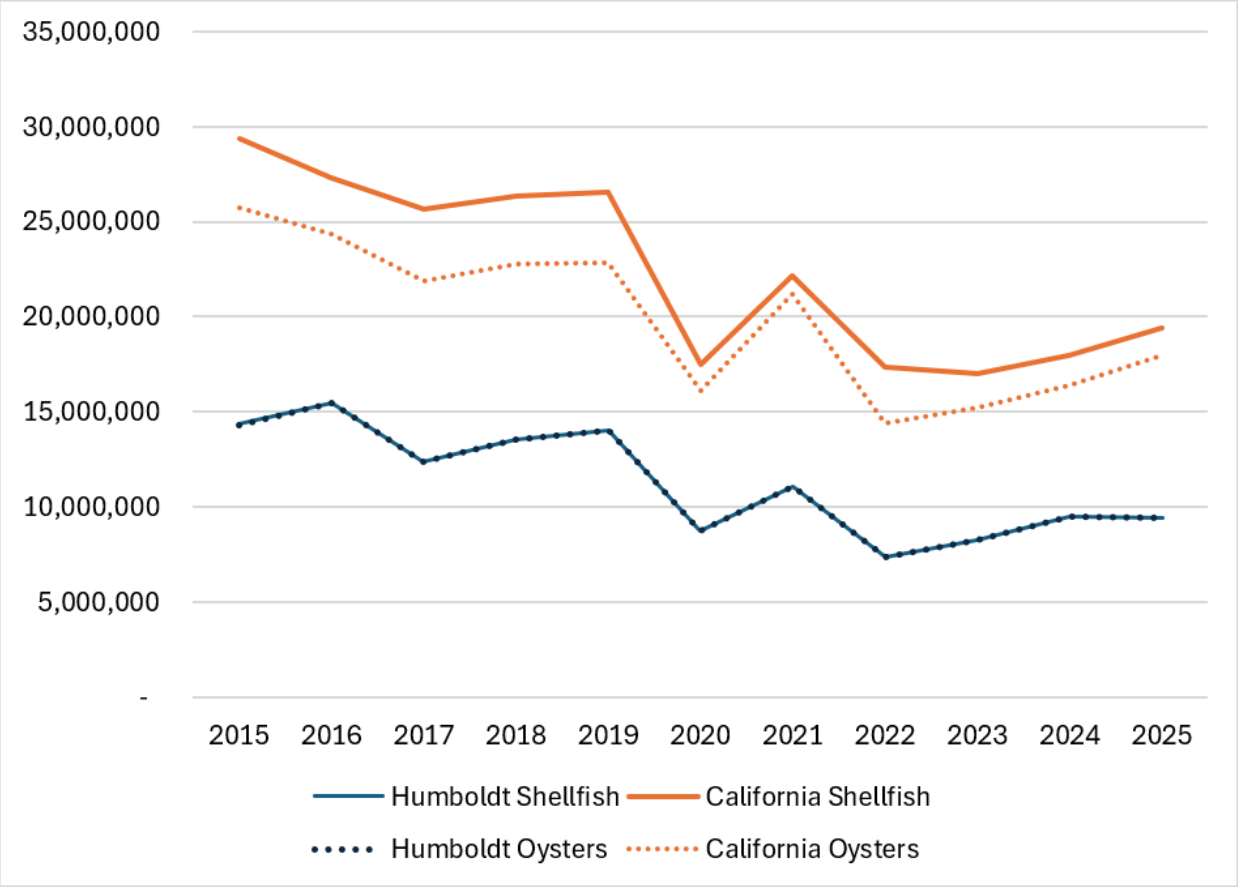
[19] California Coastal Commission. (2014). Staff report: Regular calendar — Application No. 9-13-0500 (Hog Island Oyster Company). https://documents.coastal.ca.gov/reports/2014/3/Th11a-3-2014.pdf

The evolution of the industry supported the expansion of shellfish production in Humboldt Bay. In 2009 the bay was named the Oyster Capital of California by the state legislature, estimating more than 70% of California's oysters were produced in Humboldt Bay. [20] Based on data provided the California Department of Fish and Wildlife, between 2015 and 2025 Humboldt Bay produced between 51 - 64% of California's oysters, and an average of 50% of all California's shellfish (Figure 2). [21]

Because of Humboldt Bay's high-health status, it became the only bay in California that is allowed to export seed, reportedly supplying 60 farms as of 2012, [22] and 136 in 2024.

[20] HBHD (Humboldt Bay Harbor District). 2011. Headwaters Fund of Humboldt County Application "Humboldt Bay Mariculture Expansion Project".
[21] Humboldt Bay shellfish farmers producing market-size shellfish voluntarily report production numbers to the CDFW annually. All businesses that produce market-size shellfish responded to the survey for this report, which found a production volume 5% higher than what was reported to the CDFW in 2024. This difference may reflect differences in reporting methods or how businesses reported production in each case.
[22] Walters, H. (2012, April 5). The world is yours, oyster farmer. North Coast Journal. https://www.northcoastjournal.com/news-2/the-world-is-yours-oyster-farmer-2133083/

Figure 2. Shellfish mariculture production (units) between 2015 and 2025 of oysters and shellfish in California vs. Humboldt Bay [23]



A 2025 report published in the *North American Journal of Aquaculture* on the economic contribution of aquaculture in the western region of the U.S, found that shellfish farms contributed 4,100 jobs and $361 million in total economic output in 2022, with oysters generating the most revenue. [24] Despite Humboldt Bay's key role in the shellfish industry in California and the U.S. West Coast, little was understood about the economic conditions and contributions of the industry in the Bay. In response to this knowledge gap, Laurie Richmond and other researchers from Cal Poly Humboldt, conducted a survey of shellfish

[23] Humboldt produced shellfish and oysters are nearly equal, as Humboldt has almost entirely produced oysters over the last decade apart from two two-year periods where a relatively small quantity of mussels were produced.

[24] Engle, C. R., van Senten, J., Fong, Q., & Good, M. (2025). The economic contribution of aquaculture to the U.S. Western Region. North American Journal of Aquaculture, 00, 1–13. https://doi.org/10.1093/naaqua/vraf008

businesses in Humboldt Bay in 2016 to better understand the industry's socio-economic dimensions and what factors might help support its long-term sustainability. The report found that the industry generated 101 jobs and over $19.1 million in total economic output in 2016 as well as socioeconomic benefits to the region. The report also captured what market changes the industry believed it would face over the following five years. [25]

This report builds on the 2016 study by Richmond and colleagues, providing an update on the industry's economic impacts and identifying its evolving opportunities and threats. Industry members requested this study to help them better understand current economic conditions and to prepare for potential future disruptions.

2.0 Study site and background information

Humboldt Bay is the second largest estuary in California with an area of approximately 16,000 acres [26], with 3,868 acres of tidelands leased for shellfish mariculture, according to 2024 survey results, and only about 264 that are permitted and actively cultivated. Humboldt Bay began shellfish mariculture with Eastern oysters in 1896. [27] From 1932 to 1953, the California Department of Fish and Game limited shellfish mariculture in Humboldt Bay to production of the native Olympia oyster due to the poor performance of Eastern oysters and the lack of invasive species and diseases in the Bay. [28]

Humboldt Bay has historically remained free of several shellfish pathogens and pests that are subject to regulatory certification requirements. The high-health status of the bay has allowed Humboldt Bay's shellfish hatchery and nursery programs to thrive as oysters, clams, and mussels from Humboldt Bay are allowed to be exported throughout the US

[25] Richmond, L., Fisher, W., Smith, W., Hackett, S., & Tyburczy, J. (2018). Humboldt Bay shellfish mariculture business survey: Assessing economic conditions and impact. Humboldt State University; California Sea Grant. https://fisheries.legislature.ca.gov/sites/fisheries.legislature.ca.gov/files/u8/2018-11-9%20Humboldt%20Bay%20Shellfish%20Mariculture%20Business_FINAL_REPORT.pdf

[26] California Department of Health Services. (2007). *Sanitary survey of Humboldt Bay*. State of California, Health and Human Services Agency

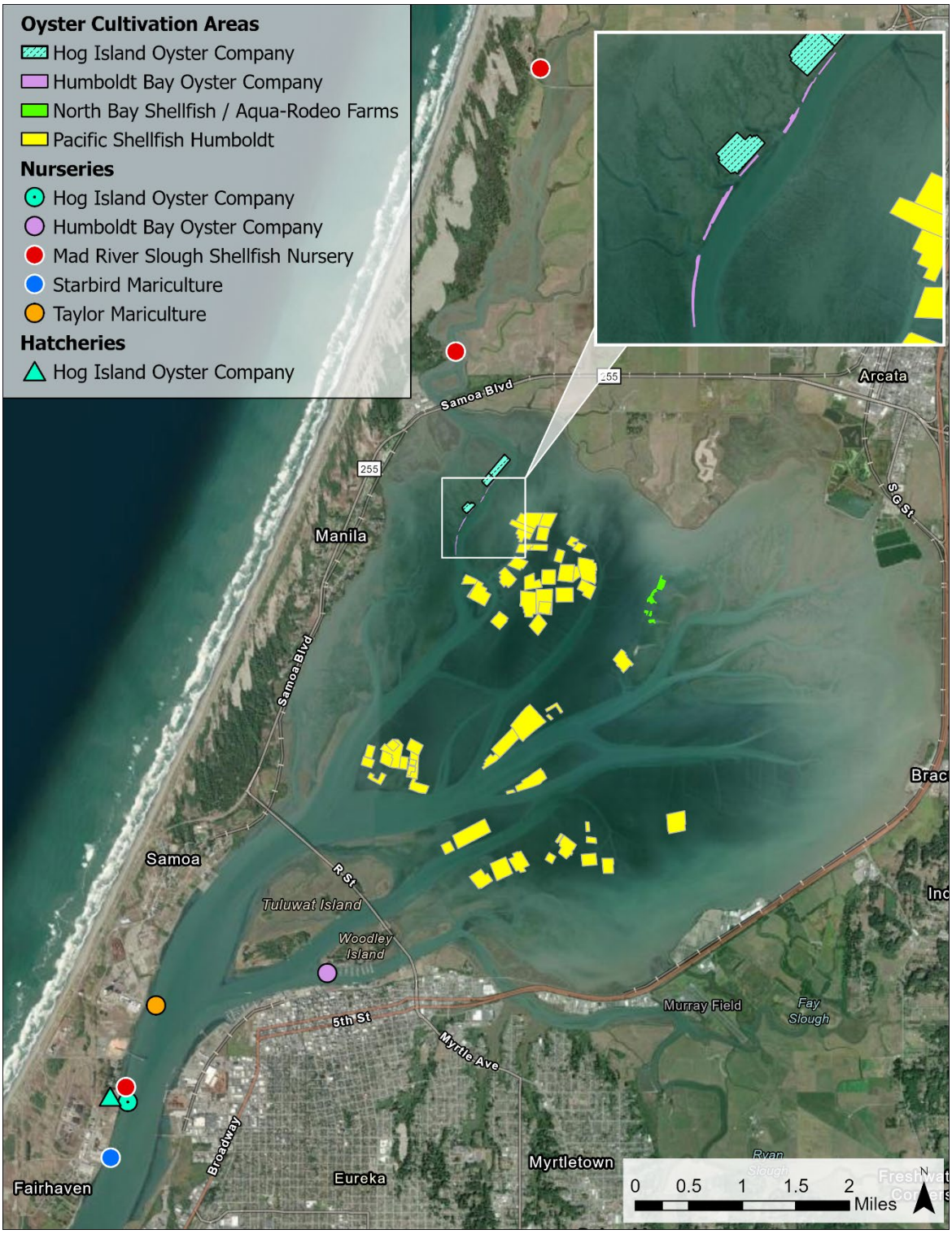
[27] Barrett, E. M. (1963). *The California oyster industry* (Fish Bulletin No. 123). California Department of Fish and Game, University of California.

