

# WRAC fact sheet

## WESTERN REGIONAL AQUACULTURE CENTER

Alaska • Arizona • California • Colorado • Idaho • Montana • Nevada • New Mexico • Oregon • Utah • Washington • Wyoming

### Characterization of Aquaculture in the Western U.S.

[wracu.org](http://wracu.org)

#### WESTERN REGION

Photo: Fish farm.

Carole Engle, Engle-Stone Aquatic\$ LLC

Jonathan van Senten, VA Seafood AREC, Virginia Tech University

Quentin Fong, Kodiak Seafood and Marine Science Center, Alaska Sea Grant

Raphael Cuevas-Uribe, Humboldt State University

Melissa Good, Kodiak Seafood and Marine Science Center, Alaska Sea Grant

The Western Region has a long history of major contributions to U.S. aquaculture, which continues to this day. The region has some of the oldest shellfish farms in the U.S., which are currently operated by a fifth generation of shellfish farmers. This region is also the birthplace of the global trout industry and the home of the first sturgeon farms and caviar production in the United States. Commercial aquaculture farms in the region raise hundreds of different species of finfish, shellfish, crustaceans, ornamental species, and algae in a variety of production systems. Finfish, crustaceans, and ornamentals, for example, are raised in open ponds, outdoor and indoor tanks, net pens, and raceways; shellfish are raised on the bottom of tidal areas, in floating and suspended bags and cages, with longlines, and on rafts.

#### The Contribution of Private Aquaculture Farms to the Economy of the Western Region

The total economic contribution of aquaculture farms in the Western Region (2022) was \$885.7 million (Table 1). Of this, \$465.3 million was from direct contributions from aquaculture farms, \$185.5 million of indirect contributions of supply chain partners, and \$235.0 million in induced output from the additional household spending from employment created. Of the total 6,002 jobs supported by aquaculture in the Western Region,

4,304 were from jobs on aquaculture farms, 568 from supply chain partners, and 1,130 were from induced effects. Additional economic contributions included \$68.6 million in federal tax revenue, \$22.2 million in state tax revenue, and \$10.0 million in local taxes (Table 2).

It should be noted that the economic contribution values in this analysis are those of the farm level. Additional impacts occur from supply chain partners, such as processors, food service companies, retailers, livehaulers, and end consumers, that may be four to seven times

Table 1. Economic contribution by type of impact.

Impact	Employment	Labor Income <sup>a</sup>	Value Added <sup>b</sup>	Output <sup>c</sup>
Direct	4,304	\$185,146,586	\$185,146,587	\$465,277,020
Indirect	568	\$45,281,860	\$79,063,138	\$185,477,068
Induced	1,130	\$75,611,959	\$140,947,799	\$234,960,872
TOTAL	6,002	\$306,040,405	\$405,157,524	\$885,714,960
Multipliers	1.39	1.65	2.19	1.90

<sup>a</sup> Employee wages, benefits, and income of business owners.

<sup>b</sup> Difference between input costs and the output (production value, typically sales revenue).

<sup>c</sup> Total annual production value, typically sales revenue.

greater than those of the farm level. For sales of baitfish and species stocked for recreational fishing, the additional economic contributions have been reported to be 36 times the value of fish purchased from

