

# North Central Regional Aquaculture Industry: Trends and Outlook



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Cover photos (clockwise from top): smoked trout filets from Freshwater Farms of Ohio, ornamental fish from Ozark Fisheries in Missouri, barramundi culture at Hanilu Farms in Indiana, in-pond raceway from Superior Aquaculture in Wisconsin, marine shrimp from RDM in Indiana, and ponds at Big House Fish Farm in Illinois.

# Summary

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This report summarizes aquaculture in the U.S. North Central Region, the U.S. at large and the world. It highlights aquaculture production and consumption, summarizes industry trends, and offers further details about aquatic species grown by region.

Aquaculture is defined in the National Aquaculture Act of 1980 as “the propagation and rearing of aquatic species in controlled or selected environments.” Ponds and lakes are common aquaculture environments in the inland U.S. Other production systems include raceways, recirculating systems, nonrecirculating systems and aquaponics. In addition to food fish, aquaculture is important for producing sport fish, ornamental fish, bait fish and aquatic species for conservation purposes.

According to the 2023 Census of Aquaculture, the NCR had 315 farms with aquaculture sales, which represented 9.1% of the U.S. aquaculture farm industry. These farms generated \$71.1 million in annual sales. Most NCR states reported aquaculture sales, not adjusted for inflation, between 2018 and 2023. The states with growth from the last census were Indiana, Kansas, Minnesota, Ohio, South Dakota and Wisconsin.

U.S. aquaculture production has not kept up with domestic growth in product demand — even when seafood supply and demand were disrupted during recent recession and pandemic periods. Several factors are cited for the lack of U.S. aquaculture expansion:

- North American producers compete with international aquaculture producers that have lower production costs, particularly labor, and can ship frozen fish products at lower price points.
- Labor available to process seafood is a limiting factor.
- Regulations for aquaculture production can be a barrier to entry.

China, Southeast Asia and India dominate world aquaculture production. Increase in global aquaculture production has predominantly occurred in inland waters. Between 2010 and 2022, the average growth rate was 3.94% for marine aquaculture and 4.41% for inland aquaculture. The observed growth in world aquaculture production has been driven by intensification, improvements in feeds, enhanced production management, and increased attention to biosecurity.

Globally, food fish provide an important source of protein and nutrition. Global fish consumption has grown at a faster annual rate than the global population. Aquaculture systems help to manage and conserve the world’s natural fisheries. They also help supply higher-value seafood products demanded by consumers in developed economies, including the U.S.

# 1. Aquaculture in the North Central Region

## 1.1 Introduction to the North Central Region

The North Central Regional Aquaculture Center (NCRAC) is a Midwest aquaculture administrative unit created to support and promote aquaculture in the North Central Region of the United States. Congress established it and funded it through the U.S. Department of Agriculture's National Institute of Food and Agriculture (USDA-NIFA). The NCRAC serves the 12 states in the North Central Region (NCR) (Exhibit 1.1.1). The region has 34 land-grant colleges and universities, but in 2022, only eight dedicated at least partial full-time equivalent to aquaculture/aquaponic extension or outreach.<sup>1</sup>

### ***Exhibit 1.1.1. Land-grant and tribal universities of the North Central Region.***

State	Land-grant college or university
Illinois	University of Illinois
Indiana	Purdue University*
Iowa	Iowa State University*
Kansas	Haskell Indian Nations University, Kansas State University
Michigan	Bay Mills Community College, Keweenaw Bay Ojibwa Community College, Michigan State University,* Saginaw Chippewa Tribal College
Minnesota	Fond du Lac Tribal and Community College, Leech Lake Tribal College, Red Lake Nation College, University of Minnesota,* White Earth Tribal and Community College
Missouri	Lincoln University,* University of Missouri*
Nebraska	Little Priest Tribal College, Nebraska Indian Community College, University of Nebraska
North Dakota	Cankdeska Cikana Community College, North Dakota State University, Nueta Hidatsa Sahnish College, Sitting Bull College, Turtle Mountain Community College, United Tribes Technical College
Ohio	Central State University,* The Ohio State University*
South Dakota	Oglala Lakota College, Sinte Gleska University, Sisseton Wahpeton College, South Dakota State University
Wisconsin	College of Menominee Nation, LacCourie Oreilles Ojibwa Community College, University of Wisconsin

\*Denotes at least partial full-time equivalent dedicated to aquaculture/aquaponic extension or outreach in the state as of publication.

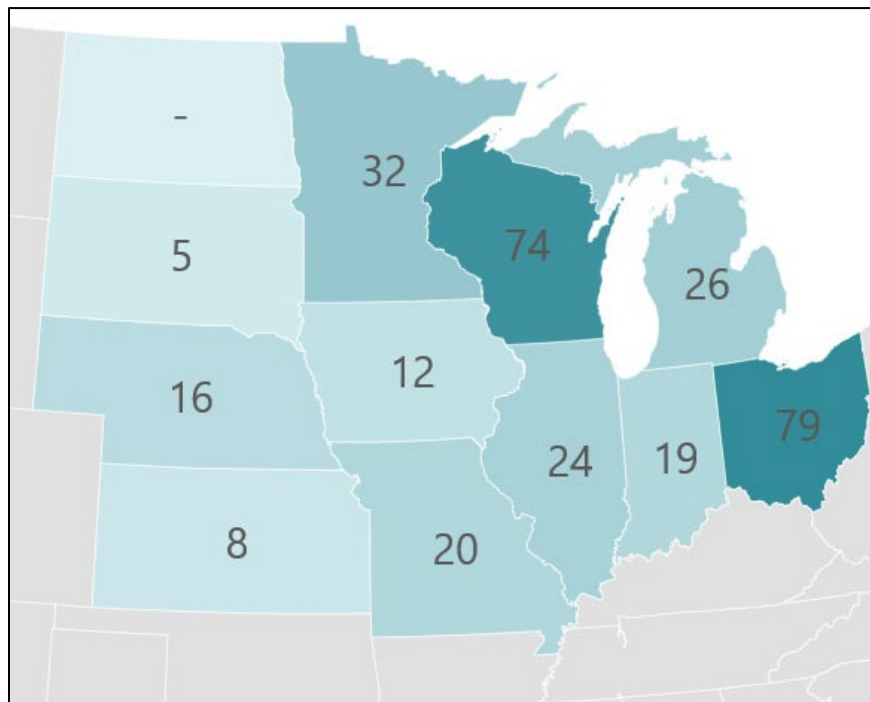
Source: Smith and Lutz (2022).<sup>1</sup>

According to the 2023 Census of Aquaculture, the NCR had 315 farms that reported aquaculture sales, which represented 9.1% of the U.S. aquaculture farm industry. These NCR aquaculture farms generated \$71.1 million in annual sales. USDA defines an aquaculture farm as a place where \$1,000 or more of aquaculture products are produced and sold or produced and distributed for restoration, conservation, enhancement or recreation within a given year.

## 1.2 Aquaculture farms

The Census of Aquaculture counted 315 farms in the NCR that sold aquaculture products in 2023. Exhibit 1.2.1 shows the number of these farms by state. These states represent 9.1% of the 3,453 aquaculture farms across the U.S. Ohio had the greatest number in the region, 79, followed by Wisconsin with 74 and Minnesota with 32.