[28] Bonnot, P. (1935). The California oyster industry. *California Fish and Game, 21*(1), 65–80.

West Coast. Today shellfish production in Humboldt Bay includes three species: Kumamoto oysters (Crassostrea sikamea), Pacific oysters (C. gigas), and Manila clams (Tapes philippinarum). This production is distributed across three main sectors: Hatchery production (Kumamoto and Pacific oysters), nursery production (Kumamoto and Pacific oysters, and Manila clams), and market-size shellfish production (Kumamoto and Pacific oysters). Market-sized production of both Pacific oyster and Kumamoto oyster depend on hatchery-produced seed, as the summertime water temperatures in Humboldt Bay and other California bays are too low to support natural spawning. [29]

[29] Conte, F. S., & Moore, T. (2001). Culture of oysters. In W. S. Leet, C. M. Dewees, R. Klingbeil, & E. J. Larson (Eds.), California's Living Marine Resources: A Status Report (pp. 500–506). California Department of Fish and Game. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=34258

Figure 3. Map of Humboldt Bay commercial shellfish operations in 2026 [30]



[30] GIS cultivation area data was provided by the California Department of Public Health (CDPH). The location of nurseries and hatcheries is based on information provided by CDPH and through conversations with business owners.

The general process for shellfish production includes four major stages: hatchery production, seed setting, nursery, and farm grow-out (Table 4). Each production stage allows for various market paths and business models. There are currently eight commercial mariculture operators in Humboldt Bay. All are located north of the harbor mouth entrance and with all intertidal market production areas located in the Northern section of Humboldt Bay, referred to as Arcata Bay (Figure 3). Of these operators, one currently operates a commercial shellfish hatchery, five maintain floating upweller systems (FLUPSYs) nurseries, five operate intertidal oyster beds for market production, three operate restaurants, and four have operations outside of the Humboldt Bay region (Table 5).

Figure 4: Photograph of Justin Mojonnier, director of science and technology at Hog Island Oyster Co., handling broodstock at the company's hatchery in Humboldt Bay.

Table 4. The four main stages of shellfish production used in Humboldt Bay

Stage	Species cultured in Humboldt Bay	Description
Hatchery Production (Larvae)	Kumamoto and Pacific oyster	Staff spawn adult oysters and use their gametes to produce larvae. Oyster larvae are maintained in culture tanks and fed live microalgae for 18 to 21 days. When larvae reach the final pediveliger stage, they are collected and sold for setting.
Seed-Setting (Spat)	Kumamoto oyster, Pacific oyster, Manila clam	Oyster pediveliger larvae can be set on large shell (cultch) or small ground up oyster shell (microcultch). Most oysters produced in Humboldt Bay are set on microcultch to produce single oysters. Manila clam larvae do not require a cultch material for setting. Settle larvae, called spat can be sold farms or maintained on small mesh upwelling tables until they can be retained on a 2 mm mesh screen.
Nursery (Seed)	Kumamoto oyster, Pacific oyster, Manila clam	Once spat are retained on a 2 mm mesh screen they are transferred to a nursery raft (or a FLUPSY) and referred to as seed. In the nursery, seed are exposed to raw sea water and it's phytoplankton communities, which supports rapid growth. Seed is sold to farms for planting or kept in the nursery until they reach a maximum of 36 mm in length.
Farm Grow-out	Kumamoto and Pacific oyster	Operators can plant oyster seed at any size between 2mm – 36mm. Smaller seed are kept in small mesh baskets and require more maintenance; however, small oysters are more economical so many growers invest in smaller seed and more handling time. Operators use various gear types to grow oysters in the intertidal zone, including oyster shell on lines, suspended baskets, and on-bottom culture gear. Once planted, oysters can take from one to three and half years to reach market size, depending on gear type, tidal height, environmental conditions, and species.

Table 5. Humboldt Bay shellfish businesses and permitted types of operations 2026 [31]

Operator/ Permittee	Hatchery	Seed-setting	FLUPSY	Market Production	Restaurant Operations [32]	Operations outside of Humboldt
Aqua Rodeo Farms				X	X	
Hog Island Oyster Co.	X	X	X	X	X	X
Humboldt Bay Oyster Company			X	X		
Mad River Slough Shellfish Nursery			X			
North Bay Shellfish				X		
Pacific Shellfish				X		X
Starbird Mariculture			X			X
Taylor Mariculture		X	X		X	X

3.0 Methods

The research team developed a 35-question survey to administer to each of the shellfish mariculture businesses operating on Humboldt Bay (Appendix I). The survey instrument was adapted from Richmond et al.'s 2018 report, [33] which used a 2013 assessment of mariculture activities on the U.S. West Coast conducted by Northern Economics, Inc. as its original foundation [34]. This allowed for a direct comparison of industry conditions in 2016 and 2024, which was supplemented by production data from the California Department of Fish and Wildlife (CDFW) to better understand industry trends the last decade. Core questions covering employment, tidelands, facilities and equipment, expenditures,

[31] Information on the permitted types of operations was provided by the Humboldt Bay Harbor, Recreation, and Conversation District.
[32] Restaurant operations may operate under separate business names or entities from those listed but fall under the same parent corporation or company.
[33] Richmond, L., Fisher, W., Smith, W., Hackett, S., & Tyburczy, J. (2018). Humboldt Bay shellfish mariculture business survey: Assessing economic conditions and impact. Humboldt State University; California Sea Grant. https://fisheries.legislature.ca.gov/sites/fisheries.legislature.ca.gov/files/u8/2018-11-9%20Humboldt%20Bay%20Shellfish%20Mariculture%20Business_FINAL_REPORT.pdf
[34] Northern Economics, Inc. (2013). *The economic impact of shellfish aquaculture in Washington, Oregon and California*. Prepared for the Pacific Shellfish Institute. https://www.pacshell.org/pdf/Economic_Impact_of_Shellfish_Aquaculture_2013.pdf

production, revenue, marketing, collaboration, and the industry's future were retained from the 2018 survey instrument. Additional questions were developed to capture areas of emerging concern to the industry, with a focus on seed production and distribution, and the potential downstream impacts of disruptions to that production in Humboldt Bay. An early version of survey instrument was provided to representatives of the shellfish industry for review. Their feedback was used to revise the survey to better reflect today's industry conditions.

Surveys were provided to representatives from each of the eight businesses operating in the bay, offered as both digital or physical documents. Businesses were able to complete the survey at their own pace, and the research team was available to answer questions. Seven of the eight businesses completed the survey, but; not all participants answered every question. In some cases, the research team followed up with participants where answers were unclear or to verify the accuracy of the data.

Economic data from business operations are sensitive, and several steps were taken to ensure confidentiality. The data collection and analysis process was conducted in accordance with an approved Cal Poly Humboldt Institutional Review Board protocol. Survey results are presented in aggregate form, and the study followed the commonly accepted confidentiality practice in economic and social science reporting, under which aggregate findings are not reported if they include data from fewer than three businesses. In the results section, questions answered by fewer than three businesses are denoted with a dash. The goal of the study is to describe the conditions of the industry in Humboldt Bay as a whole, not to characterize individual shellfish mariculture businesses.

This report compares industry conditions in 2016 and 2024 using the common core questions from the Richmond et al. 2018 report, allowing for direct comparison across the years. To confirm 2016 and 2024 are representative years suitable for comparison, they were evaluated against long term production records from the CDFW. Total shellfish production in Humboldt Bay declined from 2015 to 2025 at a rate of roughly 690,000 per year (linear regression, $R^2 = 0.67$, $p = 0.002$), with a notable dip in 2020 consistent with

pandemic-related disruption. When comparing 2016 and 2024 against the this trend using standard outlier diagnostics, neither year deviates meaningfully from the expected pattern. Therefore, both years reflect typical conditions, and do not skew the comparison with an unusually high or low production year.

4.0 Results

All figures in this section are reported in 2026 dollars, with both 2024 and 2016 values adjusted for inflation using the U.S. Consumer Price Index. [35]

4.1 Employment

Survey results from seven of the eight business in Humboldt reported 53 full-time employees and 7 part-time employees in the local shellfish mariculture industry in 2024. Combined these positions represent roughly 57 full-time equivalents (FTE's) [36] (Table 6), with payroll costing $4,758,559 (see Table 11, Section 4.4). Compared 100 FTE's in 2016, employment has declined by 43%.

The 2024 median annual compensation for mariculture employees was $39,142 and the mean was $83,483 per employee. The data indicates the income for Humboldt Bay mariculture employees notably increased from 2016 to 2024. The median compensation per employee increased by approximately 41%, or $11,000, and average compensation by roughly 102%, or $42,0000. This is consistent with the increase in labor income, and decrease in the number of employees between 2016 and 2024. The difference between the median and mean in both years can be explained in part by the small number of businesses in the Bay, each with a unique set of operations, employees, and net incomes that may skew the data.

[35] U.S. Bureau of Labor Statistics. (n.d.). *CPI inflation calculator*. U.S. Department of Labor. Retrieved May 2026, from https://www.bls.gov/data/inflation_calculator.htm

[36] A full-time equivalent (FTE) is a measurement of full time jobs supported at a rate of 2080 hrs/year. For this analysis, part-time jobs are considered half-time, or 0.5 FTEs.

Table 6: Reported employment data for the Humboldt Bay shellfish mariculture industry, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting)

Employment type	2016	2024
Full-time employees	98	53
Part-time employees (~0.5 FTEs)	3	7
Total employees (FTE)	100	57

Shellfish mariculture operations support various employment positions (Table 7). Participants were asked to place each employee into the role that best describes their position, even if they perform multiple duties. In 2016 and 2024, the most common positions are laborers or farmhands, followed by managers and supervisors. Across both years, businesses did not have employees dedicated to sales or deliveries, suggesting those functions are handled by employees in other roles, performed by employees outside of Humboldt County or contracted out.