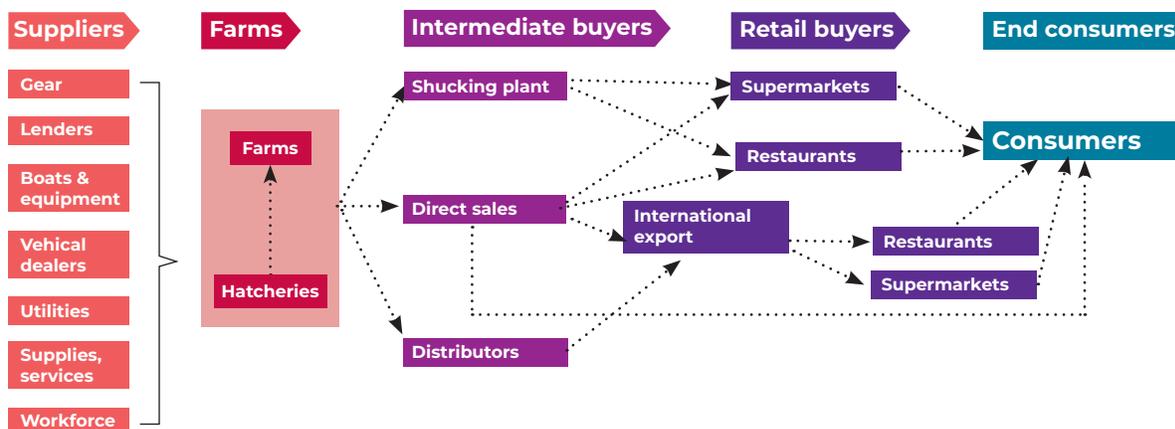
farms (Deisenroth et al., 2012). Aquaculture entrepreneurs in the region have developed diverse supply chains through which different aquaculture products move to reach the end customers and

consumers. A 2024 supply chain analysis of aquaculture businesses in the region identified 219 different supply chains for aquaculture products in the region. Figures 1a and 1b present generalized supply chain

Table 2. Economic contribution of tax revenue.

Impact	Local	State	Federal	Total
Direct	\$108,267	\$6,718,581	\$37,893,675	\$44,720,523
Indirect	\$3,577,543	\$5,602,761	\$11,196,597	\$20,376,901
Induced	\$6,265,783	\$9,889,647	\$19,493,110	\$35,648,540
TOTAL	\$9,951,593	\$22,210,989	\$68,583,382	\$100,745,964

a) Shellfish (oysters, clams, other)



b) Finfish (sold to processors, live markets, and for recreational opportunities)

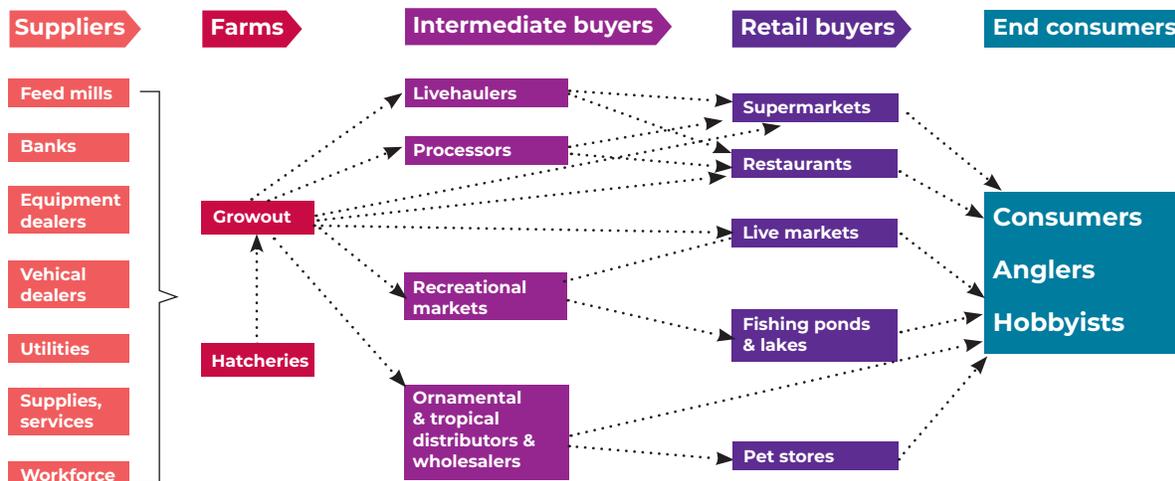


Figure 1. Generalized supply chain maps for: a) shellfish and b) finfish in the Western Region.

maps for various shellfish and fin-fish products, respectively.