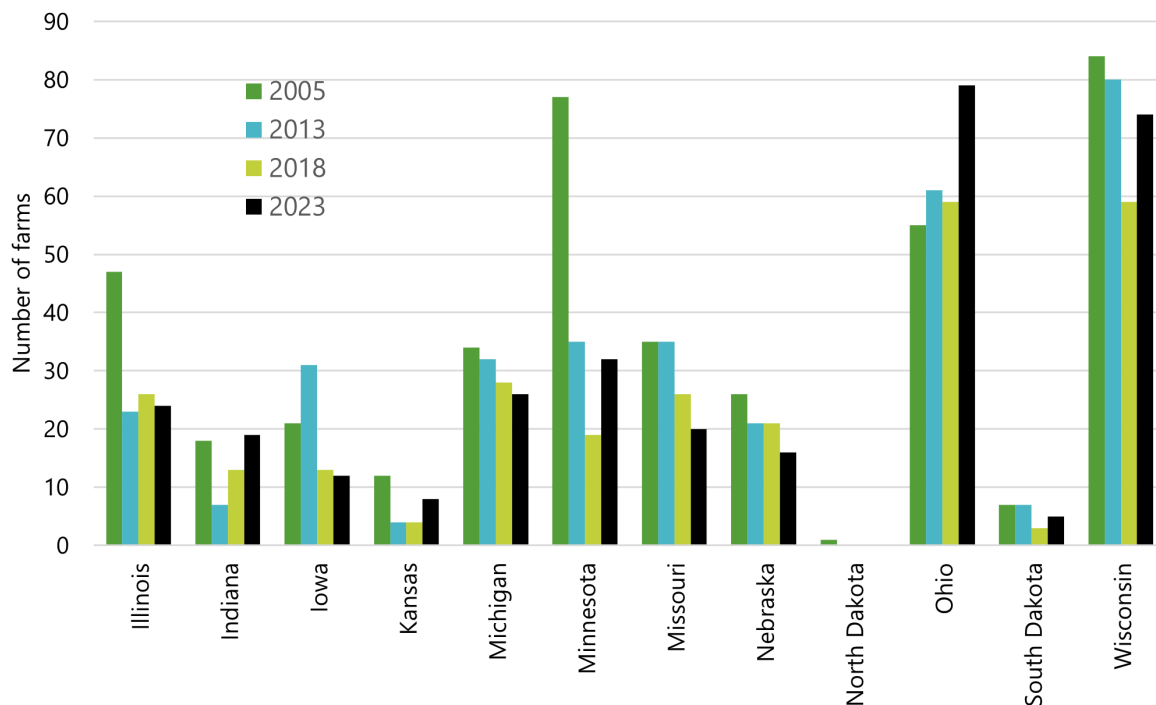
***Exhibit 1.2.1. Aquaculture farms in the North Central Region, 2023.***



Source: USDA National Agricultural Statistics Service.<sup>2</sup>

Exhibit 1.2.2 shows the number of aquaculture farms by NCR state reported for the past four censuses. Most states have seen a long-term decline in aquaculture farm numbers. NCR states that showed growth in the number of farms between the 2018 and 2023 Census of Aquaculture were Indiana, Kansas, Minnesota, Ohio, South Dakota and Wisconsin.

### ***Exhibit 1.2.2. Aquaculture farms in North Central Region, 2005–2023.***



Source: USDA National Agricultural Statistics Service.<sup>2</sup>

## **1.3 Aquaculture farms by type**

Exhibit 1.3.1 reports aquaculture product sale categories for individual NCR states and the U.S. Most of the farms in the NCR, 205, are involved in food fish production. The NCR represents 21% of all U.S. food fish farms, with the states of Wisconsin and Ohio having a strong concentration in operations. More than 45% of the U.S. aquaculture farms in the sport fish and bait fish categories are located in the NCR. Sport fish, primarily raised for lake or stream stocking, are more clustered in Ohio, Wisconsin and Illinois. Bait fish operations are more commonly found in Ohio, Minnesota and Wisconsin.

***Exhibit 1.3.1. Number of aquaculture farms by product type sold, 2023.***

	<b>Food fish</b>	<b>Sport fish</b>	<b>Bait fish</b>	<b>Ornamental fish</b>	<b>Miscellaneous aquaculture</b>
Illinois	10	14	4	3	2
Indiana	13	10	2	5	2
Iowa	5	5	4	1	8
Kansas	8	8	4	0	2
Michigan	20	7	5	4	2
Minnesota	8	8	20	2	1
Missouri	16	5	9	3	4
Nebraska	14	9	3	5	2
North Dakota	-	-	-	-	-
Ohio	53	36	21	26	7
South Dakota	3	1	3	0	0
Wisconsin	55	15	18	3	1
Total NCR farms	205	118	93	52	31
Total U.S. farms	968	249	205	315	238
Percentage NCR of U.S. farms	21	47	45	17	13

Source: USDA National Agricultural Statistics Service.<sup>2</sup>

In the NCR, farmers produce a wide variety of species, such as Atlantic salmon, barramundi, bluegill, catfish, hybrid bluebill, hybrid striped bass, largemouth bass, rainbow trout, tilapia, walleye, yellow perch, as well as freshwater prawns and saltwater shrimp. However, certain fish species are more prominently raised in the NCR. Exhibit 1.3.2 presents farm numbers for major fish species prominent in the NCR region and shows the relationship to all U.S. aquaculture farms. For example, hybrid striped bass are produced on 17 farms in the NCR, which represents 30% of all U.S. farms that raise this species. Yellow perch (87%), walleye (80%) and crappie (63%) represent fish species in production largely on NCR aquaculture farms.

***Exhibit 1.3.2. Aquaculture farms by species, 2023.***

<b>Fish species</b>	<b>NCR farms</b>	<b>U.S. farms</b>	<b>Percentage of U.S.</b>
Bass, hybrid striped (food fish)	17	57	30%
Carp (food fish)	31	84	37%
Catfish (food fish)	39	398	10%
Yellow perch (food fish)	72	83	87%
Tilapia (food fish)	39	147	27%
Trout (food fish)	88	335	26%
Bass, largemouth (sport fish)	92	193	48%
Crappie (sport fish)	41	65	63%
Sunfish (sport fish)	73	169	43%
Walleye (sport fish)	37	46	80%
Fathead minnows (baitfish)	81	150	54%
Goldfish (baitfish)	9	34	26%
Golden shiners (baitfish)	35	81	43%
Goldfish (ornamental)	26	66	39%
Koi (ornamental)	41	138	30%

Source: USDA National Agricultural Statistics Service.<sup>2</sup>

## **1.4 Aquaculture sales**

According to USDA census data, NCR aquaculture farms sold \$71.1 million of agricultural products in 2023. This estimate represents the gross value of sales before marketing and production costs are deducted. Note that it does not include the value of aquaculture products distributed for restoration, conservation, enhancement or recreational purposes.

Exhibit 1.4.1 presents further details about aquaculture sales in 2023 and changes from the previous census for NCR states and the U.S. NCR states represent 3.7% of U.S. aquaculture sales. It is noteworthy that most NCR states that reported aquaculture sales demonstrated growth between 2018 and 2023. NCR states' sales grew a collective 66% versus the 26% growth achieved by all U.S. states, not adjusted for inflation. Although NCR states accounted for only 2.5% of the food fish sales, they had more than 20% of aquaculture sales in the sport and bait fish categories.