The number of laborers and farmhands declined substantially from 79 in 2016 to 42 in 2024. This accounted for nearly the entire reduction in staff between the two years, which coincided with a decline in cultivated acreage (Section 4.2) and an increase in seed production (Section 4.5 & 4.6). This shift reflects the labor intensive work required to grow out market-sized shellfish compared to nursery and hatchery operations.

Table 7. Reported number of employees by occupation in the Humboldt Bay shellfish mariculture industry, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting)

Occupation	2016	2024
Owner/Operators	4	4
Managers/ Supervisors	14	14
Laborers/Farm Hands	79	42
Marketing/Sales	0	0
Maintenance/Safety	3	0
Delivery	0	0
Other	1	0
Total Employees	101	60

Several respondents noted an expanded employment footprint through vertically integrated operations, including hatcheries, downstream grow-out areas and restaurants primarily outside of Humboldt County. For confidentiality, exact numbers of out-of-region positions have been excluded from this report and are not included in total economic output calculations.

4.2 Tidelands

In 2024, survey participants leased 3,868 acres of tidelands in Humboldt Bay and cultivated 263.5 acres. In 2016, shellfish mariculture businesses leased 4,045 acres and cultivated 386 acres. While leased acres modestly declined, cultivated acres significantly declined by 32%. (Table 8) Roughly 123 historically cultivated acres of tidelands were idle in 2024.

Based on publicly available data, some of this decline reflects a deliberate contraction by the industry's largest operator by grow-out area, Pacific Shellfish. Following the California Coastal Commission's 2017 denial of a proposed expansion, Coast Seafoods (Pacific Shellfish) reduced its permitted oyster cultivation beds from 300 to 279 acres and reduced its overall operational footprint by nearly 1/3. [37]

Survey participants leased Humboldt Bay tidelands at a median rate of roughly $358 per acre in 2024. Compared to an annual median rate of $110 per acre in 2016, the rental rate increased 137%. Two businesses subleased acreage to other operators in 2016 and 2024, and several businesses plan to expand their grow-out areas over the next five years.

[37] California Coastal Commission. (2017). Staff report: Application No. 9-17-0646 (Coast Seafoods Company). https://documents.coastal.ca.gov/reports/2017/9/w22b/w22b-9-2017-report.pdf

Table 8. Reported tideland acreage under control [38] and cultivation for Humboldt shellfish mariculture businesses, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting)

Tidelands	2016	2024	% Change
Acres under control in Humboldt Bay	4,045	3,868	-4%
Acres under cultivation in Humboldt Bay	386	264	-32%
Acres under control outside Humboldt Bay	10,160	12,150	20%

In 2024, the industry supported one farmhand (FTE) per 6.3 cultivated acres and produced about 34,000 market-sized oysters per acre, compared to one farmhand per 4.9 acres and about 25,000 oysters per acre in 2016. While 2024 shows higher per-acre output and labor efficiency, only two years of data do not confirm a trend. Variation in year-to-year production, business mix and operational conditions could account for some or all of the difference. However, it does indicate that if cultivated acreage increases as projected, production and labor demand are expected to grow alongside it, possibly lagging slightly behind as grow-out can take 1-3 years.

4.3 Facilities and Equipment

In 2024, Humboldt Bay shellfish mariculture businesses owned or leased 16 land-based structures totaling 106,470 square feet — an increase of nearly 38% from 77,300 facility square feet in 2016. The addition of one facility — from 15 to 16 — accounts for part of that increase. Boat and vessel counts remained unchanged at 18, while the number of FLUPSYs grew from 13 to 16, reflective of increased investments in seed production (Sections 4.4 & 4.5). The number of tumblers and sorters used declined from 15 to 11. Only two businesses use land-based upwellers or downwellers, to maintain confidentiality, the number of these systems is not included in this report.

Access to cold storage was a leading concern reported in 2016. In 2024 six businesses responded when asked if they had cold storage space, but only two business reported

[38] Leased or otherwise held under permit

having any cold storage space available to them. One business who reported cold storage space in 2016 survey did not respond to this question in the 2024 survey. Three of the businesses reported insufficient cold storage, with a cumulative additional 1,780 square feet of cold storage desired. The data indicates that cold storage is an ongoing issue, and it has not been fully addressed since 2016.

Four businesses reported estimated electricity consumption for 2024 totaling 628,600 kWh, but a median of only 8,600 kWh. Higher loads were associated both with larger businesses and those with nursery operations.

Table 9. Reported equipment owned by Humboldt Bay shellfish mariculture businesses, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting)

Equipment Type	2016	2024
Facilities/Buildings	15	16
Boats/Vessels	18	18
FLUPSYs	13	16
Land-based Upwellers/Downwellers [39]	18	~
Tumblers/Sorters	15	11

Four of the six businesses lend equipment to other operators in the bay at least once a year, consistent with the working relationships in 2016. Three businesses anticipate significant capital investment in equipment over the next five years as they expand.

[39] Because only two businesses used land based upwellers or downwellers in 2024, the number is excluded to maintain confidentiality.

Figure 5. Photograph Hog Island Oyster Co. Humboldt Bay hatchery. Larvae tanks are located on the back wall, with upwellers and downwellers in the center and to the left.

The industry uses various culture methods, reflecting product type and type of operation (farm, nursery or hatchery). Table 10 lists the methods and number of businesses using them. Examples of various methods are available in Figures 5 and 6.

Table 10. Reported production methods used by shellfish mariculture businesses in Humboldt Bay in 2024 (7 of 8 businesses reporting)[40]

Production Methods	# of businesses using this method total
Hanging Baskets	2
Stick and Bag (off-bottom)	1
Rack & Bag	2
Intertidal Long Lines	1
Tray & Raft	2
Land-based Upwellers and Downwellers	2
FLUPSYs	5

[40] Based on survey results and publicly available information.

Figure 6. Photograph of Rack & bag oyster culture (foreground, Humboldt Bay Oyster Company) and hanging baskets on intertidal longlines (background, Hog Island Oyster Co.), Humboldt Bay, California

4.4 Expenditures

Direct expenditures for the Humboldt Bay shellfish mariculture industry in 2024 totaled roughly $11.5 million, compared to $16 million in 2016, representing a 28% reduction (Table 11).

Along with this overall decline, the composition of expenditures has also shifted substantially. Labor expenditures rose from $4.1 million in 2016, which was 25.8% of total expenditure, to $4.8 million in 2024, 41.5% of total expenditure, and making labor the single largest expense in 2026. This increase occurred despite a decrease in employment, primarily among farmhands and laborers. Section 4.1 discusses this relationship in more detail.

Combined shellfish seed and larvae expenditures totaled $3.2 million, or 27.9% of total expenditures in 2024; a decline from $5.9 million in 2016, when seed and shellfish purchases represented 36.7% of total expenditures. This decline may reflect the reduction

in market product, and/or increasing capacity of Humboldt Bay businesses to produce their own seed in-house or source seed locally at lower prices with an increase in local supply.

In 2024, facility leases and mortgages cost $833,000, the third-largest cost increase, up 60% from 2016. It is also the third-largest cost behind seed and larvae, accounting for 7.3% of all expenditures.

Freight was the fourth-largest cost in 2024 at $644,000, accounting for 5.6% of all expenditures and a 132% increase from 2016. Ice costs dropped 84% between 2016 and 2024, down to about $9,000. This could be associated with reduced cold storage space in 2024, a shift in preservation and transportation methods or the difference in how market-sized shellfish, and seed and larvae are handled.

Reported spending on other capital expenditures declined sharply, from $3.2 million in 2016 to $428,000 in 2024. This category is assumed to represent investment in durable, long-term assets such as vessels, buildings, and upweller systems, as well as gear and equipment that respondents described as lasting for decades. Because these assets provide value over many years rather than serving as inputs consumed within a single year of production, capital expenditures are excluded from the calculation of annual economic output and of value added described in Section 5.0. This exclusion accounts for a substantial share of the reported 28% decline in total expenditures over the period; excluding capital expenditures, the decline in expenditures would be closer to 14%. The research team expects businesses to incur a large portion of these capital costs outside the region, as much of shellfish production equipment is specialized and unlikely to be produced regionally.

Environmental monitoring and permitting showed the largest cost increase, growing 251% from 2016 to reach $267,000 in 2024. However these costs only accounted for 2.3% of all expenditures. Additionally, health compliance and permitting costs grew roughly 39% since 2016 but account for only 0.4% of expenses. Permitting and monitoring costs were not

separated in the survey, and to the degree these costs included regulatory fees versus labor or lab costs is not clear. Despite making up small portion of total expenditures, the increase in permitting and monitoring costs is a key concern among local businesses (Section 4.9).

Table 11. Reported expenditures by category, Humboldt Bay shellfish mariculture industry, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting) (2026 dollars)

Expenditure Category	2016	% of Total	2024	% of Total	% Change
Labor	$4,138,296	25.80%	$4,758,559	41.50%	15%
Shellfish Seed & Larvae	$5,889,240	36.70%	$3,197,133	27.90%	-46%
Facility Leases	$524,270	3.30%	$833,356	7.30%	59%
Freight	$277,157	1.70%	$643,718	5.60%	132%
Total Utilities	$298,792	1.90%	$451,397	3.90%	51%
Capital Expenditures (other)	$3,172,491	19.80%	$427,964	3.70%	-87%
Repair and Maintenance	$726,570	4.50%	$423,727	3.70%	-42%
Environmental Monitoring/Permitting	$76,210	0.50%	$267,199	2.30%	251%
Insurance	$386,388	2.40%	$166,326	1.40%	-57%
Federal Taxes	$253,316	1.60%	$116,284	1.00%	-54%
Gas/Fuel	$121,948	0.80%	$98,712	0.90%	-19%
State and Local Taxes	$80,809	0.50%	$70,924	0.60%	-12%
Health Compliance/Permitting	$31,335	0.20%	$43,416	0.10%	39%
Ice	$58,893	0.40%	$9,386	0.10%	-84%
Total Expenditures	**$16,035,715**	**100%**	**$11,508,103**	**100%**	**-28%**

Three of seven respondents reported difficulty obtaining seed and larvae over the past five years, primarily attributing this to the inability to source strains that are in high demand. Five of six respondents plan to expand seed and larvae production in Humboldt Bay over the next five years, citing an increased demand and lower operational costs to produce seed compared to market-sized shellfish.

4.5 Production and Revenues

The Humboldt Bay shellfish mariculture industry generated $15.79 million in 2024, a 17% increase from $13.50 million in 2016 (Table 12).