The Western Region is the second-greatest aquaculture-producing region in the U.S., just behind the Southern Region. Washington led the nation in aquaculture farm sales of aquaculture products in 2022 (USDA-NASS, 2024). Western Region states also play important leadership roles in production of some of the major aquaculture species produced on U.S. aquaculture farms. For example, in the shellfish sector, Washington leads the nation in mollusk production, California ranks fifth and Oregon eighth (USDA-NASS, 2024). The Western Region plays an especially important role in the U.S. trout sector, with the top two states in farmed trout sales in 2022 (Washington and Idaho), California fourth, Oregon sixth, Colorado seventh, and Utah eighth. In addition, California farmers played a major role in developing a farmed sturgeon and caviar-producing sector in the U.S. and internationally.



Photo credit: Keri Rouse, Virginia Tech University

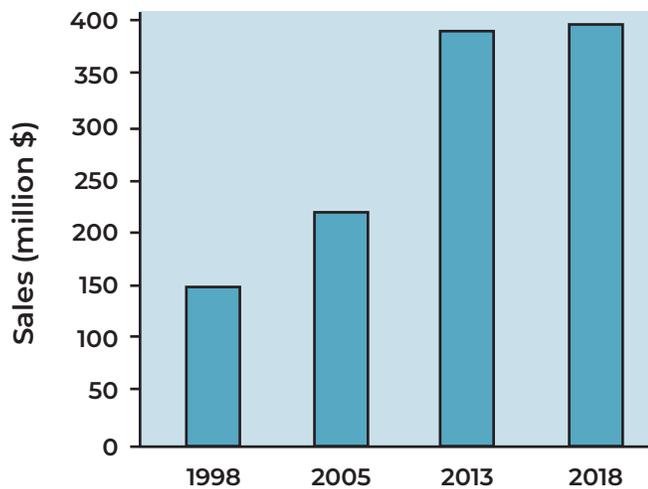
**Farmed largemouth bass displayed for sale in live fish market.**

Approximately 86% of U.S. farmed sturgeon and caviar production is in California with Idaho ranking second. California also led the nation in tilapia production in 2018, producing nearly a third (31%) of total U.S. tilapia sales with Idaho ranked fourth (USDA-NASS, 2018). More specific information on aquaculture in the aquaculture-producing states in the region can be found in the fact sheets on Alaska (Engle et al., 2024a), California (Engle et al., 2024b), Colorado (Engle and van Senten, 2024a), Idaho (Engle et al., 2024c), Oregon (Engle and van

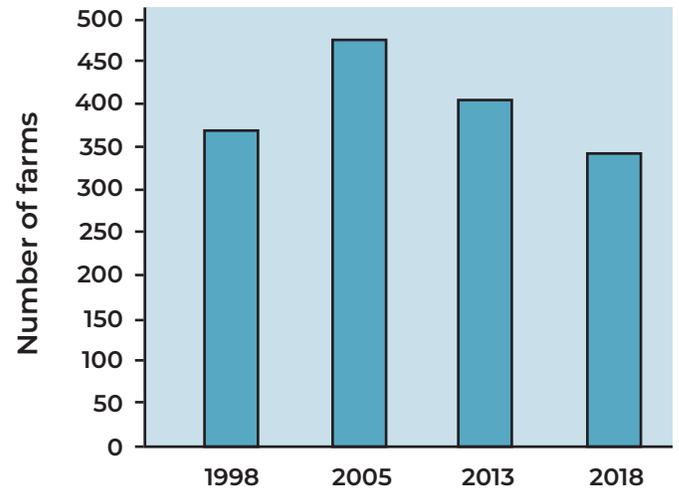
Senten, 2024b), Utah (Engle and van Senten, 2024c), and Washington (Engle and van Senten, 2024d).

Aquaculture sales in the Western Region more than doubled from 1998 to 2013, followed by an additional 2% growth from 2013 to 2018 (Figure 2a). The number of aquaculture farms in the region, however, decreased by 15% from 2005 to 2013 with an additional 16% decrease from 2013 to 2018 (Figure 2b). The leading aquaculture crop in the Western Region (by sales) is oysters, followed in descending order by trout, geoduck clams, manila

**a) sales (million \$)**



**b) number of farms**



**Figure 2. Aquaculture in the Western Region, 1998 to 2018 by: a) sales (million \$) and b) number of farms.** Source: USDA-NASS (2000, 2006, 2014, 2019)

clams, tilapia, catfish, largemouth bass, sturgeon, and hybrid carp (Figure 3a), with minor production of other aquaculture crops. There were more oyster farms in the region than of other species, followed by the number of trout, manila clam, catfish, geoduck clam, largemouth bass, tilapia, sturgeon, and hybrid carp farms (Figure 3b).