**Exhibit 1.4.1. Value of aquaculture products sold, 2023.**

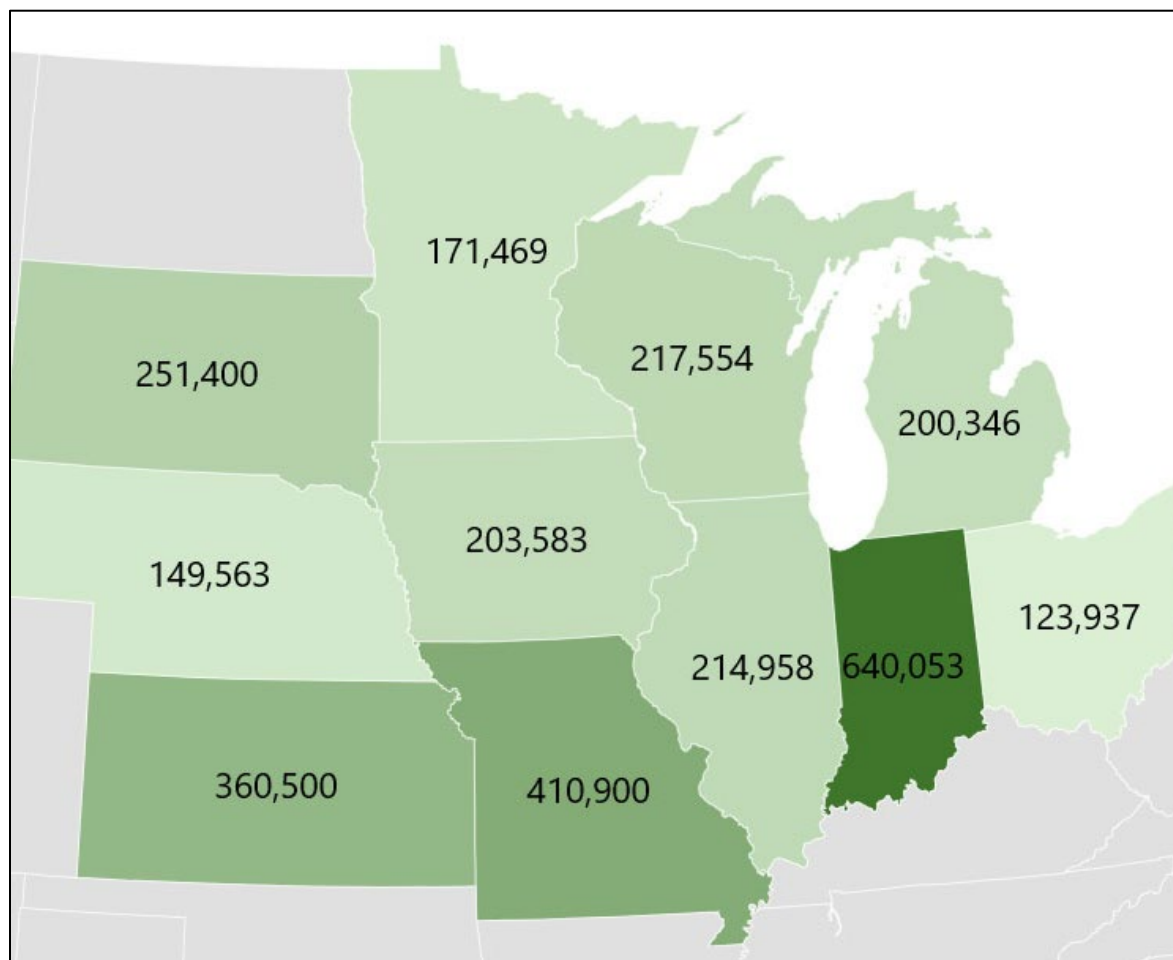
Geographic area	Total		Food fish		Sport fish		Bait fish	
	Sales (\$1,000)	5-year change (%)	Sales (\$1,000)	5-year change (%)	Sales (\$1,000)	5-year change (%)	Sales (\$1,000)	5-year change (%)
Illinois	5,159	26	-	-	3,985	39	-	-
Indiana	12,161	257	6,726	-	-	-	-	-
Iowa	2,443	-36	-	-	273	137	163	31
Kansas	2,884	188	1,249	68	1,459	-	-	-
Michigan	5,209	69	2,537	38	1,013	24	-	-
Minnesota	5,487	38	210	-	2,224	31	2,907	84
Missouri	8,218	7	4,631	-9	-	-	-	-
Nebraska	2,393	-13	2,023	-14	248	-22	106	-
North Dakota	-	-	-	-	-	-	-	-
Ohio	9,791	47	3,335	25	2,095	36	3,633	70
South Dakota	1,257	-	-	-	-	-	1,061	-
Wisconsin	16,099	158	-	-	-	-	4,031	98
Total NCR	71,101	66	20,711	38	11,297	43	11,901	8
United States	1,908,022	26	819,556	14	54,390	38	48,125	67
Percentage NCR of U.S.	3.7		2.5		20.8		24.7	

Source: Adapted from the USDA National Agricultural Statistics Service.<sup>2</sup> Note: Some state data are withheld for confidentiality purposes.

## 1.5 Average sales by farm

Average sales by NCR aquaculture farm are found in Exhibit 1.5.1. North Dakota was unable to be calculated because no aquaculture farms or sales were reported. Indiana, with \$640,053 in sales, was highest in sales per farm of the NCR states, followed by Missouri with \$410,900. U.S. average sales per aquaculture farm was \$552,569 in 2023.

***Exhibit 1.5.1. Average sales by aquaculture farm, in dollars, 2023.***



Source: USDA National Agricultural Statistics Service.<sup>2</sup>

## 1.6 Acres in production

The Census of Aquaculture provides acreage information related to aquaculture production. NCR states constitute 16.9% of the U.S. freshwater production area for aquaculture. In 2023, the NCR states had 66,361 acres in freshwater production, with Minnesota representing about 84% of that acreage.

***Exhibit 1.6.1. Freshwater aquaculture acres, 2023.***

Geographic area	Acres	Percentage of U.S. acres
Illinois	599	0.2
Indiana	804	0.2
Iowa	394	0.1
Kansas	1,328	0.3
Michigan	969	0.2
Minnesota	55,673	14.2
Missouri	1,490	0.4
Nebraska	356	0.1
North Dakota	197	0.1
Ohio	1,735	0.4
South Dakota	1,642	0.4
Wisconsin	1,174	0.3
Total	66,361	16.9

Source: USDA National Agricultural Statistics Service.<sup>2</sup>

Improvements in production technology, fish genetics and nutrition allow aquaculture producers to produce higher volumes of fish from the same or less production area. Still, data on the observed changes between censuses indicate that aquaculture production has become increasingly more consolidated in the North Central Region and in the United States, with a smaller number of operations cultivating higher acreage. This trend might be related to an increasing regulatory burden on U.S. aquaculture farms, which causes compliance costs that create competitive disadvantages for U.S. producers,<sup>3</sup> especially the smallest ones.

## 1.7 Methods used in production

Production systems used on NCR aquaculture farms include ponds, tanks, flow-through raceways, aquaponics, recirculating aquaculture systems (RAS), and cages or pens. Exhibit 1.7.1 shows methods used on farms by each NCR state. Many species may be cultured in multiple systems, although not all species can be cultured in all production systems. This production system flexibility leads to further complex situations when attempting to identify optimal growth conditions, average growth and survival, feed conversion ratio, and costs of production for a particular species and production system.

***Exhibit 1.7.1. Aquaculture production methods by number of farms, 2023.***

<b>Geographic area</b>	<b>Ponds</b>	<b>Flow-through raceways</b>	<b>Recirculating systems</b>	<b>Non-recirculating systems</b>	<b>Cage or pens</b>	<b>Aquaponic systems</b>
Illinois	23	8	6	5	2	2
Indiana	24	6	12	8	1	0
Iowa	20	5	4	6	4	0
Kansas	16	6	7	8	4	0
Michigan	27	26	7	10	0	0
Minnesota	72	24	7	16	0	0
Missouri	25	14	4	11	2	2
Nebraska	20	17	9	13	3	1
North Dakota	4	1	0	1	0	0
Ohio	56	13	42	20	8	17
South Dakota	10	6	5	7	0	0
Wisconsin	89	44	22	23	0	8
<b>Total farms</b>	<b>386</b>	<b>170</b>	<b>125</b>	<b>128</b>	<b>24</b>	<b>30</b>