Additionally, the composition of revenue shifted substantially. Seed sales rose 50%, from $4.6 million in 2016 to $6.95 million in 2024; accounting for 44% of total industry revenue, up from 34% in 2016. Pacific oyster revenue more than tripled from $470,000 to $1.79 million, driven by production volumes, which rose 101%, and higher per-unit prices, up 89% to $1.36/oyster. Conversely, Kumamoto oyster revenue declined from $8.39 million in 2016 to $7.06 million in 2024, with a 17% decline in production volume and only a 1% increase per-unit price to $0.91/oyster. While market-size oyster production declined 9% from 2016 revenue remained practically the same as the price/unit increased between the two years.. The reduction in market-size oyster sales volume is consistent with a decrease in cultivated tidelands and can also be partly attributed to the reduction in the operational footprint of Pacific Shellfish since 2017.

Seed production grew from approximately 182 million units in 2016 to 459 million units in 2024, a 152% increase. This increase can be attributed to an expanded capacity for hatcheries and nurseries in Humboldt Bay over the last decade. Section 4.6 includes additional details on seed production in Humboldt Bay.

Table 12. Reported production and revenue for the Humboldt Bay shellfish mariculture industry, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting) (2026 dollars)[41]

Product	2016 Volume	2016 Revenue	% Rev	2024 Volume	2024 Revenue	% Rev
Pacific oysters (market-sized)	656,562	$469,896	4%	1,317,792	$1,786,773	12%
Kumamoto oysters (market-sized)	9,299,170	$8,393,970	62%	7,736,400	$7,056,111	40%
Total market-sized oysters	**9,955,732**	**$8,864,402**	**66%**	**9,054,192**	**$8,842,884**	**56%**
Seed	**182,209,000**	**$4,631,022**	**34%**	**459,029,000**	**$6,950,138**	**44%**
TOTAL		**$13,495,424**			**$15,793,022**	

[41] Only six of eight businesses reported sales revenue for market-sized oysters. Where data was not available, oyster value based the CDFW's average retail/wholesale price per shell for the state from 2020 ($0.65) adjusted for inflation ($0.85). See CDFW (2021).

Humboldt Bay shellfish farmers producing market-size shellfish voluntarily report production numbers to the CDFW annually. All businesses that produce market-size shellfish responded to the survey for this report, which found a production volume 5% higher than what was reported to the CDFW in 2024. This difference may reflect differences in reporting methods or how businesses reported production in each case.

Net-business income – that is revenue minus all expenditures except for capital assets – from operations in the Bay increased substantially from 2016, up from approximately $900 thousand to $4.7 million. However, the median net-business income across the seven participating businesses was only $26,400, with three of the businesses operating at a loss in 2024. These factors reflect the variability of profitability across both businesses and years, revealing tight margins for success and sustainability in the industry for certain businesses. Net-business income may also be a factor of the businesses structure and accounting practices, particularly across businesses that are vertically integrated and transact with themselves.

4.6 Seed Production

Humboldt Bay serves as a major nursery for the U.S. West Coast shellfish mariculture industry, supplying seed to shellfish growers from Southern California to Alaska. There are currently five businesses operating nurseries and producing seed in Humboldt Bay, four of which responded to the survey. The four nursery operators collectively produced more than 459 million units of seed in 2024, a 152% increase from 2016. In 2024, seed sales accounted for $6.95 million in revenue, 44% of total revenue for the Humboldt Bay industry. Hog Island Oyster Co is the only business to operate a hatchery in Humboldt Bay, established circa 2014. It sets larvae and sells it as seed to other nurseries for grow out or uses it in its own nursery operations. This report does not include larvae as a production category to protect confidential information

Humboldt bay nursery operators reported selling seed to 136 different shellfish businesses in 2024. According to the USDA census, there were 205 shellfish farms operating in AK, WA,

OR, and CA in 2023; which have 19, 147, 17, and 22 farms respectively. [42] This indicates that as much as 66% of shellfish farms on the U.S. West Coast purchased some portion of their seed stock from Humboldt Bay in 2024, with the majority of those farms located in Washington.

According to the 2023 U.S. Department of Agriculture Census of Aquaculture, U.S. producers grew nearly 518 million market-size Pacific oysters, Kumamoto oysters and Manila clams combined. Using literature on species-specific mortality rates, the research team estimates 237.7 million seed produced in Humboldt Bay in 2024 will survive to market size. Meaning seed produced in Humboldt Bay in 2024 could yield the equivalent to 46% of production in 2023 across the three species. Humboldt Bay Manila clam seed produced in 2024 would account for 60% of national market-size production, and Humboldt Bay Pacific and Kumamoto oyster seed produced in 2024 would account for 33% of national market-sized production. However, these findings are based on limited data and production by species can vary year to year. To protect producers' confidential information, Pacific and Kumamoto oyster seed production are not broken down by species in this report. Section 5 explores the economic impacts of this production.

[42] U.S. Department of Agriculture, National Agricultural Statistics Service. (2024). 2023 Census of aquaculture (Table 19, "Mollusk sales by species 2023 and 2018"). https://www.nass.usda.gov/Publications/AgCensus/2022/Online_Resources/Aquaculture/aqua_1_019_019.pdf

Table 13. Humboldt Bay seed production as a proportion of market-size shellfish production. [43]

Species	HB Seed Production 2024 [44]	Estimated Mortality Rate	Estimated Survival to Market Size	US Market Size Production 2023	Estimated U.S. Market Share Supplied
Oysters	163,060,000	22 - 46% [45]	89,691,600	271,054,000	33%
Manila clams	295,969,000	~50% [46]	147,984,500	246,906,000	60%
Total	**459,029,000**		**237,676,100**	**517,960,000**	**46%**

In 2024, Humboldt Bay producers retained 8.7% of the seed they grew in to use in their own operations, while they transferred or sold 91.3% to other growers. Just over 5% of total seed sales remained in California — 3.5% stayed in Humboldt Bay and 1.5% went to Tomales Bay, Morro Bay and San Diego Bay in California. The remaining 94.9% was distributed out of state, primarily to 13 or more bays in Washington and Oregon and Alaska (Table 14). Figure 1 shows the 2024 distribution of Humboldt Bay seed by bay and state.

Table 14. Reported destination of sales from Humboldt Bay shellfish mariculture businesses in 2024 (7 of 8 businesses reporting)

Destination	Units	% of Total
Humboldt Bay	16,152,580	3.50%
California (not Humboldt Bay)	7,065,000	1.50%
All of California	23,217,580	5.10%
Outside of California	435,811,420	94.90%
Outside of US	-	0.00%

[43] Species mortality rates are based on reviewed literature. The research team has requested shellfish species mortality from the USDA Farm Service Agency (FSA), which uses them as part of their Emergency Assistance for Livestock, Honeybees, and Farm-Raised Fish (ELAP) program. This report may be updated in the future to reflect any new data on mortality rates that is received, which would have an effect on estimated downstream economic impacts.

[44] One business which has a permitted nursery did not report their seed production.

[45] On the mortality rate of Pacific Oysters, see Evans and Langdon (2006); Burge et al. (2007); de Melo, Durland, and Langdon (2016); de Melo et al. (2018); and Hollarsmith et al. (2020). The highest observed mortality rate of 46% was used for this analysis. On the mortality rate of Kumamoto oysters, see Langdon et al. (2025). The reported mortality rate of 34% was used for this analysis.

[46] On the mortality rate of Manila clams see, Dethier et al. 2019. A mortality rate 50% was used for this analysis.

Figure 1. Map of reported Humboldt Bay shellfish seed distribution, 2024 (7 of 8 businesses reporting) [47]

[47] Map based on reported location of shellfish seed sales by bay or state. Bays not included due to map scale are Little Skookum Inlet and Hammersley Inlet, located in South Puget Sound near Oyster Bay. This map is not representative of supply routes.

Shellfish businesses in Humboldt Bay also rely heavily on seed produced in the bay. All seven survey participants with grow-out operations in Humboldt Bay source at least some of their seed from through their own nurseries or other operations in the bay. No respondents source seed or larvae from outside the United States.

Three of seven respondents had difficulty accessing seed and larvae over the past five years, attributed to a lack of in-demand strains. Five of six plan to expand seed and/or larvae production in Humboldt Bay over the next five years. These plans are based on growing demand, lower cost and operational footprint compared to market-size grow-out and interest in producing new strains, including triploid Pacific oysters, native Olympia oysters and Atlantic oysters. In 2024, fewer respondents experienced challenges accessing seed and larvae compared to 2016.

Seed production did not expand uniformly across the industry. One smaller producer became less competitive on price as larger operations entered the Bay, leveraging economies of scale.

Respondents emphasized that Humboldt Bay's high-health status is what makes it a key nursery for the U.S. West Coast's shellfish industry. Multiple growers identified the introduction of Ostreid herpesvirus-1 (OsHV-1) as the greatest existential threat to the bay's seed production. According to respondents, the virus causes 50% mortality in market-size oysters in Tomales Bay and has been detected in other California ports. One grower said, "If a disease gets into Humboldt Bay, all outside seed sales will stop."

While not an official classification this report uses the term 'high-health status', adopted from local shellfish business owners, to describe Humboldt Bay's long-standing disease-free history and continued ability to meet testing and biosecurity requirements that enable businesses to obtain approval to import seed to other states. Washington, which had the highest sales volume of farmed shellfish in the U.S. in 2023, and is the primary destination of seed exported out of Humboldt Bay, has strict biosecurity measures in place to protect their industry from disease. According to the Washington Department of Fish and Wildlife's

(WDFW), anyone seeking to import live shellfish into Washington from out of state for aquaculture purposes must undergo valid infectious shellfish disease agent testing every 12 months ('health certification') and have a WDFW-approved biosecurity plan in place (or operate under a 'High Health Plan'). This testing includes screening for OsHV-1 and other infectious diseases, and additional sampling may be required based on events or actions within the West Coast commerce region (AK, BC, WA, OR, and CA) and Hawaii that the WDFW deems a risk of disease introduction. Humboldt Bay is the only location in California listed as an approved source for import of Pacific and Kumamoto oyster, and Manila Clam seed into Washington.[48] Similar testing requirements exist at every state on the U.S. West Coast, all which Humboldt reportedly exported to in 2024. Section 4.9 discusses respondents concerns around biosecurity further.

4.7 Markets

In 2024, the seven respondents collectively sold market-sized shellfish to 177 businesses and seed produced in Humboldt Bay to 136. Sales by volume of market-sized shellfish were concentrated in California, while seed sales were distributed along the U.S. West Coast. Section 4.6 discusses the geography of seed sales.

Restaurants remained the largest sales venue for market shellfish (38% of sales in 2024), followed by wholesalers and retailers. Direct-to-consumer sales declined sharply from 16% in 2016 to 1.1% in 2024, and sales through the Arcata Oysterfest dropped from 4% to 0.1% (Table 15). The industry anticipates similar shifts toward consolidation and wholesale markets and away from restaurants and retail over the next five years (Section 4.10).

