

WRAC fact sheet

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Characterization of Aquaculture in the Western U.S.

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CALIFORNIA

Photo: Finfish farm.

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California is the fifth-largest aquaculture-producing state (by value of sales) and produces more sturgeon, tilapia, and hybrid carp (sold for foodfish) than any other state in the U.S. California is also a major consumer of seafood, consuming more than three times more seafood from commercial fishing and farming than it produces (Fong et al. 2022). In fact, international imports of seafood still account for 70 to 85% of the total seafood consumed in the U.S. (NOAA 2023).

California aquaculture farmers

and growers supply very fresh, locally raised products, primarily to markets in California. Multiple diverse supply chains have been created and sustained by aquaculture producers to supply these local, in-state markets. A recent supply chain analysis, funded by the Western Regional Aquaculture Center, identified 89 distinct supply chains for aquaculture products in California. Figure 1 illustrates the variety of supply chains identified in this analysis.

California aquaculture is diverse and includes a variety of finfish

species raised in freshwater and a robust shellfish farming sector in marine waters along the coast. Major sectors of freshwater aquaculture include farmed production of sturgeon, tilapia, catfish, largemouth bass, trout, and hybrid carp. Spirulina, a freshwater alga, is also raised and sold as a nutritional product. Marine aquaculture in the state consists primarily of farmed oysters and clams, with additional production of other shellfish such as mussels, abalone, and some experimental production of seaweed.

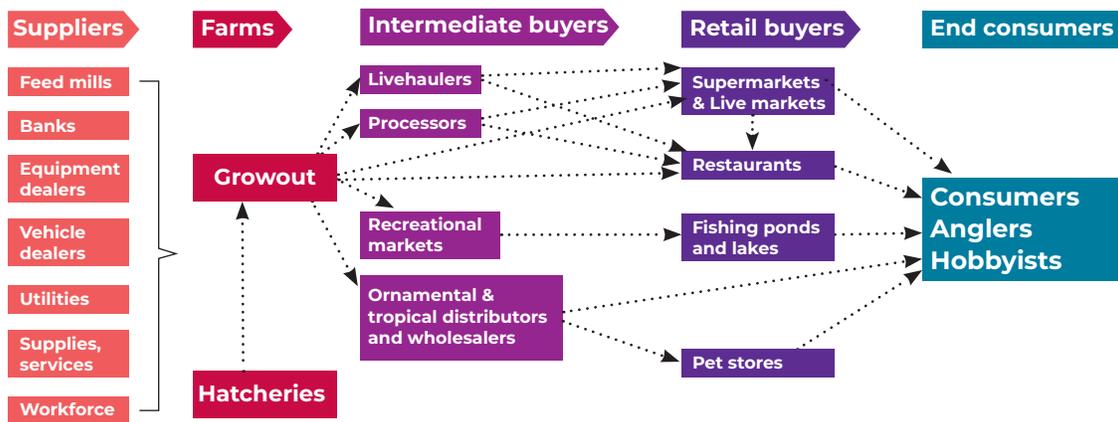


Figure 1. Generic supply chain map for aquaculture products in California.

The Contribution of Aquaculture to the Economy of California

The total economic contribution of aquaculture farms in California (in 2022 \$) was estimated to be \$336.4 million (Table 1). Of this, \$193.1 million was from direct contributions from aquaculture farms, \$63.1 million from indirect contributions of supply chain partners, and \$80.2 million in induced output from the additional household spending from employment created. Of the total 962 jobs supported by aquaculture in California, 387 are on aquaculture farms, 190 from supply chain partners, and 385 from induced effects. Additional economic contributions include \$23.9 million in federal tax revenue, \$9.7 million in state tax revenue, and \$4.7 million in local taxes (Table 2). It should be noted that these estimates of the economic contributions are estimated at the farm level. Sales into recreational markets generate substantial, additional impacts (from expenditures by anglers) that were not accounted for in this analysis. In another study that surveyed anglers and first point-of-sale customers in the western region, combined multiplier effects were 22 times greater than those at the farm level for economic output and more than 200 times greater for employment (Diesenroth et al., 2012).

Hatchery Aquaculture Production

Aquaculture farming begins with spawning and reproduction of the animals in specialized hatchery facilities. In California, some farms have developed their own hatchery facilities and sell “fingerlings” (the

young fish that are stocked into growout facilities) to other farms that do not have hatchery facilities. Shellfish seed is mostly purchased from hatcheries in other states as are fingerlings of some minor finfish species. Most finfish farms in California rely on fingerlings produced within the state.