Source: USDA National Agricultural Statistics Service.<sup>2</sup>

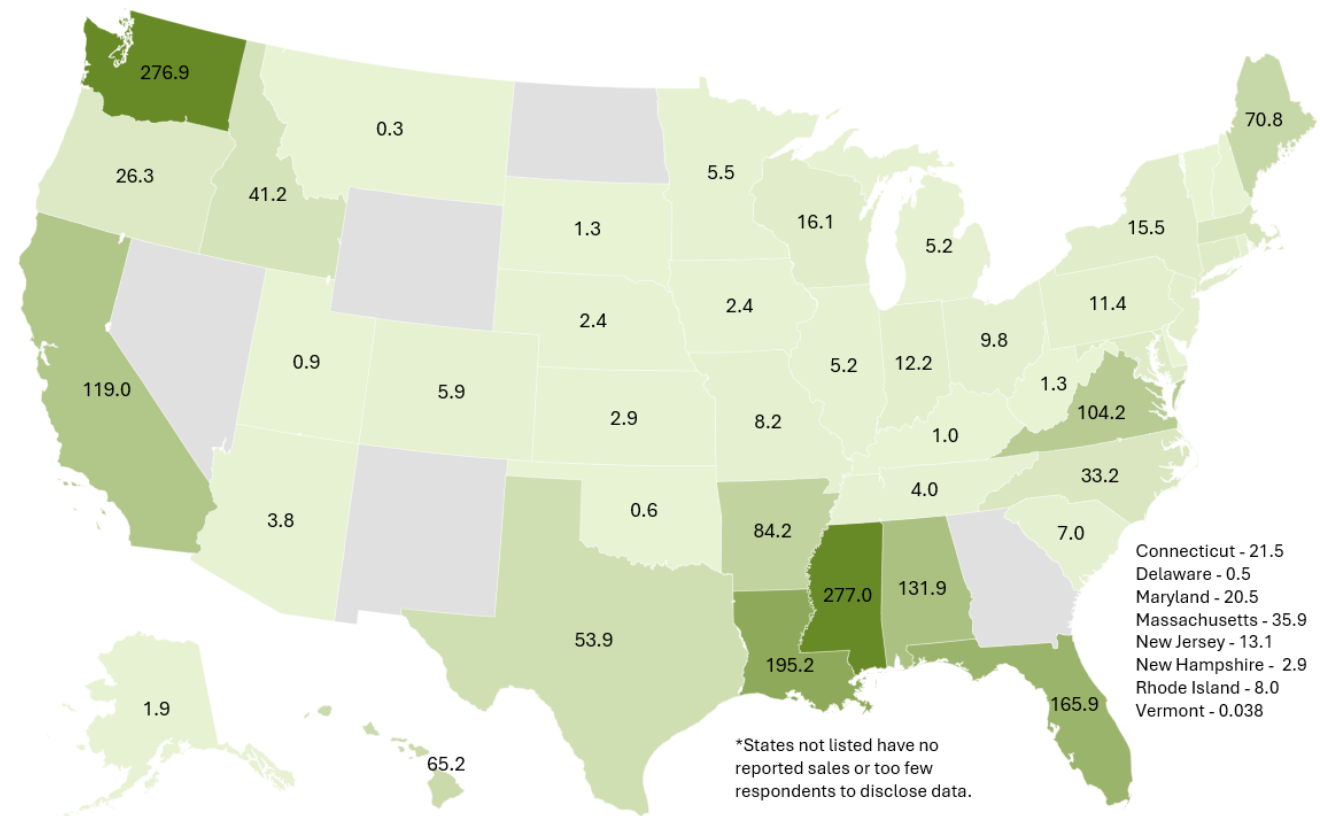
Despite having a shorter growing season, 80% of NCR farms employ ponds in some phase of aquaculture production, whereas 35% use flow-through raceways, 27% use nonrecirculated tanks and 26% use recirculating aquaculture systems, according to the Census of Aquaculture 2023.

## 2. Aquaculture in the U.S.

### 2.1 Major U.S. aquaculture production areas

Mississippi and Washington lead in aquaculture production value. Both produced more than \$200 million of aquaculture products in 2023. Mississippi leads in farmed catfish. Mississippi's strength was mainly due to major improvements in catfish pond management practices and production technology.<sup>4</sup> Washington focuses on marine aquaculture — notably salmon and mollusks. Louisiana, Florida, Alabama, California and Virginia each produced more than \$100 million of aquaculture products in 2023. Exhibit 2.1.1 highlights production value by state; darker hues indicate higher values.

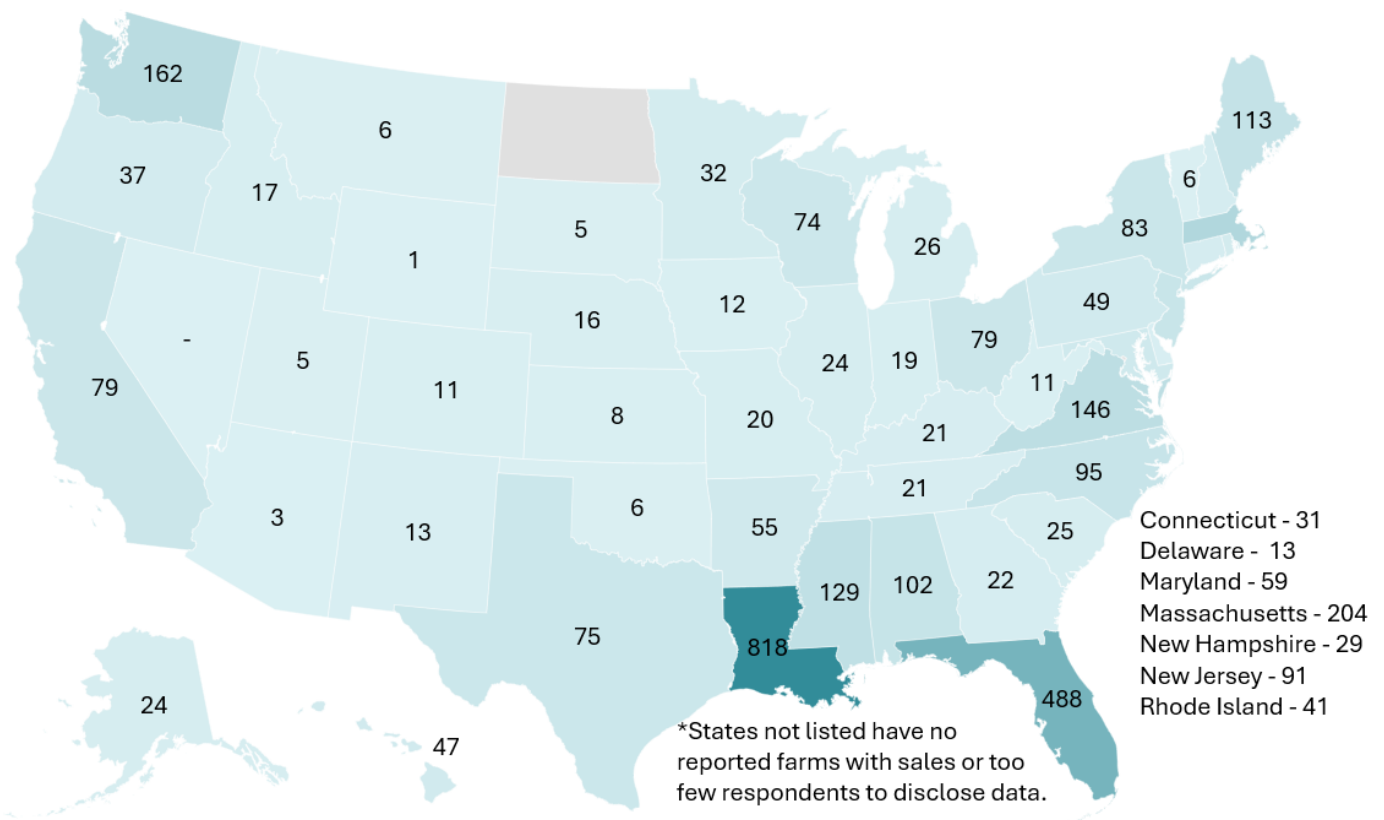
**Exhibit 2.1.1. U.S. aquaculture sales, in thousand dollars, 2023.**



Source: USDA National Agricultural Statistics Service.<sup>2</sup>

Crawfish farms make Louisiana the U.S. leader in crustacean production. Crawfish production is labor-intensive compared with raising other aquaculture products and requires relatively small production areas per farm. Because of its focus on crawfish production, which is associated with smaller production areas per farm, Louisiana had the most aquaculture farms of any state in 2023 (Exhibit 2.1.2). Florida ranked second with a large number of ornamental fish and mollusks producers.

### ***Exhibit 2.1.2. U.S. aquaculture farms, 2023.***



Source: USDA National Agricultural Statistics Service.<sup>2</sup>

The value of aquaculture production concentrates in the Gulf Coast and Southern states. More than half of the country's catfish production is in Mississippi. Alabama is the second largest catfish producer, and Arkansas and Texas also have substantial catfish production. Louisiana aquaculture focuses on crustaceans and mollusks — crawfish and oysters.