[48] Washington Department of Fish and Wildlife. (2023). WDFW shellfish import approval requirements for shellfish aquaculture. https://wdfw.wa.gov/sites/default/files/2025-08/wdfw-shellfish-import-requirements-aquaculture-2023.pdf

Table 15. Reported venues of market-sized shellfish sales by Humboldt Bay mariculture businesses, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting)

Venue of Sales	2016	2024
Restaurants	42.00%	38.10%
Retail Outlets	--	--
Wholesalers [49]	--	--
Direct to Customers	16.00%	1.10%
Arcata Oysterfest	4.00%	0.10%

Figure 7. Photograph of Humboldt Bay Provisions, local oyster bar in Eureka supplied by Aqua Rodeo Farms

In 2024, approximately 19.5% of market shellfish sold stayed in Humboldt County, while 80.5% was sold elsewhere in California (Table 16), representing a substantial shift from 2016, when 79% of market shellfish sales remained in Humboldt County and 21% went to

[49] Only two businesses surveyed reported selling product to wholesalers in 2024; to maintain confidentiality, sales to wholesalers and retail outlets are omitted. Sales to wholesalers and retail outlets were also omitted from the 2018 report.

other California markets. The shift reflects expanded distribution by Humboldt growers and strong demand for the region's shellfish in California's restaurant and retail markets.

Table 16. Reported locations of market-sized shellfish sales by Humboldt Bay mariculture businesses, 2024 (7 of 8 businesses reporting) vs. 2016 (6 of 6 businesses reporting)

Location of Sales	2016	2024
Humboldt County	79%	19%
California (not Humboldt County)	21%	81%
Outside of California [50]	--	--
Outside of U.S.	0%	0

4.8 Collaboration and Community Work

Industry engagement with the broader community and researchers increased substantially from 2016 to 2024. In 2024, businesses participated in approximately 46 Humboldt Bay-related scientific studies, community initiatives or activities, compared to 11 in 2016. Employee time dedicated to these efforts grew from 34 hours per month in 2016 to 135 hours per month in 2024. Engagement included partnerships with academic institutions, federal and state agricultural research programs, local workforce development organizations and community service organizations. Based on the hours of labor and the average compensation per employee (approximately $83,000), engagement added roughly $65,000 economic value to the local community.

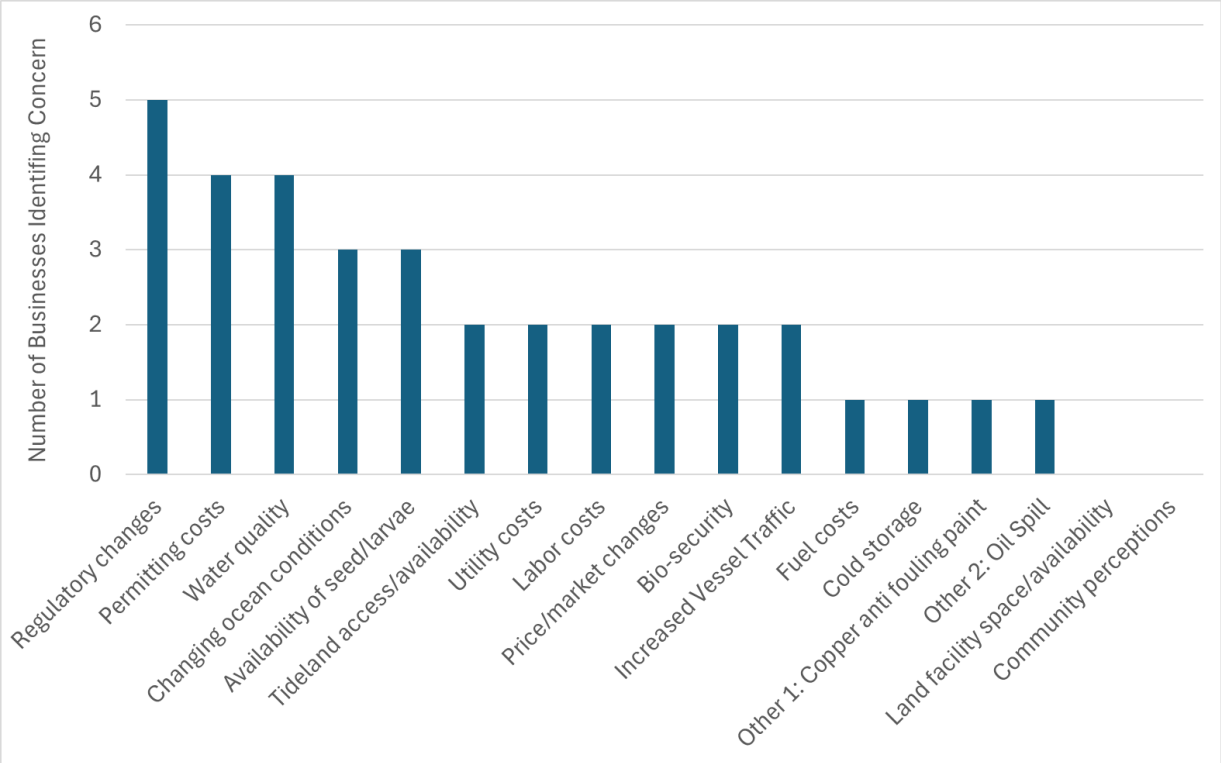
[50] Only one of the surveyed businesses reported sales outside of California, to maintain confidentiality, those businesses sales were removed from the analysis of sales distribution.

Figure 8. Photograph of Garrett Collins, operations manager, giving a tour of the Taylor Mariculture Nursery Floating Upweller Systems (FLUPSYs) in Humboldt Bay to a group of community representatives.

4.9 Concerns for the Future

In 2024, respondents identified regulatory changes, permitting costs, water quality, changing ocean conditions, and availability of seed and larvae among their top five concerns related to the future of their shellfish mariculture business. Tideland access and availability, utility and labor costs, price and market changes, biosecurity, and increased vessel traffic were lesser concerns, while fuel costs, cold storage, copper antifouling paint, and the risk of oil spills were each noted by one respondent (Figure 11). However, many of these concerns overlap and grouping them creates a clearer picture.

Figure 9. Reported perceived industry threats in 2024: number of businesses that listed each concern within their top five concerns for the future of the shellfish mariculture industry in Humboldt Bay.



Respondents ranked their concerns based on several themes: increasing costs and regulatory burdens, water quality in the bay, biosecurity, changing ocean conditions ,and compounding stressors. A number of respondents directly tied these concerns to potential impacts from the proposed Humboldt Bay Offshore Wind Heavy Lift Marine Terminal project.

Costs and regulatory burdens. Respondents identified rising fuel, labor, utility, and permitting costs among their top five concerns. Permitting costs were a primary concern after regulatory changes. Participants described regulation as slow and costly, and they expressed concern that requirements will increase over time. One participant said regulatory and permitting costs are increasing at a much higher rate than product price, compounded by "the regulatory burden coupled with reduced regulatory support." Smaller operators stated requirements for a small business are roughly the same as for large

businesses, and maintaining records and permits leaves limited time for farming. This pattern is documented beyond Humboldt Bay: van Senten et al. (2020) found California has the highest shellfish regulatory costs of any Pacific coast state — averaging $125,072 per farmed hectare, more than double the next-highest state — and that smaller-scale producers carry a disproportionately greater per-hectare burden, since largely fixed compliance costs are spread across less production. [51] Section 4.4 identifies these cost burdens under Expenditures , which demonstrates significant increases in labor, utility, leasing , environmental permitting and monitoring costs.

Water quality. Four respondents identified water quality as a primary concern after permitting costs. Two respondents wrote “oil spills” and “anti-fouling paint,” which pose a direct risk to water quality. One respondent said, "We grow a raw food product in our waterways. Quality and ability to harvest is directly tied to water quality." Another stated, "We need clean water to grow our product, so that takes top priority." Participants noted rainfall-related closures and sewage spills are ongoing constraints to production potential, which magnify other cost constraints and burdens. These responses underscore that water quality is not simply an environmental concern, but the foundation of shellfish production.

Biosecurity. Two respondents stated Humboldt Bay's high-health status is the most important factor that makes it a key nursery for the U.S. West Coast's shellfish industry. Other respondents mentioned the threat of disease as other key concerns and two identified increased vessel traffic as a top concern. Multiple respondents identified the potential introduction of Ostreid herpesvirus-1 as the most significant risk to the bay. Respondents perceived biosecurity risks to be directly related to increased vessel traffic, also a top concern. Respondents noted the bay's uniquely strong tidal exchanges and healthy stable ecosystems, combined with its high-health status make it uniquely suited

[51] van Senten, J., Engle, C. R., Hudson, B., & Conte, F. S. (2020). Regulatory costs on Pacific coast shellfish farms. Aquaculture Economics & Management, 24(4), 447–479. https://doi.org/10.1080/13657305.2020.1781293

for shellfish seed cultivation, and that maintaining current operations and growth plans is not viable in any other California bay.

In Australia, economic impacts from OsHV-1 microvariant outbreaks were severe. In the Georges River estuary outbreak, all three farms ceased production within days of a mass mortality event, and after the 2013 Hawkesbury River outbreak only three of 14 businesses continued oyster production. In Tasmania, the 2016 OsHV-1 outbreak's direct cost exceeded AUS$12 million and roughly 80 people lost their jobs. The virus also cut seed supply from Tasmanian hatcheries to South Australian farmers, leaving them short of market-sized oysters one to two years later. The situation is still considered unresolved. [52]

Changing ocean conditions. While three respondents ranked changing ocean conditions as among their top five concerns, the majority of respondents acknowledged it as a concern. Respondents linked changing ocean conditions to downstream effects, including ocean acidification and summer oyster mortality syndrome due to compounding environmental stressors. One respondent said changing ocean conditions will, and have already affected, seed availability. This is an example of how impacts to the seed supply chain cascade through the broader industry.

Port development and the Heavy Lift Marine Terminal. Concerns over biosecurity, anti-fouling paint, oil spills and increased vessel traffic may account for emerging concerns regarding the proposed Humboldt Bay Offshore Wind Heavy Lift Marine Terminal and related port-development activities. Respondents stated increased out-of-area vessel traffic could introduce diseases into the bay, with potentially catastrophic consequences to nurseries and seed production. Respondents also noted the terminal's potential threat to water quality, as anti-fouling paint is under consideration for use on the turbines' floating foundations

[52] Fuhrmann, M., Castinel, A., Cheslett, D., Furones Nozal, D., & Whittington, R. J. (2019). The impacts of ostreid herpesvirus 1 microvariants on Pacific oyster aquaculture in the Northern and Southern Hemispheres since 2008. *Revue Scientifique et Technique (International Office of Epizootics), 38*(2), 491–509, at 500. https://doi.org/10.20506/rst.38.2.3000

These concerns highlight the industry's exposure to economic and environmental pressures, compounding tight margins and limited control over operational disruptions. Despite these risks, the industry has grown, and several respondents expressed long-term commitments to the bay. Many of these businesses are family-owned. One respondent said they hope to grow their business to create a legacy that lasts for generations. Another plans to expand infrastructure and presence in Humboldt Bay because it remains the only viable location in California. While the industry has concerns about potential threats, it must substantially invest in the bay's long-term future, a dynamic that elevates the stakes for how threats are managed going forward.