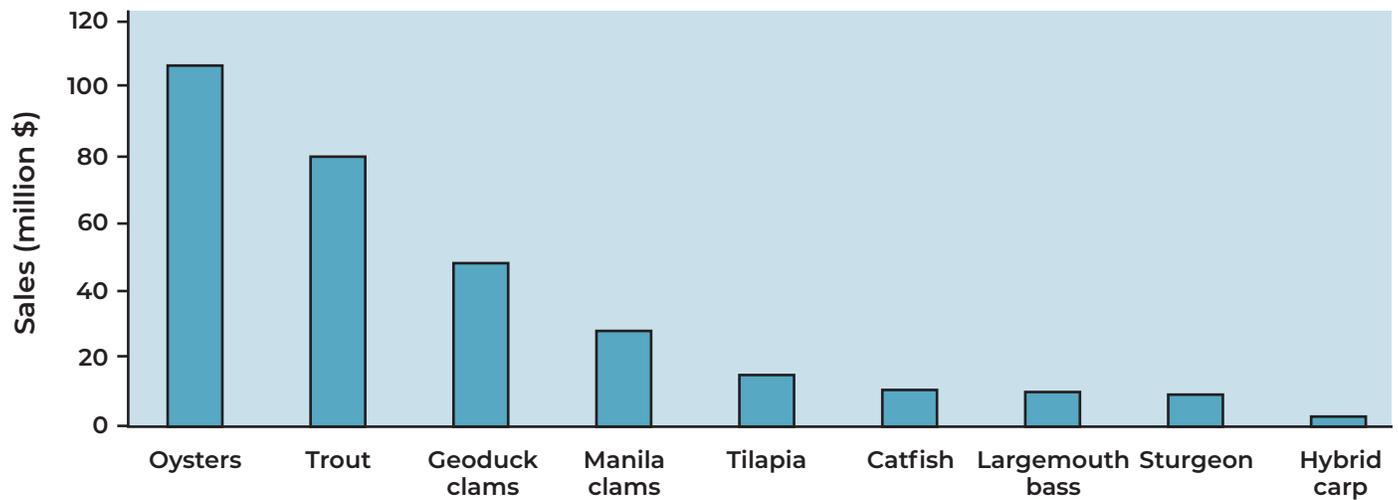
The state of Washington led the region in aquaculture sales in



Photo credit: Keri Rouse, Virginia Tech University

Shellfish displayed for sale in live fish market

a) Sales (millions \$)