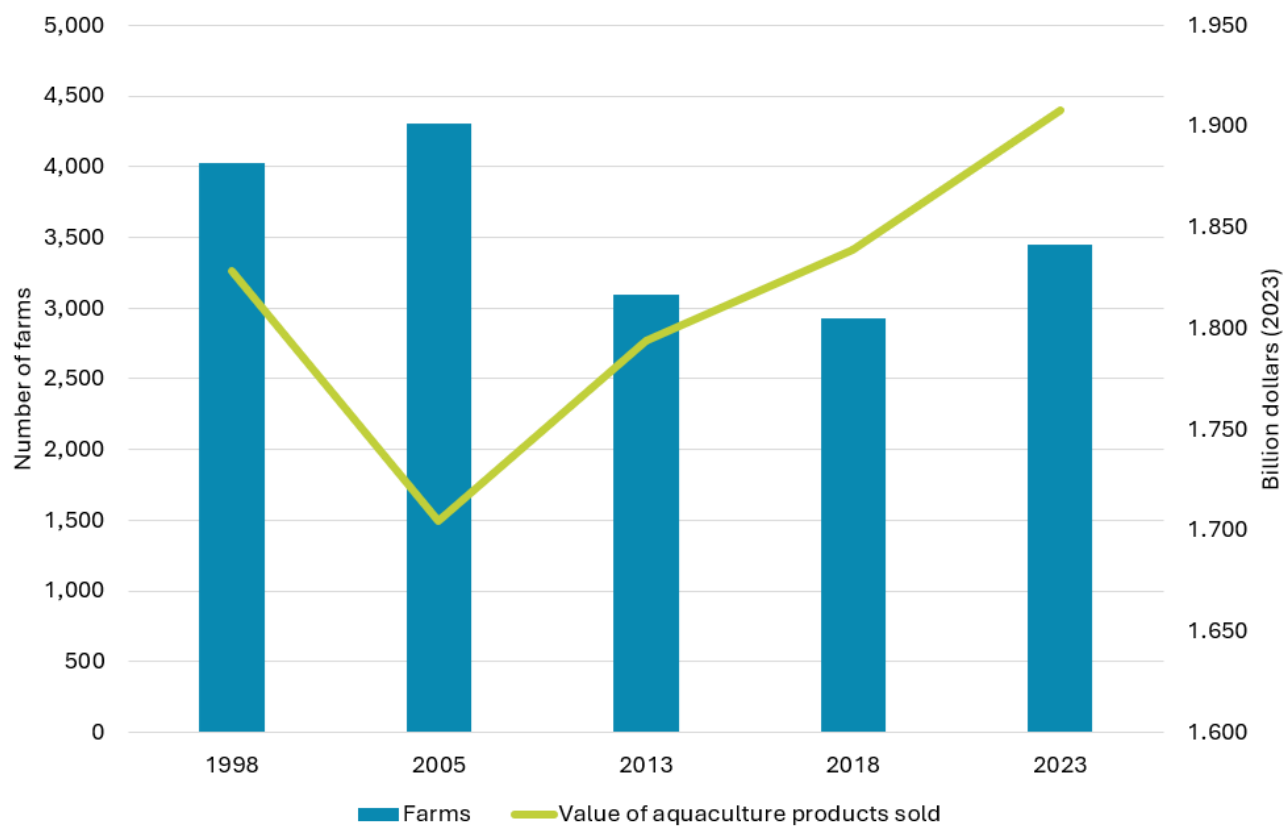
Three Pacific Coast states have notable aquaculture industries. Rooted in mollusk sales, Washington leads aquaculture production in the Pacific states. After catfish, trout is the next leading finfish produced by U.S. aquaculture farms, with rainbow trout being the main species. U.S. aquaculture producers also harvest some brook trout and brown trout. Idaho produces more farmed trout for food than other states. California is the country's leading tilapia producer and a significant trout producer.

Aquaculture is diversified along the Atlantic Coast. Maine and Virginia, the leading Atlantic states, primarily focus on saltwater aquaculture (i.e., mollusks). North Carolina is the leading state for hybrid striped bass. Florida aquaculture producers focus mainly on ornamental fish and saltwater aquaculture, especially shrimp and clams.

## 2.2 U.S. aquaculture industry growth

Exhibit 2.2.1 shows the number of U.S. aquaculture farms and sales, adjusted for inflation, from 1998 to 2023. Since 2018, farm numbers have increased 17.8% and sales 3.7%. From 2013 to 2018, there was a 5.2% decrease in the number of U.S. aquaculture farms, but product sales increased by 2.5%.

***Exhibit 2.2.1. U.S. aquaculture farms and product sales, adjusted for inflation.***



Note: Sales are in 2023 dollars to adjust for inflation.

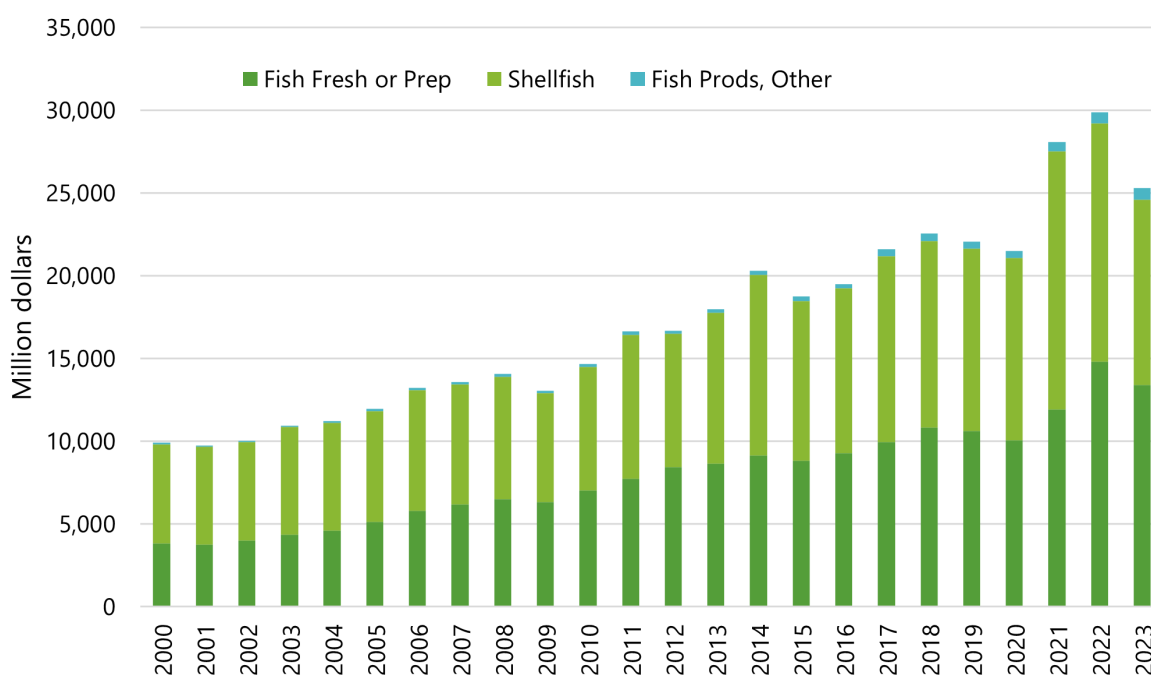
Source: 2023 Census of Aquaculture.<sup>5</sup>

## 2.3 U.S. seafood imports

Increases in fresh and frozen seafood consumption could favor domestic aquaculture production, but U.S. aquaculture producers struggle to compete with large international aquaculture producers that often have lower costs. Thus, imports have largely supplied the increased demand for seafood in the U.S., and many seafood exporters view the U.S. as a premium target market.

The U.S. imported \$25 billion worth of seafood in 2020 (Exhibit 2.3.1). Leading imports have included shrimp, salmon and tuna. Federal agency estimates indicate between 70% and 85% of all seafood consumed in the U.S. is imported.<sup>6</sup> The total value of fishery product imports decreased by about 15% from 2022 to 2023.