Figure 10. Photograph of Hog Island Oyster Co. hatchery manager, Juan Avellaneda, cleaning the facility's greenhouse between two rows of microalgae used to feed the oyster larvae.

4.10 Projections for the Next Five Years

Survey participants responded with cautious optimism regarding operational changes over the next five years. Most businesses expected to maintain operations or expand. Results suggest expansion is contingent on access to clean water and adequate tidelands, protection from biosecurity threats, and management of overall costs.

Employment. Six businesses expected workforce changes over the next five years, projecting full-time employment in their Humboldt Bay operations to increase 75% due to growth, citing nursery expansions, favorable regulatory and market conditions, or improved use of existing resources.

Equipment and facilities. Respondents anticipate modest, targeted equipment investments over the next five years, including new boats, additional FLUPSYs, expanded pumping capacity, clam tray rafts, electric sorters, and refrigerated cold storage.

Production and methods. In narrative comments, three of four respondents expected to double or triple seed and market shellfish output over the next five years. One respondent expected to increase market-sized shellfish production by 250%. Additionally, respondents plan to expand or diversify production methods, including longlines, intertidal floating flip bags, additional FLUPSYs, tray rafts, and grow-out baskets. Most of these modifications are contingent on acceptable permit amendments.

Markets and revenue. Growth strategies among respondents included expanding direct sales, securing additional wholesale accounts, growing seed sales and broadening market reach. Looking at projected venue shifts for market shellfish, respondents anticipated maintaining or reducing sales to restaurants and retail outlets, with several being intent on entering or expanding wholesale markets. Direct-to-customer sales projections were a mix of anticipated increases and decreases.

5.0 Economic Contribution Assessment

The economic contribution assessment of the Humboldt Bay shellfish industry is based on survey results from 7 of 8 businesses operating locally, and all values are reported in 2026 dollars.

This assessment found that the mariculture industry in 2024 directly supported 60 individual jobs (57 FTEs), generated approximately $4.8 million in local labor income, $187 thousand in taxes, and $4.7 million in net business income, totaling $9.7 million in value

added to the economy. The industry spent approximately $6.1 million on intermediate inputs – consumable goods and services – resulting in approximately $15.8 million in direct industry output. This output excludes capital expenses, which are assumed not to be consumed within the year analyzed, i.e., durable assets such as vessels, buildings, and upweller systems that provide productive value across multiple years rather than being used up in a single season.

An economic contribution assessment captures both the direct contributions of the industry and the indirect and induced effects generated when those direct dollars circulate through the regional economy. Following the methodology used in Richmond, et al. (2018), this study applies a total economic multiplier of 1.97, originally developed by Northern Economics, Inc. (2013) [53] for the California shellfish industry. This means that each dollar of direct economic activity generated by the industry is expected to produce an additional $0.97 in indirect and induced economic activity in the surrounding region. Applying this multiplier to the $15.8 million in industry output in 2024 yields a total economic output of approximately $31.1 million.

[53] Northern Economics, Inc. (2013). *The economic impact of shellfish aquaculture in Washington, Oregon and California*. Prepared for the Pacific Shellfish Institute. https://www.pacshell.org/pdf/Economic_Impact_of_Shellfish_Aquaculture_2013.pdf

Table 17. Reported contributions of the Humboldt Bay shellfish mariculture industry based on survey results in 2024 (7 of 8 businesses reporting) and 2016 (6 of 6 businesses reporting) (2026 dollars)

Economic Indicator	2016	2024	Change
Businesses	6	8	2
Jobs (FTEs)	100	57	-43%
Payroll	$4,138,296	$4,758,559	15%
Taxes	$334,125	$187,208	-44%
Net business income	$930,991	$4,712,884	406%
Value Added	**$5,403,412**	**$9,658,651**	**79%**
Intermediate inputs	**$8,092,012**	**$6,134,371**	**-24%**
Direct Industry Output	**$13,495,424**	**$15,793,022**	**17%**
Total Economic Output (1.97 multiplier)	**$26,585,985**	**$31,112,254**	**17%**

The multiplier was developed from statewide California data, and reflects economic output across the state not what activity actually retained in Humboldt County. However, the survey data can be used to estimate how much of the industry's spending stays in the region. According to survey results, the industry spent an estimated $1.63 million on local goods and services. All 57 jobs are local positions and the $4.76 million in labor income is paid to local workers. Respondents also spent roughly $833 thousand to lease facilities locally for their operations. This results in approximately $7.22 million in direct local spending (Table 18). To maintain confidentiality net business income is not reported as being local or going out of region.

Table 18. Reported local expenditures of the Humboldt Bay shellfish industry in 2024 (seven of eight businesses reporting)

Local Expenditures	2024
Payroll	$4,758,559
Local Goods and Services (excluding shellfish seed)	$1,626,940
Facility Leases	$833,356
Direct Local Spending	**$7,218,855**

This local spending figure in Table 18 reflects gross dollar flows within the region. Locally-sourced seed is excluded to avoid double-counting inter-business transactions within Humboldt Bay. Taxes were reported as either state/local or federal, and so were also excluded from local spending. This local spending generates additional indirect and induced activity as those dollars circulate through the regional economy.

The research team was provided access to data from the 2016 survey conducted by Richmond et al. (2018) to calculate and compare results (Table 17). Compared to 2016, the number of reported jobs supported by the industry in 2024 declined by 43%, taxes paid declined by a reported 44%, and the amount spent on intermediate goods and services declined by 24%. At the same time, labor income increased 15%, and with an increase in revenue and decline in expenditures, net business income increased substantially by 406%. As a result, the value added by the industry increased by 79%, and total economic output by 17%. However, the 2016 report included data from all 6 existing businesses in Humboldt Bay, whereas the 2024 report includes data from 7 out of 8 businesses, indicating that the economic contributions from 2024 are underreported by an unknown amount. It is possible that the unresponsive business operated at a loss in 2024, which could lower value added (through negative net business income) without reducing output, since output reflects revenue rather than profitability.

Furthermore, we can conclude that the true economic contribution of the industry is greater than just total economic output listed above, as it does not consider: (i) the downstream contributions of the Humboldt Bay seed production to the larger industry, (ii) unreported economic activity outside of Humboldt Bay by larger vertically integrated firms, or (iii) additional cultural and community benefits – including events and associated tourism. These factors are explored in more depth below.

Contributions from shellfish seed production. Economic multipliers capture contributions of the backward linkages of an industry, namely the goods and services it purchases from suppliers and the household spending induced by its wages. They are not

designed to capture forward linkages, that is, the downstream activity dependent on an industry's output as a critical input. The multiplier used in this analysis therefore reflects the purchases made by Humboldt Bay's operators but not the downstream market-sized shellfish production at the farms that rely on Humboldt Bay seed. Because Humboldt Bay supplies seed to more than half of all shellfish farms on the U.S. West Coast (as reported in Section 4.6), these forward linkages are a critical component of the region's economic significance.

Quantifying these forward linkages – or downstream impacts – is difficult, as there is limited data on the scale of seed production and consumption across the U.S. West Coast industry, which makes it hard to precisely estimate either the industry's reliance on Humboldt Bay seed or the economic contribution that seed represents. To approximate its scale, this report combines self-reported seed production data from the 2024 survey (Appendix A), USDA 2023 Census data, a review of the literature on species mortality, and Engle et al.'s 2025 economic contribution study of aquaculture in the U.S. Western Region.

As established in Section 4.6, nurseries in Humboldt Bay may account for an estimated 46% of U.S. market-size production across the three locally produced species. According to USDA 2023 Census data [54], Manila clams, Pacific oysters, and Other oysters (used here as a proxy for Kumamoto) accounted for approximately 82% of the U.S. West Coast shellfish industry's sales revenue in 2023, which contributes to a regional shellfish industry that in the previous year (2022) had generated $360 million in total output and 4,119 jobs.

Combining these figures yields a rough estimate of the portion of the industry that might depend on Humboldt Bay seed as a primary input. If these three species represent 82% of output, and Humboldt Bay supplies seed for 46% of their market-size production, then Humboldt Bay seed is the primary supply input to approximately 38% of the U.S. West

[54] U.S. Department of Agriculture, National Agricultural Statistics Service. (2024). 2023 Census of aquaculture (Table 7, "Mollusk Production and Sales by Species and Size Category – United States: 2023"). https://www.nass.usda.gov/Publications/AgCensus/2022/Online_Resources/Aquaculture/aqua_1_007_007.pdf

Coast shellfish industry (0.82 × 0.46). This is equivalent to an estimated $88.9 million in market-size shellfish production, $155.5 million in total economic output, and1,560 jobs, supported through forward linkages. This estimate rests, however, on the assumption that a species group's share of sales revenue from market-sized shellfish is equivalent to its share of total economic output, and compares that output across different years. That assumption is imperfect since revenue structures vary across species, regions, farms, and season, so the figure above should be read as an order-of-magnitude indication rather than a precise value.

While the magnitude is uncertain, it is significant. Humboldt Bay seed is a primary input to a substantial portion of the U.S. West Coast shellfish industry. The loss of that input would cascade beyond Humboldt Bay's direct linkages. In the case of disease introduction, the loss would likely be irreversible. This exposure is compounded by the lack of substitute estuaries. According to respondents, no other bay in California could support a comparable seed industry today. Beyond the direct economic stakes, geographic diversity of hatcheries and nurseries, like Humboldt, makes the industry more resilient to supply shocks.

The ocean acidification events beginning in 2007 offer a precedent: they caused mass larval mortality at hatcheries and nurseries across the West Coast, marked the first documented economic impact of ocean acidification in the United States, and are estimated to have cost the U.S. Pacific Northwest shellfish industry nearly $110 million while directly or indirectly jeopardizing approximately 3,200 jobs. [55]

Additional community and cultural benefits. Beyond measurable economic output, the Humboldt Bay shellfish industry provides community and cultural benefits that are difficult to quantify but important to the region's identity. A clear example is the Arcata Bay Oyster Festival, which marked its 35th year in 2025 and drew roughly 15,000 attendees. The

[55] Ekstrom, et.al. (2015). Vulnerability and adaptation of US shellfisheries to ocean acidification. Nature Climate Change, 5(3), 207–214. https://doi.org/10.1038/nclimate2508

festival honors the region's aquaculture heritage and the local food and beverage scene, featuring the people who work in these industries and the marine life they harvest.