b) Number of farms

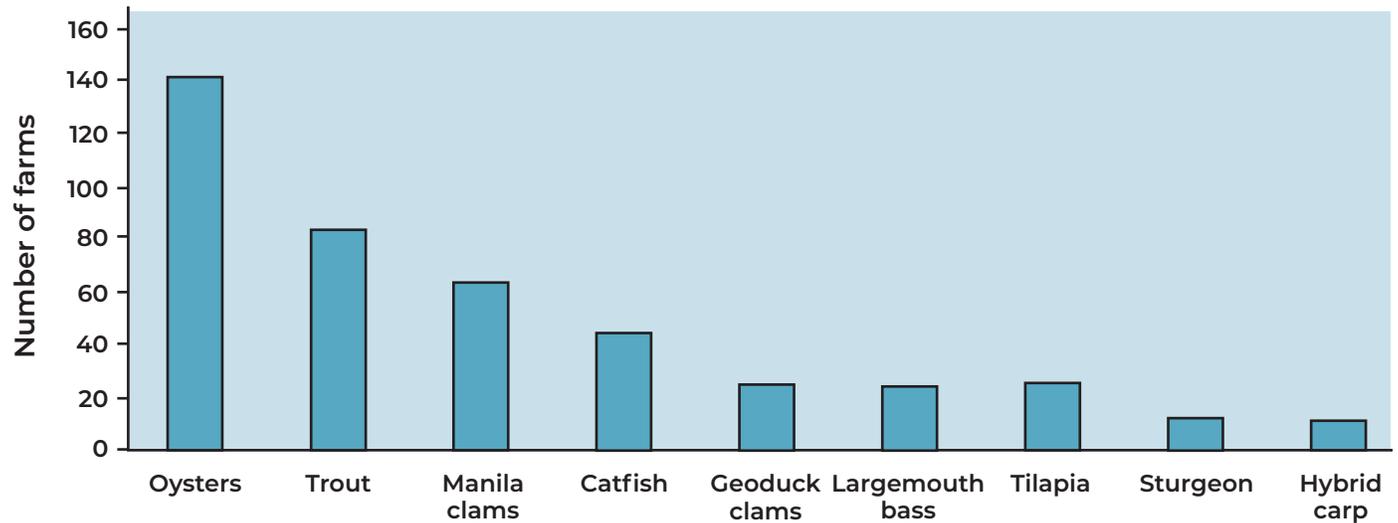


Figure 3. Top species farmed in the Western Region, 2018, by: a) sales (\$) and b) number of farms.

Source: USDA-NASS (2019)

2022 and was followed by California, Idaho, Oregon, Colorado, and Utah, with minor sales reported in the other states in the region (USDA-NASS, 2024) (Figure 4). Aquaculture sales from Washington farms accounted for 55% of all sales from the region. Combined sales of Washington and California were 78%, 92% with Idaho sales, and 99.7% when Oregon sales were included. Thus, four states accounted for 99.7% of the aquaculture sales produced in the region.

**Hatchery Aquaculture Production**

Aquaculture farmers purchase or raise their own young shellfish and finfish in hatcheries with specialized equipment and facilities. Adult broodstock must be maintained in good condition throughout the year so that they will spawn and produce eggs. Eggs are hatched under controlled conditions and the young shellfish (referred to as seed or spat) or finfish (newly hatched fish are called fry) are



Photo credit: Keri Rouse, Virginia Tech University

**Golden rainbow trout.**

then raised to a size appropriate for stocking into growout facilities.

The Western Region is home to some of the leading trout and shellfish hatcheries in the U.S. that supply shellfish seed and finfish eggs, fry, and fingerlings (young fish typically from approximately 1 to 6 inches in size) across the U.S. and internationally. Many warmwater finfish farms in the region, especially those that raise tilapia, catfish, largemouth bass, hybrid catfish, and sturgeon, have developed their own hatchery facilities on farms.

Other farms purchase shellfish seed, finfish fry, or fingerlings from other farms.

**Shellfish Aquaculture in the Western Region**

Shellfish farms in the Western Region raise a variety of different species. Oysters farmed in the region include the Pacific, Kumamoto, native Olympia, Eastern, and European oysters, with the Pacific oyster being the major species raised in the region. Manila clams are the species of clam that is most widely raised on shellfish farms, but geoduck clam farming has grown in importance given its high export value. Additional shellfish raised in the region include softshell clams, blue (or bay) mussels, and abalone are also farmed in the region.

Oysters raised are sold either in clusters to shucking plants or as individual oysters for consumption on the half shell. Shucked oysters are often sold in supermarkets or to restaurants for various dishes and preparations, while oysters on the half shell are popular in oyster bars, raw bars, and as appetizers in restaurants. Manila clams are