### ***Exhibit 2.3.1. U.S. fish product imports.***



Source: USDA Foreign Agricultural Service (2024).<sup>7</sup>



## 3. Global aquaculture

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### 3.1 Global aquaculture production\*

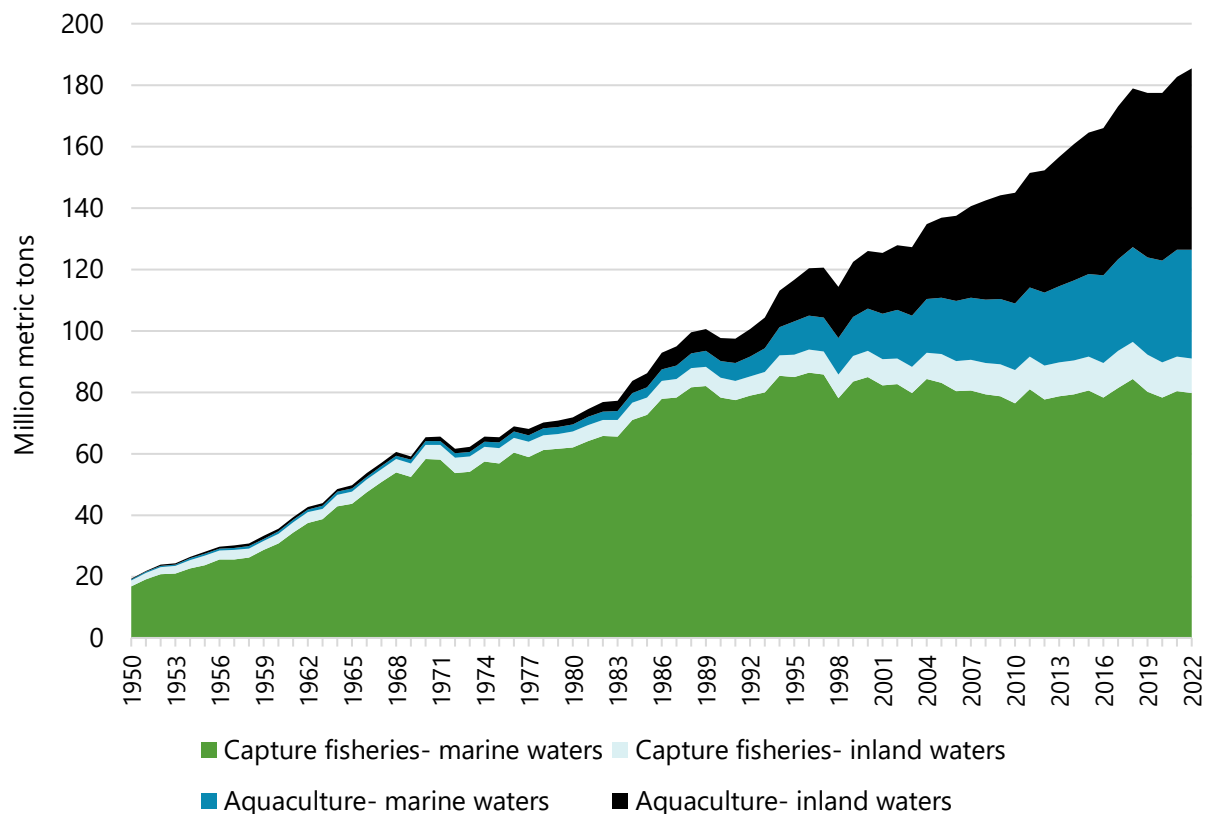
In 2022, the global production volume of aquatic animals from aquaculture was 94.4 million metric tons, which for the first time exceeded the volume from capture, which was 91 million metric tons. This shift resulted from a historical trend of exponential growth in world aquaculture production and stagnation in the capture of aquatic animals. Marine and inland capture fisheries are subject to risks driven by overharvesting, bycatch, illegal fishing, habitat loss and damage, climate change and marine pollution.<sup>8</sup> Aquaculture mitigates some of these risks.

The observed growth in world aquaculture production has been driven by intensification, improvements in feeds, enhanced production management, and increased attention to biosecurity.<sup>10</sup> Exhibit 3.1.1 shows that this increase in aquaculture production has predominantly occurred in inland waters. Between 2010 and 2022, the average growth rate was 3.94% for marine aquaculture and 4.41% for inland aquaculture. The higher growth rate in inland aquaculture can be attributed to lower capital and production cost requirements, influenced by the structure and species type produced.<sup>10</sup> Additionally, the regulatory framework for marine aquaculture is complex and fragmented in many parts of the world, including the U.S., which impedes the expansion of operations.<sup>11</sup>

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\*Numbers presented in this chapter refer to aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (such as corals, pearls, shells, and sponges) and algae. Volume data is expressed in live weight equivalent for aquatic animals.

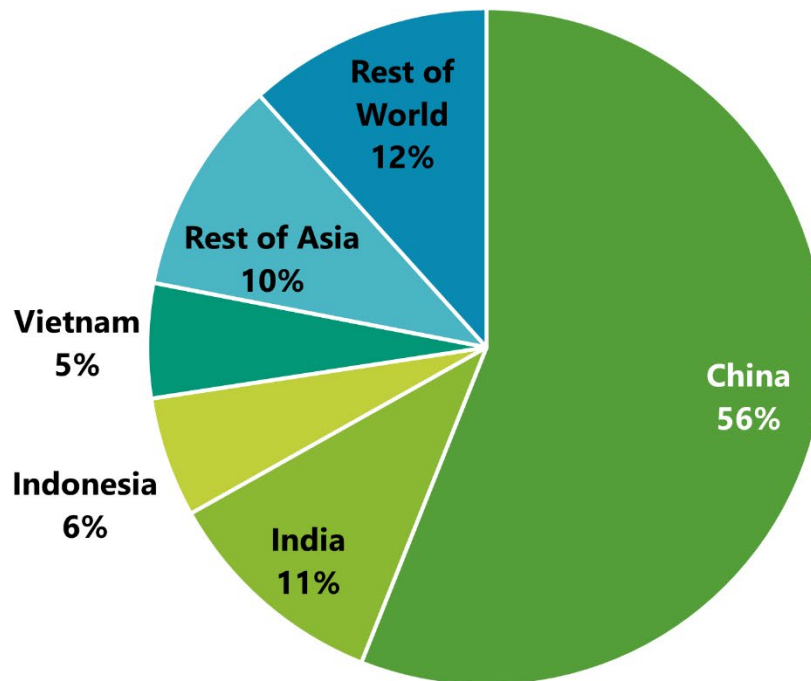
**Exhibit 3.1.1. World capture fisheries and aquaculture production.**



Source: Food and Agriculture Organization of the United Nations (2024).<sup>9</sup>

China, Southeast Asia, and India dominate the world aquaculture production. By far the largest producer, China produced more than half of the global aquaculture volume and value in 2022. India ranked second, followed by Indonesia and Vietnam (Exhibit 3.1.2). These four countries accounted for more than 75% of the global aquaculture production volume and 80% of the global aquaculture value.

**Exhibit 3.1.2. Global animal aquaculture (excluding algae) production by volume, 2022.**

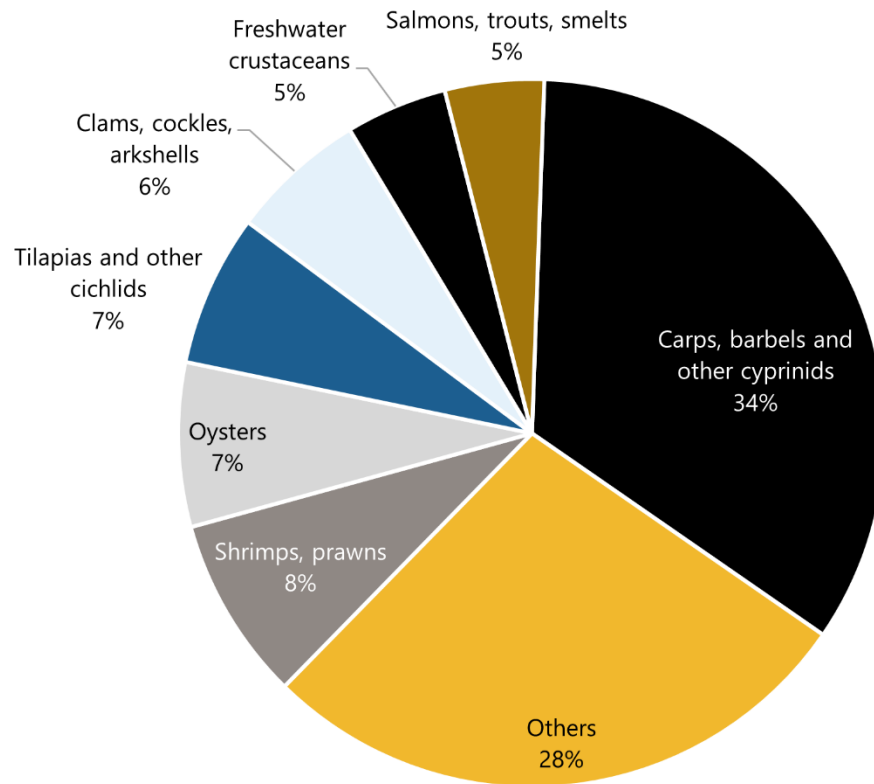


Source: Food and Agriculture Organization of the United Nations (2024).<sup>9</sup>