Figure 11. Photograph of Scott and Grace Sterner, owners of North Bay Shellfish, and their son Kyle promoting the first annual Arcata Oyster Festival in 1990. [56]

According to a 2025 KHSU interview with Gloria Baker, operations and events manager for the Arcata Chamber of Commerce, about 60% of attendees came from outside Arcata, Eureka, and McKinleyville, with people reportedly traveling from across the country to attend. The festival in 2025 hosted around 15 oyster vendors, 20 food vendors, and 45 artisan vendors, alongside numerous nonprofit organizations. [57]

Additionally, local shellfish businesses contribute to the California North Coast region through volunteerism and community engagement. In 2024, Humboldt Bay shellfish businesses dedicated roughly 1,620 employee hours to local scientific studies, community initiatives and partnerships with academic institutions, agricultural research programs,

[56] Randy Thieben, Photograph, *The Times-Standard* (Eureka, CA), 1990
[57] McGeary, S., & Zepeda, A. (2025, June 10). North Coast Conversations: Oyster Festival 2025 [Audio segment]. KHSU. https://www.khsu.org/show/north-coast-conversations/2025-06-10/north-coast-conversations-oyster-festival-2025

workforce development groups and community service organizations. In 2024, this effort added approximately $65,000 in benefits to the local community.

Economic activity outside of region. To maintain confidentiality due to a lack of responses to questions regarding operations outside of Humboldt, this analysis also does not fully capture economic contributions of some of the larger vertically integrated businesses, e.g. the production of seed exported to grow-out areas outside of the area, or market-sized shellfish going to the restaurants and bars of the same company in or outside of the region.

To maintain confidentiality, this report does not attempt to quantify those impacts, and it is important to recognize that they are not fully captured in this report.

6.0 Conclusion

In 2024, the Humboldt Bay shellfish mariculture industry directly supported 57 FTE jobs, generated approximately $4.8 million in labor income, $9.7 in value added, $10.2 million in local spending, and $31.1 million in total economic output. These figures are conservative estimates and likely understated. They are based on data from seven of eight operating businesses and do not capture economic activity directly generated through vertically integrated operations extending outside Humboldt County or the contribution of Humboldt Bay shellfish seed production to the larger industry. Additionally, the industry provides community and cultural value to the region through volunteer partnerships and annual events and activities featuring the industry's history and prominence in the bay.

Since 2016, the industry has restructured. Total employment and market-sized oyster production have declined, while the number of businesses, revenue, labor income, seed production, and total economic output have increased. These trends are consistent with a shift toward larvae production and reduced market-sized shellfish production.

In 2024, approximately 95% of the 459 million units of seed produced in the region were primarily distributed to farms in Washington, Oregon and Alaska. Combining survey data

with USDA census production figures, it is estimated Humboldt Bay accounts for roughly 46% of U.S. market-size production across the three species it seeds — Pacific oyster, Kumamoto oyster and Manila clam — and its seed serves as the primary supply to approximately 38% of the region's shellfish industry by economic output. While these estimates are uncertain given the limited data on U.S. West Coast seed production, they indicate that Humboldt Bay has significant downstream economic contributions to the U.S. West Coast industry. This report estimates the value of this downstream economic activity at approximately $155.5 million in annual economic output and supporting over 1,500 jobs.

Several key expenditures increased between 2016 and 2024, even though total expenditures and output declined. Regulatory changes were the most frequently cited concern. Permitting was described as slow and costly with disproportionate compliance burdens on smaller operators. These cost pressures, often largest amongst smaller farms, suggest individual businesses may have limited capacity to absorb additional disruptions.

The majority of respondents plan to expand operations over the next five years. However, growth is contingent on favorable regulatory conditions, biosecurity, and the ecological health and stability of Humboldt Bay, which depends on its water quality and high-health status. Multiple respondents identified the potential introduction of OsHV-1 as a significant threat to the U.S. West Coast industry. Introduction of this virus would cause mass mortality of shellfish and halt seed export, with reportedly no other viable location for similar nursery operations. Respondents frequently cited biosecurity, water quality, increased vessel traffic, and environmental impact concerns in relation to the proposed Humboldt Bay Offshore Wind Heavy Lift Marine Terminal project.

Additional details on the U.S. West Coast shellfish seed production would improve the ability to estimate the industry's full economic contribution to the region. Ongoing, periodic replication of this survey would also enable the industry to better track and communicate its economic conditions over time.

Glossary of Terms

Definitions are drawn from the usage and context of this report. Shellfish mariculture terms appear first, followed by economic and analytical terms.

Shellfish and Mariculture Terms

Biosecurity. Practices and conditions that prevent the introduction and spread of diseases, pests, and invasive organisms.

Broodstock. Sexually mature adult shellfish selected and held for reproduction, whose spawning produces the gametes used to generate larvae in a hatchery.

Cultch. The material, typically whole or ground oyster shell, onto which oyster larvae attach and settle. Large shell is termed cultch and finely ground shell microcultch; the latter allows production of single oysters.

Downweller. A land-based nursery tank in which water flows downward through a screen holding young shellfish, used alongside upwellers in hatchery and nursery operations.

Estuary. A partly enclosed coastal body of water where freshwater from rivers mixes with seawater. Humboldt Bay is the second largest estuary in California and the setting for the industry.

Floating Upweller System (FLUPSY). A floating nursery structure in which pumped seawater is forced upward through containers of juvenile shellfish, delivering natural phytoplankton and promoting rapid growth.

Gametes. The reproductive cells (eggs and sperm) released by spawning broodstock and combined to produce larvae in the hatchery.

Grow-out. The process of raising shellfish from seed to harvestable market size. May occur on the same farm that produced the seed or at a separate operation, including farms outside Humboldt Bay.

Hatchery. A facility where broodstock are spawned and the resulting larvae are reared in culture tanks on live microalgae until they reach the pediveliger stage. Only one hatchery operates in Humboldt Bay.

High-Health Status. A term adopted from Humboldt Bay shellfish growers to describe the bay's long standing disease free history and continued ability to meet the requirements to import live shellfish for aquaculture into other states. Under the Washington Department of Fish and Wildlife this includes: valid infectious shellfish disease agent testing every 12 months ('health certifications') and a WDFW-approved biosecurity plan (which may be satisfied by an existing High Health Plan).

Intertidal. The zone of shoreline exposed at low tide and submerged at high tide. Market-size oyster production in Humboldt Bay currently occurs on intertidal beds.

Larvae. The free-swimming early life stage of shellfish, reared in a hatchery. Oyster larvae are fed live microalgae for roughly 18 to 21 days until they reach the pediveliger stage and are ready to set.

Mariculture. The farming of marine organisms, here shellfish, in natural coastal habitats such as bays and estuaries. A marine subset of aquaculture.

Market-sized shellfish. Shellfish that have grown large enough to be sold for consumption, as distinct from seed or larvae.

Microalgae. Microscopic phytoplankton grown as live feed for larvae and juvenile shellfish in hatchery and nursery operations.

Mortality rate. The proportion of shellfish that die before reaching market size.

Nursery. The production stage in which set spat, once retained on a 2 mm mesh screen, are grown, often in a FLUPSY or nursery raft, on raw seawater and natural phytoplankton until they reach seed size (up to about 36 mm).

Ocean acidification. The decline in seawater pH caused by absorption of atmospheric carbon dioxide, which impairs shell formation in larvae and has other environmental impacts.

Ostreid herpesvirus-1 (OsHV-1). A virus, including microvariant strains, that causes high mortality in oysters, especially juveniles.

Pediveliger. The final larval stage of an oyster, at which the larva develops a foot, is competent to settle, and can be collected and sold for setting.

Rack-and-bag culture. A grow-out method in which oysters are held in mesh bags supported on racks above the bay bottom in the intertidal zone. One of several culture methods used in Humboldt Bay.

Remote setting. A technique in which hatchery-produced larvae are shipped elsewhere and induced to settle (set) on cultch at the growing site.

Seed. Juvenile shellfish, grown from set spat, that are large enough to plant for grow-out or sell to other farms (in Humboldt Bay, up to about 36 mm).

Setting (set). The stage at which pediveliger larvae attach to a surface and metamorphose into sessile juveniles. After settling, they are termed spat.

Spat. Newly settled juvenile shellfish, produced when larvae set. Spat are grown on upwelling tables until they can be retained on a 2 mm mesh screen, after which they are moved to the nursery and termed seed.

Triploid. A shellfish bred to carry three sets of chromosomes rather than two, typically rendering it sterile so that energy goes to growth rather than reproduction.

Tumbler / Sorter. Mechanical equipment used to grade shellfish by size and to condition their shape during grow-out.

Upweller. A tank or system in which seawater is pumped upward through containers of juvenile shellfish to deliver food and promote growth.

Economic and Analytical Terms

Backward linkages. The purchases an industry makes from its suppliers, plus the household spending induced by the wages it pays. Standard economic multipliers capture these upstream effects. Contrast with forward linkages.

Capital expenditures. Spending/investment on durable, long-term assets such as vessels, buildings, and equipment that provide value over many years. Because they are not consumed within a single year of production, they are excluded from annual economic output and value-added calculations in this report.

Consumer Price Index (CPI). A U.S. Bureau of Labor Statistics measure of the average change in prices paid by consumers over time. Used here to adjust 2016 and 2024 dollar figures for inflation so they can be compared and reported in constant 2026 dollars.

Direct industry output. The value of goods and services produced by the industry itself, equal to value added plus intermediate inputs. It reflects revenue from production before the multiplier is applied.

Forward linkages. The downstream economic activity that depends on an industry's output as a critical input. Standard multipliers do not capture these. In this report, farms that rely on Humboldt Bay seed represent forward linkages.

Full-time equivalent (FTE). A standardized measure of employment equal to one full-time job at 2,080 hours per year.

Indirect effects. Economic activity generated when an industry purchases goods and services from its suppliers, who in turn make their own purchases.

Induced effects. Economic activity generated when workers in an industry (and its suppliers) spend their wages on household goods and services in the region.

Intermediate inputs. Goods and services purchased from other industries and consumed within a single year of production; distinct from durable capital goods.

Labor income. Total employee compensation generated by the industry, including wages and payroll.

Economic multiplier. A factor that scales direct economic activity up to a total that includes indirect and induced effects.

Total economic output. Direct industry output plus all indirect and induced activity generated as the industry's spending and wages circulate through the regional economy. In this report total economic output is calculated using an existing economic multiplier.

Value added. An industry's own contribution to economic output, equal to the sum of labor income, net business income, and taxes on production.

Vertically integrated. Describing a business that controls multiple stages of the production and supply chain.

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APPENDIX A

Copy of the Humboldt Bay Shellfish Mariculture Survey

Introduction

Your business has been invited to participate in the **2025 Humboldt Bay Shellfish Mariculture Survey** being conducted through California Sea Grant and the Schatz Energy Research Center. This survey builds upon the 2018 Humboldt Bay Shellfish Mariculture Business Survey conducted by Cal Poly Humboldt, with many questions repeated to allow for a comparison of changes in the industry over time. **The data collected will inform an economic baseline study for the industry, helping to quantify and highlight the economic contributions of Humboldt Bay's mariculture sector at both the local and regional levels.** This information may also support the Humboldt Bay mariculture business community in ongoing planning efforts, particularly in relation to the proposed Humboldt Bay Offshore Wind Heavy Lift Marine Terminal or other port development project. This survey is designed for shellfish growers, nurseries, and hatcheries, and not all questions will be applicable to every operation.