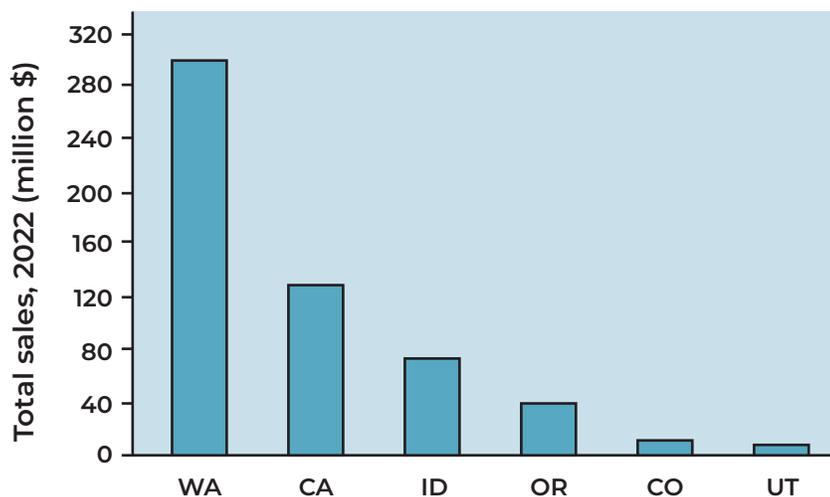


Figure 4. Top aquaculture-producing states in the Western Region.

mostly sold to restaurants and supermarkets, while most geoduck clams are sold live to markets in China and Hong Kong. While a limited amount of oysters and manila clams are exported, geoduck clams are one of the very few U.S. aquaculture products for which the majority are exported. With the recent (2022) re-establishment of trade of shellfish and the approval of the state of Washington for export to the EU, export sales from the region are likely to continue to expand.

**Finfish Aquaculture in the Western Region**

The Western Region includes many areas of low rainfall that have led to on-going attention to efficient and sustainable use of water resources throughout the region. As a result, fish farms in the Western Region have developed innovative ways to re-use water from fish crops. One example is the re-use of water from fish production to irrigate other

crops such as almonds, corn, winter wheat, or alfalfa. Some farms circulate water sequentially from one pond or tank to others, thereby producing several different crops with the same water. Other farms recirculate water through biofilters for return to individual tanks. Water is also conserved in the region through state laws on water rights. In Idaho, for example, water rights are non-consumptive by law. Thus, water leaving Idaho trout farms, the largest trout-producing state in the country, is used for multiple purposes downstream.

Finfish raised in the Western Region are sold into a variety of markets that can be categorized as sales to processors, live markets, or for recreational fishing opportunities. Foodfish sold to processors are converted to various fresh and frozen products for sale to mainstream restaurant and supermarket channels. In the Western Region, the major processed fish products are from trout. Sturgeon are also

sold mostly to processors typically at 3 to 4 years of age (~ 22 lb) which is the preferred size for restaurants and fish markets. Mature female sturgeons (7 years and older) are processed primarily for both caviar, but the remaining meat is also sold mostly to restaurants. Up until 2022, Atlantic salmon had been produced in net pens in Washington for processing into fresh and frozen products for sale to mainstream restaurants and supermarkets. Washington farmers were among some of the early pioneers of Atlantic salmon farming. Net pen salmon farming in Washington ended when the collapse of one pen during a storm led to a ban on new leases and the subsequent refusal to renew the one remaining net pen lease when it expired in 2022. The loss of net pen farming in Puget Sound resulted in the loss of approximately \$109 million of total annual economic activity and 579 jobs in various economic sectors in the state. One net pen farm in Washington that raises steelhead trout in freshwater has continued to operate under management of a private company in cooperation with a local tribal authority.

The salmon fishery in Alaska is supported by a form of aquaculture referred to as ocean ranching in which juvenile fish (smolts) are released into the ocean to grow without further care until harvested as a common property fishery by commercial, sport, and subsistence fishermen. Alaska authorizes privately owned, nonprofit corporations and tribal authorities to operate hatcheries that support salmon ocean ranching. Ocean ranching of



Photo credit: Keri Rouse, Virginia Tech University

**The Fishery, Inc., farm that raises sturgeon, largemouth bass, hybrid carp, and catfish for sale in live markets.**

salmon smolts is also allowed for tribal fisheries in Washington. This project focused on private aquaculture farms in the region and did not include ocean ranching in support of wild-caught fisheries, but estimates of its economic contribution can be found in McDowell Group (2018).