Finfish make up two-thirds of global aquaculture food fish production — about 61.6 million metric tons in 2022.<sup>9</sup> Mollusks are the second most relevant group in volume, making up 20%, but they show a historical trend of decreasing participation in the total volume produced. Crustaceans represented 13.5% of aquaculture production in 2022 and show a historical trend of increasing participation.<sup>9</sup>

Aquaculture producers worldwide focus on raising and selling higher-value seafood products. In 2018, aquaculture supplied about 52% of seafood for human consumption and accounted for 62%, or \$250 billion, of the value of seafood harvested globally.<sup>12</sup> An analysis of production volume by species (Exhibit 3.1.4) shows that carps, barbels and other cyprinids correspond to 34% of the world's aquaculture production. The relevance of carps, barbels and other cyprinids is related to their historical production in China in systems that use little or no feed and to the preferences of Chinese consumers.<sup>13</sup>

**Exhibit 3.1.4. World aquaculture production.**



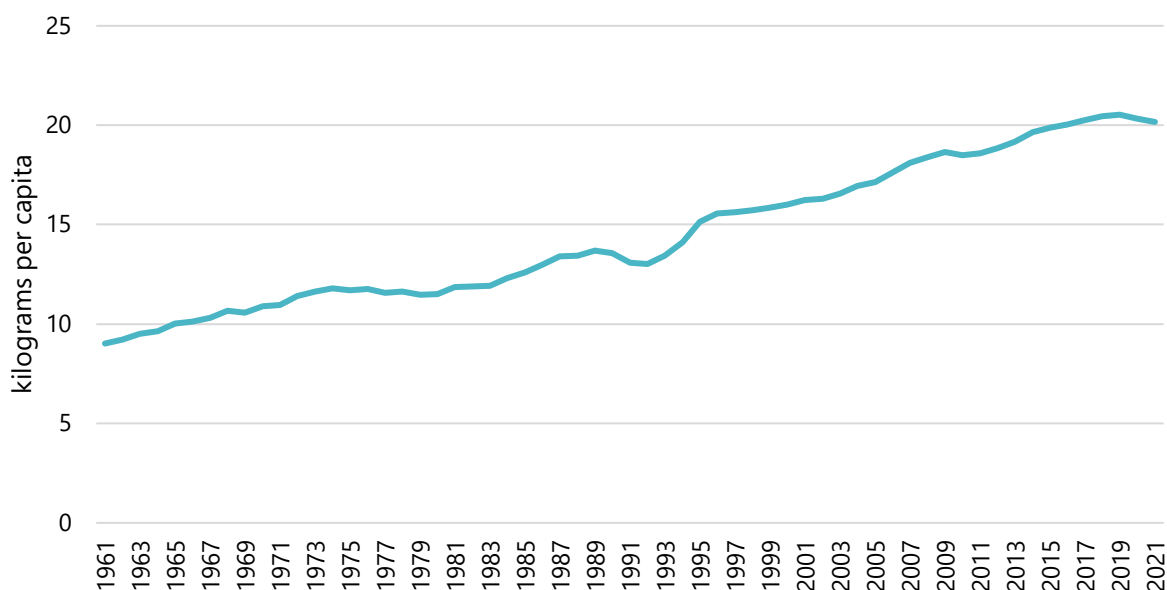
Source: Food and Agriculture Organization of the United Nations (2024).<sup>9</sup>

## 3.2 Global aquaculture consumption and demand

Aquaculture has the potential to increase protein availability and decrease malnutrition because seafood is a net contributor of protein, requiring around 0.6 kilogram of human-edible protein to produce 1 kilogram of protein in the fillet.<sup>14</sup>

Global fish consumption grew at a faster annual rate than the global population from 1961 to 2021. The annual global population growth rate during that time was 1.6%, while the annual increase in fish consumption was 3%.<sup>9</sup> Exhibit 3.2.1 shows that, from 1961 to 2021, the per capita consumption of fish and seafood grew at a rate of 1.35% a year, increasing from 9 kilogram per capita in 1961 to 20.16 kilogram per capita in 2021.<sup>15</sup>

**Exhibit 3.2.1. Fish and seafood consumption per capita.**



Source: Food and Agriculture Organization of the United Nations (2024).<sup>9</sup>

Increased fish consumption is attributed to an increasing fish harvest, including fish harvested from aquaculture. Other factors for increasing global fish consumption include the following:

- Technological developments in processing, cold chain, shipping and distribution
- Rising incomes worldwide, which strongly correlate with increased demand for animal proteins, including fish and fish products
- Reductions in loss and waste
- Increased consumer awareness of the health benefits of eating fish
- Global population growth increasing the quantity of aquaculture products demanded

- Consumer willingness to spend on eating out, as consumers in developed economies, such as the U.S., consume many aquaculture products when eating away from home

Increases in quantities demanded and supplied can also heighten marketing risk, including possibilities for saturating markets. For example, the U.S. catfish industry experienced competition from catfish-like imports in the 1990s and early 2000s. Lower-priced imports can challenge U.S. aquaculture, especially during periods of economic recession and higher feed costs.<sup>16</sup> Additionally, at the global level, even though fish consumption increases by 5% when disposable income increases by 10%, its negative response to fish prices is stronger, showing an 8% decrease in consumption when prices increase 10%.<sup>17</sup>

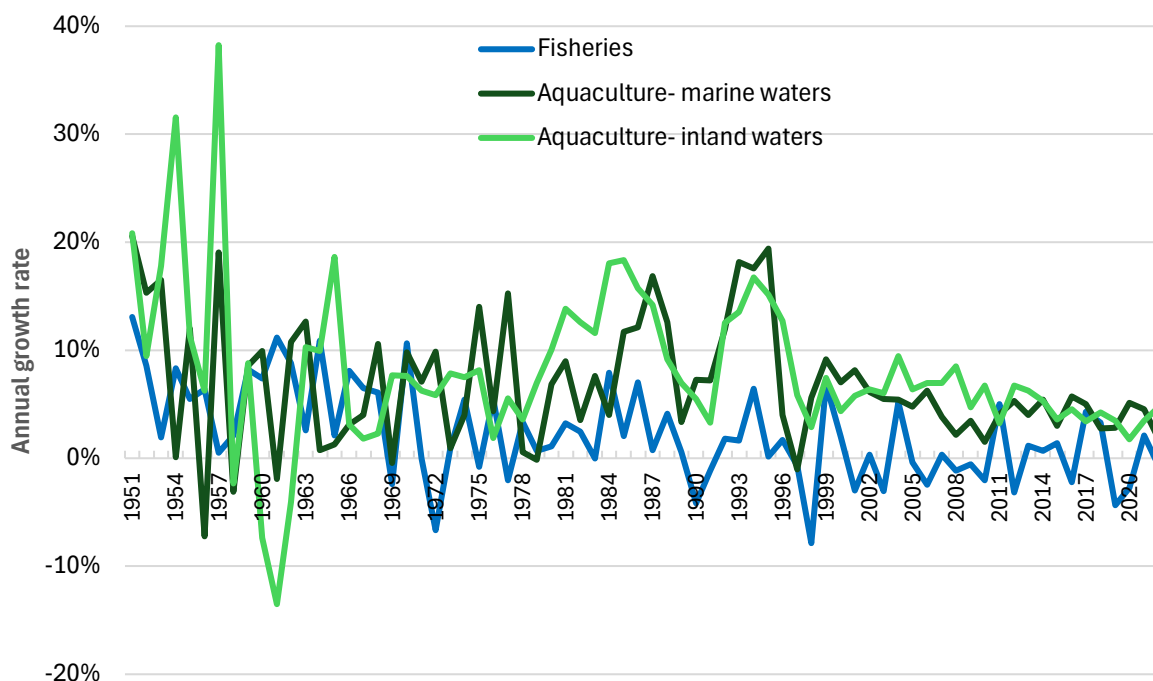
The aquaculture industry often supports laws and policies advocating for country-of-origin labeling and other measures that educate buyers about where and how fish were raised and harvested. These labels have the potential to increase the competitiveness of sustainable aquaculture production. For example, health and environmental labels have been shown to increase consumers' willingness to pay more in European countries.<sup>18</sup>

### **3.3 Global aquaculture trends**

Globally, aquaculture producers report a wide range of production systems, products and markets. This section summarizes ongoing trends among global producers across production systems and regions.