This survey may take between **1–2 hours** to complete, depending on the availability of information and the size of your operations inside and outside of Humboldt Bay. To help reduce the amount of time needed to complete this survey, you may want to gather relevant documentation or identify personnel who can provide the following information before starting the survey:

- **Employment** – Number and types of jobs inside and outside of Humboldt Bay
- **Tidelands** – Acreage and lease rates of tidelands in Humboldt Bay
- **Facilities & Equipment** – Type, quantity, and uses of equipment and facilities deployed in Humboldt Bay
- **Expenses** – Amount of expenses by line item and future estimates in Humboldt Bay
- **Production** – Shellfish production by species, volume, product type, and method of production in Humboldt Bay
- **Revenue** – Amount of revenue by product type, activity/service, and geography inside and outside of Humboldt Bay
- **Markets** – Sources and destinations of products, seed, and inside and outside of Humboldt Bay.
- **Collaborative Work** – Volunteer work and collaborative efforts in Humboldt Bay
- **Future Threats** – Company's perspectives on future threats to operations in Humboldt Bay.

Each section also includes space for additional comments, particularly about future outlooks, to provide context on industry perspectives and anticipated change.

This survey may be followed up by a 10-minute questionnaire to gain a better understanding of businesses' perspectives related to port development activities.

Confidentiality

Your responses will be kept confidential. Please do not write your name or your business name on the questionnaire. Survey results will be aggregated and anonymized to protect the privacy of individual businesses. Any personal or sensitive information will not be published or shared.

Risks & Benefits

There are no known risks to participating in this survey. There is no direct benefit to you; however, your participation will help provide valuable baseline data that supports the long-term sustainability of the mariculture industry in Humboldt Bay.

Contact Information

If you have any questions about this survey, please contact Tanner Etherton, tanner.etherton@humboldt.edu, (805) 602-8164, or Arne Jacobson, arne.jacobson@humboldt.edu.

Consent

By participating, you confirm that:

- You are 18 years or older.
- You have read and understand the information above.
- You voluntarily agree to participate.
- You understand your responses will remain anonymous and confidential.

Please indicate that you have been made aware of the research process and your rights as a participant, and that you consent to the research process described in the letter included with this survey.

[] By checking this box, I consent to the research process described in the letter included with this survey and acknowledge that I have been made aware of my rights as a participant in this survey.

Please do not write your name or the name of your business on this survey.

List of Questions:

The survey questions below were reformatted and simplified from the original survey instrument into the folwoing list of questions to meet accessibility standards.

Section A. Employment

1. **Number of employees, by where employees live and work. Please provide counts for 2024 and your estimate for 5 years out, broken down as follows:**
    - Humboldt Bay Region — full-time and part-time
    - Outside Region — full-time and part-time
2. **Number of different types of employees in the Humboldt Bay region in 2024 (one employee can only be counted in one category; select the most appropriate):**
    a. Owner/Operators
    b. Managers/Supervisors
    c. Laborers/Farm Hands
    d. Marketing/Sales
    e. Maintenance/Safety
    f. Delivery
    g. Other (please list category or categories)

    Comments on employees and anticipated change in employment in the next 5 years:

Section B. Tidelands

3. **Tidelands (grow-out grounds) permitted for aquaculture and under your control. Please provide, for both inside and outside Humboldt Bay, the 2024 acres leased, 2024 acres under cultivation, and your estimates for both 5 years out:**
    - Number of acres in Humboldt Bay
    - Number of acres outside of Humboldt Bay
4. **Lease rate: dollars per acre per year you paid in 2024.**
5. **Does your company sublease acreage to another company in Humboldt Bay? (Yes/No)**
    a. If yes, how many acres did your company sublease in 2024, and at what rate (dollars per acre per year you charge)?

    Comments on tidelands and anticipated change over the next 5 years:

Section C. Facilities and Equipment

6. **Number of buildings/facilities/structures in Humboldt Bay that your company owned or leased in 2024 (please provide the number and total square footage).**
7. **Equipment in Humboldt Bay that your operation owned in 2024:**
    a. Number of boats/vessels your business owns
    b. Number of FLUPSYs your business owns
    c. Number of land-based upwellers/downwellers your business owns
    d. Number of tumblers/sorters your business owns
    e. Estimated amount of cold storage space, in square feet (not including insulated totes)
8. **Estimated annual electrical load of Humboldt Bay business operations in 2024 (kWh).**
9. **Do you feel that your business has sufficient cold storage? (Yes/No)**

a. If no, how much more cold storage space would you prefer to have (square feet)?

10. **About how often does your business borrow major equipment from other businesses on the bay? (Never / Once a year / Once a month / Once a week / Daily)**
11. **About how often does your business lend major equipment to other businesses on the bay? (Never / Once a year / Once a month / Once a week / Daily)**

Comments on facilities and equipment, and anticipated changes over the next 5 years:

Section D. Expenses

12. **Approximate expenses for the 2024 calendar year related to Humboldt Bay operations. Please provide the 2024 amount and your estimate for 5 years out for total expenses and for each category below:**

Total expenses is likely more than the sum of the categories below.

- Labor expenses: total payroll; total non-wage benefits
- Taxes: federal; state & local
- Environmental monitoring/permitting: permit fees; monitoring fees
- Health compliance/permitting: permit fees; compliance fees
- Other expenses: facility leases/mortgage; capital expenditures (not debt services, includes gear purchases); seed; larvae; market-ready shellfish; repair & maintenance; ice; insurance carriers; freight; gas/fuel; electricity; other utilities

Comment on expenses and the extent to which you believe these will change in the next 5 years:

Section E. Production

13. **Production. Please specify units produced in 2024 for each category (Humboldt Bay only). For each species, provide total volume and the breakdown across product types:**

If you select "other" below, please list the name of the product(s).

- Species: Pacific Oysters; Kumamoto Oysters; Manila Clams; Mediterranean Mussels; Other (up to three)
- Product type for each: total volume; fresh whole; shucked/jarred; frozen; other; seed or larvae (please also specify the unit of measure)

14. **Please list the shellfish culture methods your business uses in Humboldt Bay, along with the approximate percentage each method represents in your overall operations.**

For example: intertidal longlines, stakes, hanging baskets, rack-and-bag, FLUPSY, etc. You may list up to seven methods.

Comment on Humboldt Bay production and the extent you believe these categories will change in the next 5 years and why:

Section F. Revenue

15. **Product gross sales revenue in 2024 (Humboldt Bay only). Please provide gross sales value for each of the following:**

- Pacific Oysters (market size); Kumamoto Oysters (market size); Manila Clams (market size); Mediterranean Mussels; Seed; Larvae; Other (up to two, please list)

16. **Total product sales revenue in 2024 (all operations).**
17. **Total revenue in 2024 (Humboldt Bay only).**
18. **What was your total business revenue from all operations in the U.S. in 2024?**

19. **In total, approximately how many different businesses did your business sell market-size shellfish to in 2024?**
20. **In total, approximately how many different businesses did your business sell seed and/or larvae to in 2024?**
21. **Please list non-shellfish sources of revenue your company generates in the Humboldt Bay region.**
22. **Does your company (both within and outside Humboldt Bay):**
    a. Operate another tourist attraction, such as farm tours offered on a regular basis? (Yes/No; if yes, what percentage of revenue?)
    b. Operate a restaurant, oyster bar, or retail store? (Yes/No; if yes, what percentage of revenue?)
    c. Sell branded merchandise related to your company? (Yes/No; if yes, what percentage of revenue?)
    d. Have third-party certifications? (Yes/No; if yes, which certifications does your company have?)
23. **Approximately what percentage of your total business revenue in 2024 came from activities in each of the following: Humboldt Bay region; California; Oregon; Washington; Alaska; Hawaii; the U.S.?**

    Comments on sources of revenue and anticipated changes in the next 5 years:

Section G. Markets

24. **Approximately what percentage of your Humboldt Bay produced market shellfish (not including seed & larvae), or other aquaculture products, goes to these various types of outlets? Please provide 2024 and your estimate for 5 years out for each:**
    - Restaurants; retail outlets; wholesalers; direct to customer; Arcata Oysterfest; direct to farm; other (please list)
25. **Approximately what percentage of your Humboldt Bay produced market shellfish (not including seed & larvae) is sold to these various locations? Please provide 2024 and your estimate for 5 years out for each:**
    - Humboldt County; California; Oregon; Washington; Alaska; Hawaii; United States; outside the U.S.
26. **For your operations in Humboldt Bay, what percentage of your seed/larvae came from these various locations in 2024:**
    a. Your own company's operations within Humboldt Bay
    b. Your own company's operations within the U.S.
    c. Other operations within Humboldt Bay
    d. Other operations within the U.S.
    e. Other operations outside the U.S.
27. **If you produce seed/larvae in Humboldt Bay, what percentage went to these various outlets in 2024:**
    a. Your own company's operations within Humboldt Bay
    b. Your own company's operations within the U.S. (please list the bays where these operations are located)
    c. Sold to other businesses/entities within Humboldt Bay
    d. Sold to other businesses/entities within California
    e. Sold to other businesses/entities within the U.S. (please list the bays where these businesses/entities are located)
28. **Please list any businesses/entities that you supply with seed/larvae that you would be comfortable with our research team contacting.**

Please provide the name of the business and the name and email of a good point of contact, if known.

29. **Have you experienced challenges getting seed in the past 5 years? (Yes/No) If yes, what challenges?**
30. **Do you have plans to get into or increase seed/larvae production in Humboldt Bay in the next 5 years? (Yes/No) Why?**

    Comment on Humboldt Bay production and the extent you believe these categories will change in the next 5 years and why:

Section H. Collaborations / Community Work

31. **In 2024, approximately how many Humboldt Bay-related scientific studies, community initiatives, or other engagement activities did your business participate in?**
32. **In 2024, approximately how many employee hours per month were spent on collaborative/engagement activities?**

    If comfortable, can you list the agencies, initiatives, or studies that you were or are a part of?

Section I. Future Threats

33. **Rank (in numbered order) your top five concerns/threats related to the sustainability of your mariculture business, from the following list:**
    - Tideland access/availability; permitting costs; fuel costs; utility costs; labor costs; changing ocean conditions; price/market changes; availability of seed/larvae; water quality; cold storage; land facility space/availability; community perceptions; regulatory changes; bio-security; increased vessel traffic; other (up to two, please list)
34. **Why did you prioritize the threats that you did?**

Additional Comments

Please share any additional comments about your business and anticipated future changes.