Other foodfish raised in the Western Region are sold to fish markets that hold live fish in tanks and aquaria for purchase as live fish by patrons of the fish markets. These live fish markets also serve as distributors of fresh, local, farm-raised fish to restaurants who purchase the fish either whole or processed. Tilapia, catfish, largemouth bass, sturgeon, hybrid carp, and hybrid striped bass are the main aquaculture grown finfish species sold through these outlets. These markets have invested in large tanks, pumps, and filters to hold live fish following delivery from farms. Additional investments are made to install aquaria (and associated pumps and filters) to display live fish for customers who select those they wish to purchase. Most live fish markets include a cleaning

station where a store employee will clean and cut the fish purchased to specifications of customers. Most shoppers cook the fish on the same day purchased to take advantage of the high degree of freshness. Live fish sales of this nature have been described as “having a garden inside the produce section” or “an orchard in the fruit department.” Specialized businesses have developed to haul fish live from farms to these fish markets.

Other finfish raised in the Western Region are sold for stocking to support recreational fishing in the various states. Angling is a major recreational activity in the region that draws tourists and fishermen from across the country and the world. Millions of fishing licenses are sold in every state with the value of fishing estimated to be worth billions of dollars from expenditures on boats, tackle, lures and bait, travel expenses, and guides. Trout, catfish, largemouth bass, and other species are raised on farms for stocking into fishing ponds, lakes, and streams on private and in some public waters throughout the region. Agencies in several states

contract with private growers to stock selected public lakes. Those stocked into urban lakes provide access to opportunities for families who may not be able to travel to remote fishing streams and lakes to not only enjoy fishing, but have a local source of nutritious fresh fish. Recreational fishing opportunities, especially trout fishing, contribute to the region’s attractiveness to tourists. Quality fisheries, however, depend upon active programs that stock trout and other species raised on private aquaculture farms.

### Other Aquaculture Crops in the Western Region

Tribal hatcheries and publicly funded state and federal hatcheries also raise fish for stocking into freshwater and marine environments to enhance fishing opportunities. Publicly funded hatcheries are also a form of aquaculture that supports aquaculture supply chain businesses such as feed mills, but it was beyond the scope of this project to survey publicly funded hatcheries.

Interest in other aquaculture crops has grown in the region. A few farms have raised algae for



Photo credit, l to r: Keri Rouse, Virginia Tech University; Taylor Shellfish Farms

Left to right: Sturgeon caviar; Taylor Shellfish oysters

many years for sale as nutraceutical-grade products used in cosmetics or as nutritional supplements. Other farms have explored ways to raise seaweed such as Pacific dulse, ogo, nori and kelp (bull, ribbon, sugar, giant, dragon, three- and five-ribbed, and split). Other aquaculture entrepreneurs use ranching methods to produce sea urchins, shrimp in shipping containers, and various aquatic ornamental organisms for sale to the pet trade.

### Trends in Aquaculture Production in the Western Region

Aquaculture in the Western Region has made substantial economic contributions to the regional economy through the development of new, innovative farming sectors and supply chains. Sales have generally grown over time; recent studies have shown that consumer demand for locally raised aquaculture crops could support a substantially greater volume of farmed production (Engle et al., 2019, 2023; van Senten et al., 2020). Constraints to growth of aquaculture in the region have been reported to be primarily related to an inefficient and overlapping regulatory environment that results in lengthy delays. Regulatory approaches have been suggested that have potential to effectively address the underlying environmental concerns related to aquaculture for which regulations were developed while still supporting aquaculture businesses and their associated contributions to employment and to the economy (van Senten et al., 2018; Engle et al., 2021).

### References

Deisenroth DB, Bond CA, and Loomis JB. 2012. The economic contribution of the private, recreation-based aquaculture industry in the Western United States. *Aquaculture Economics & Management* 16: 1–6.

Engle C, Fong Q, Good M, and van Senten. J. 2024a. Alaska mariculture. Western Region Aquaculture Center Fact Sheet, Seattle, Washington.

Engle C, van Senten J, Donovan B, and Cuevas-Uribe R. 2024b. California mariculture. Western Region Aquaculture Center Fact Sheet, Seattle, Washington.