Steady growth has been occurring in global aquaculture since 1961 (Exhibit 3.3.1). Global production of farmed aquatic animals grew by 5.3% annually from 2001 to 2016. Increases in finfish production, especially in China, propelled this growth.<sup>9</sup> The growth rate slowed to 4% in 2017, 3.69% in 2018, and 3% in 2020, its lowest level in the past 27 years. Between 2020 and 2022, it increased to 3.75%.

### ***Exhibit 3.3.1. Annual growth rate of world aquaculture production volume.***



Source: Food and Agriculture Organization of the United Nations (2024).<sup>9</sup>

Aquaculture production in China grew by only 1.44% and 2.85% in 2019 and 2020, respectively. In 2021 and 2022, it increased by 3.23% and 3.25%, respectively. However, the increase in aquaculture production outside of China was 5.6% in 2019 and 3.2% in 2020, rising to increases of 4.7% and 4.1% in 2021 and 2022, respectively. These numbers reflect the fact that, although aquaculture growth has slowed in China, other Asian producers, including Indonesia and Bangladesh, are more rapidly increasing their production.<sup>9</sup>

International trade continues to be central for major aquaculture producers. The U.N. estimates that the global total trade value of fish for human consumption has annually exceeded the trade value of meats raised on land since 2016.<sup>9</sup>

China and Vietnam are the top two global fish exporters by volume, and aquaculture production is a large portion of their total seafood exports. In 2023, Japan remained the largest seafood export destination for China, followed by the United States and South Korea. However, China's seafood exports to the United States decreased by 14.4% in volume and 21.6% in value from 2022<sup>19</sup> due to tariffs and retaliatory measures imposed by the two countries.<sup>20</sup> Aquaculture also figures substantially in fish export volumes from Thailand, Indonesia and India. Production specifically for export has factored into aquaculture industry growth in South and Southeast Asia.

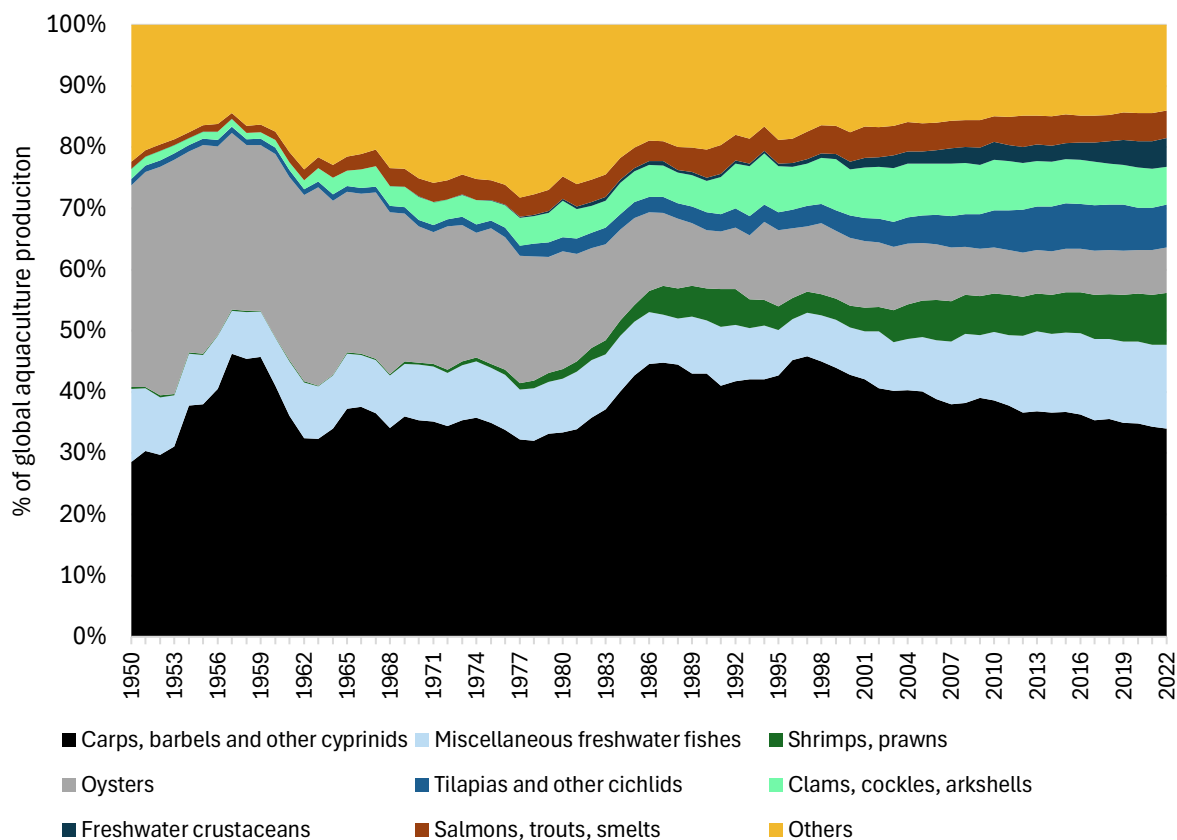
Some countries play important trade roles regionally. Norway has long been an important fish exporter to Europe. Chile has emerged as an important aquaculture exporter to North America and other markets. Both Norway and Chile focus on Atlantic salmon production.<sup>21</sup> Canada also has an important maritime aquaculture sector.

It is often noted that the U.S. aquaculture industry has not kept pace with increasing seafood consumption in the U.S. The country's seafood demand has been mainly supplied by imports. However, globally, aquaculture products are primarily used in the country where they are produced. A 2021 article stated, "The growing importance of domestic markets, particularly in Asia, means that over 89% of aquaculture input does not enter into international markets."<sup>21</sup>

Production diversification refers to expanding into different product categories. Data suggest that aquaculture farms have diversified (Exhibit 3.3.2). Carps and other cyprinids have been consistently the most relevant group in volume, but their participation in global aquaculture production has decreased, while the participation of shrimp and prawns, tilapias and other cichlids, freshwater crustaceans and miscellaneous freshwater fishes has increased. Growth in Asian freshwater shrimp, crab and crawfish production has driven freshwater aquaculture diversification globally.



**Exhibit 3.3.2. Participation of different groups of animals in the global aquaculture production volume.**



Source: Food and Agriculture Organization of the United Nations (2024).<sup>9</sup>

Biosecurity is important because disease is a risk to aquaculture industry sustainability and profitability. The biosecurity challenge comes from pathogens, parasites and pests — often termed “PPP” in the industry. Many global advances have been made in identifying and treating PPP in high-value, widely traded aquaculture.<sup>21</sup> In many cases, aquaculture biosecurity improvements can be linked with improvements and discoveries made in agricultural science and human medicine. Biosecurity remains a major concern, however, as highlighted in a U.N. report:

“Aquatic animal disease is one of the most serious constraints to the expansion and development of sustainable aquaculture. Globally, a trend in aquaculture is that a previously unreported pathogen that causes a new and unknown disease will emerge, spread rapidly, including across national borders, and cause major production losses approximately every three to five years. Such serious transboundary aquatic animal diseases are most often caused by viruses, but occasionally, a bacterium or a parasite may be the causative agent.”<sup>22</sup>

The field of aquaculture biosecurity has seen significant activity recently, with the highest number of research publications recorded in 2021.<sup>23</sup> The future of biosecurity will require a focus on data collection and analysis under collaborative arrangements between stakeholders,<sup>24</sup> improving diagnostic tools and surveillance systems for prompt response to disease outbreaks,<sup>25</sup> and the development of production standards, monitoring, and enforcement of compliance mechanisms.<sup>23</sup>

To prevent disease outbreaks, careful planning and site selection for aquaculture are crucial. Implementation of best management practices includes monitoring stocking densities, ensuring high-quality feed and broodstock, maintaining clean cages, using vaccines and rotating species.<sup>26</sup>

Additionally, experiences from the largest aquaculture-producing countries indicate that policies have shaped the geographical distribution of aquaculture growth. Finding the right policy balance between semisubsistence farms, small and medium enterprises (SMEs), and large-scale commercial operations is essential.<sup>26</sup>

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