Freshwater Aquaculture

Freshwater aquaculture farms in California primarily sell finfish. Of the total freshwater finfish sold, 83% are sold as food and 17% sold for stocking into private and public fishing lakes to support recreational fishing by anglers (Table 3). Various production systems have been

Table 1. Contribution of the aquaculture sector to the economy of California.

Type of impact	Employment (number of jobs)	Total economic output (\$)
Direct economic impact	387	\$193.1 million
Indirect economic impact	190	\$ 63.1 million
Induced economic impact	385	\$ 80.2 million
Total economic impact	962	\$336.4 million

Table 2. Tax revenue generated from the aquaculture sector in California.

Tax category	Tax revenue (\$)
Federal	\$23.9 million
State	\$9.7 million
Local/county	\$4.7 million
Total	\$38.3 million



Photos: Keri Rouse for Virginia Tech

California fish farm that raises sturgeon, catfish, largemouth bass, and hybrid carp.

developed to raise fish in California, including earthen ponds, raceways (mostly for trout), and indoor and outdoor tanks. A key characteristic of fish farms across production systems is the attention paid to re-use of water. Some farms recirculate water through biofilters for return to individual tanks, while others circulate water sequentially from one pond or tank to others, thereby producing several different crops with the same water. Still other California farms re-use water from their fish production facilities to irrigate other crops, such as almonds, corn, winter wheat, and alfalfa.

Live Fish Sold for Food

More than half (61%) of the sales from foodfish raised in California are sold to fish markets that hold live fish in tanks and aquaria for purchase as live fish by their patrons. 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 markets with live fish sections also have constructed and staffed a cleaning station where a store employee will clean and cut the fish to the customers' specifications. 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 in supermarkets have been

described by survey respondents as “having a garden inside the produce section” or “an orchard in the fruit department.”

Some California farms, particularly those that raise catfish, largemouth bass, and hybrid carp, transport fish in hauling tanks designed specifically to keep live fish healthy during transport to supermarkets. Other farms, especially those that raise tilapia, sell to separate businesses that specialize in hauling fish live. These livehaulers purchase fish from farms and deliver them to supermarkets for re-sale the same day. These specialized fish-hauling companies constitute a business sector that developed specifically to provide transportation services to aquaculture farms.

Freshwater aquaculture in

California includes production of a wide variety of warmwater and coldwater fish. The major foodfish crops raised include sturgeon, tilapia, channel catfish, largemouth bass, and hybrid carp (Table 3). Of these, 37% of the value (\$) of freshwater fish product sales were from sturgeon,¹ followed by tilapia (17%), trout (8%), catfish (14%), largemouth bass (13%), and hybrid carp (3%). Sales of tilapia, largemouth bass, and hybrid carp were almost exclusively to markets for sale as live fish to patrons that value the improved flavor of very fresh, live seafood. All channel catfish raised were sold live to fish markets. While some sturgeon were also sold live to fish markets, 62% of the sales were to processors for caviar production, with remaining meat sales mostly to restaurants.

Table 3. Freshwater aquaculture sales percentages by species and principal markets in California.

Species	Percent of sales statewide	Percent of sales by species	
		Foodfish (%)	Recreational (%)
Sturgeon ^a	37%	100%	0%
Tilapia	17%	97%	3%
Catfish	14%	65%	35%
Largemouth bass	13%	99%	1%
Trout	10%	8%	92%
Hybrid carp	3%	100%	0%
Other ^b	6%	66%	34%
Total freshwater sales	100%	83%	17%

^a Includes sales of caviar produced from sturgeon, live fish sold as foodfish, and sturgeon meat.

^b Includes hybrid striped bass, sportfish other than largemouth bass, baitfish, ornamentals, and crustaceans.

¹ Sales of sturgeon include sales of live fish to supermarkets, but also sales of caviar and sturgeon meat.



Photos: Keri Rouse for Virginia Tech

Live fish market in California selling farm-raised fish.