Engle C and van Senten J. 2024a. Colorado aquaculture. Western Region Aquaculture Center Fact Sheet, Seattle, Washington.

Engle C, van Senten J, and Boldt N. 2024c. Idaho aquaculture. Western Region Aquaculture Center Fact Sheet, Seattle, Washington.

Engle C and van Senten J. 2024b. Oregon aquaculture. Western Region Aquaculture Center Fact Sheet, Seattle, Washington.

Engle C and van Senten J. 2024c. Utah aquaculture. Western Region Aquaculture Center Fact Sheet, Seattle, Washington.

Engle C and van Senten J. 2024d. Washington aquaculture. Western Region Aquaculture Center Fact Sheet, Seattle, Washington.

Engle CR, van Senten J, and Fornshell G. 2019. Regulatory costs on U.S. salmonid farms. *Journal of the World Aquaculture Society* 50(3):522-549. doi.org/10.1111/jwas.12604.

Engle CR, van Senten J, Schwarz M, Hartman K, Gustafson L, Johnson K, and Creekmore L. 2021. Farm-level cost drivers of salmonid fish health inspections. *Journal of Aquatic Animal Health* 33(4):199–219. DOI: 10.1002/aah.10139.

Engle CR, van Senten J, Clark C, and Boldt N. 2023. Has the regulatory compliance burden reduced competitiveness of the U.S. tilapia industry? *Fishes* 8(2):151. 10.3390/fishes8030151.

—continued on next page



Photo credit: Gary Fornshell

Ornamental fish farm supplied by geothermal water.



Photo credits, l to r.: Hog Island Oyster Company; Bobbi Hudson Pacific Shellfish Institute

left to right: Geoduck clams; Pacific oyster clusters on longlines, North Hood Canal, Washington

McDowell Group. 2018. Economic impact of Alaska salmon hatcheries. Available at: <https://mckinleyresearch.com/wp-content/uploads/2022/04/economic-impact-of-alaskas-salmon-hatcheries.pdf>. Accessed May 2, 2024.

USDA-NASS. 2000. Census of Aquaculture 1998. National Agricultural Statistics Service, United States Department of Agriculture, Washington, DC. (not online; print version).

USDA-NASS. 2006. Census of Aquaculture 2005.\* National Agricultural Statistics Service, United States Department of Agriculture, Washington, DC. Accessed April 1, 2023.

USDA-NASS. 2014. Census of Aquaculture 2013.\* National Agricultural Statistics Service, United States Department of Agriculture, Washington, DC. Accessed April 1, 2023.

USDA-NASS. 2019. Census of Aquaculture 2018.\* National Agricultural Statistics Service, United States Department of Agriculture, Washington, DC. Accessed April 1, 2023.

USDA-NASS. 2024. 2022 Census of Agriculture. National Agricultural Statistics Service, United States Department of Agriculture, Washington, DC. Accessed May 3, 2024.

van Senten J, Engle CR, Hartman K, Johnson KK, and Gustafson LL.

2018. Is there an economic incen-

tive for farmer participation in a uniform health standard for aquaculture farms? An empirical case study. *Journal of Preventive Veterinary Medicine* 156:58–67. 10.1016/j.prevetmed.2018.05.007.

van Senten J, Engle CR, Hudson B, and Conte FS. 2020. Regulatory costs on Pacific coast shellfish farms. *Aquaculture Economics & Management* 24(4):447–479. DOI: 10.1080/13657305.2020.1781293.

\*Census of Aquaculture 2005, 2013, and 2018 available at: [https://www.nass.usda.gov/Surveys/Guide\\_to\\_NASS\\_Surveys/Census\\_of\\_Aquaculture/index.php](https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Census_of_Aquaculture/index.php).

---

For more information, contact Jonathan van Senten at [jvansenten@vt.edu](mailto:jvansenten@vt.edu) or Carole Engle at [cengle8523@gmail.com](mailto:cengle8523@gmail.com)

*This project was supported by the Western Regional Aquaculture Center award number 2020-38500-32561 from the United States Department of Agriculture National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.*