Live Fish Sold for Recreational Angling

Angling in California is an important recreational outlet for many residents, with two million licenses sold in 2020 (Amundsen 2021). California anglers contribute to the state's economy through expenditures on boats, tackle, lures and bait, travel expenses, and guides. Private aquaculture farms raise various species of freshwater fish that are purchased by private owners of ponds and fishing lakes and by state and federal agencies to support recreational fishing in the state. Most trout (92%) farmed in California support recreational fishing opportunities (Table 3). Moreover, blue catfish raised in California are sold to fishing lakes for use by anglers. Of the total volume of catfish raised in the state, (channel, and blue catfish), 35% of the sales volume was blue catfish stocked into fishing lakes to support recreational fishing (Table 3). The "Other"² category of live fish sales included hybrid striped bass, warmwater sportfish, baitfish, and ornamental fish, of which 34% of sales were to recreational markets.

Live Fish Sold to Processors

The major sales from freshwater farms to processors are sturgeon, which are processed into caviar and meat. The farmed sturgeon industry began in California with sales that date back to 1985, followed by rapid growth in the mid-1990s (Van Eenennaam et al. 2004). The development of sturgeon farming technologies resulted in private farms that created supply and value chains for U.S. domestic caviar production. Prior to the advent of a U.S. sturgeon farming sector, most caviar products sold in the U.S. had been imported from Russia and Iran. Some U.S. sturgeon farms have integrated processing of sturgeon and caviar production into their overall farming business, whereas other companies have specialized in caviar production and purchase sturgeon from growout farms. The meat that remains following caviar production is sold into restaurant supply chains.

Market Advantages of Live Fish Sales

The fish raised and sold live from California farms provide a supply

In addition to private farms, California has multiple publicly funded state and federal hatcheries that raise fish for stocking into freshwater and marine environments to enhance fishing opportunities. Publicly funded hatcheries also support aquaculture supply chain businesses such as feed mills, but it was beyond the scope of this Western Region Aquaculture Center project to survey publicly funded hatcheries and measure their economic impact to California.

² Sales of fish species combined into the "other" category were those that could not be reported separately for confidentiality reasons.

of locally raised, high-quality, very fresh seafood. These farmed aquatic products compete in the broader general seafood market, which is supplied largely by imported seafood shipped mostly as frozen product. Frozen seafood products often are thawed and sold in supermarkets as “fresh” products on ice. Regardless of whether sold fresh or frozen, imported products pass many days on a boat or in the supermarket before being purchased and consumed. Seafood products have high moisture content that is impacted by the length of time following processing, even when iced properly and frozen promptly after processing. Clearly, seafood that has been transported for many miles is not as fresh as that of a live fish. The California farmed fish supply chains are relatively short, with far fewer miles traveled, and therefore, lower carbon footprints. Other supply chains require fish to be transported much farther, undergo processing at various facilities, and frequently include wholesalers, distributors, and food service intermediaries before reaching the consumer. Consequently, the live fish supply chain that has been developed by California’s aquaculture farms



Photo: Keri Rouse, Virginia Tech University

Finfish farm in California.

results in a higher value product because of the higher quality derived from its freshness.

Marine Aquaculture

Aquaculture farming in marine waters of California consists primarily of shellfish farms that raise oysters and clams, with some minor production of mussels and abalone. Experimental work on raising marine finfish and various types of seaweeds has been ongoing for some time, with some minor sales reported of seaweed. Some marine species, such as white seabass, are

raised for enhancement of natural stocks in marine waters.

Oysters raised in California are sold into various supply chains, which include shucking plants (accounting for approximately 54% of the oysters sold) and sales directly from farms to restaurants, oyster bars, supermarkets, and directly to consumers through various outlets, including online sales (46%) (Table 4). Other shellfish farmed, such as clams, mussels, and abalone, are sold primarily as live product directly to restaurants, supermarkets, and consumers.

Table 4. Marine aquaculture sales percentages by species and principal markets, California.

Species	Percent of total California marine sales	% sales of each species sold to shucking plants	% sales of each species sold directly to restaurants, supermarkets, and direct to customers
Oysters	83%	54%	46%
Clams	2%	0%	100%
Other (mussels, abalone)	15%	0%	100%
Total marine sales	100%	45%	55%



Photo: Wendy Sealey

Finfish farm.

Conclusions

California aquaculture has created and sustained 89 different supply chains that contribute to the state's economy through direct and indirect ways while also providing jobs that increase household incomes. The state's aquaculture crops provide a local source of very fresh seafood products produced by farmers who have developed innovative water re-use practices as a component of overall attention to environmental stewardship.

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