

III. Aquaculture Production from 1994 to Present

A. Foodfish Production

This section includes aquaculture production estimates and comments on all types of edible fish that are cultured. It is divided into the following categories: pen-farmed/land based produced salmon, trout, catfish, tilapia, hybrid striped bass, and other foodfish. The 'other foodfish' category refers to any other type of cultured foodfish.

1. PEN-FARMED/LAND-BASED SALMON CULTURE

Table 4 provides production estimates since 1994 with future projections of pen-farmed/land based salmon for the twelve western region states. Prior to 1994, Washington, Oregon, California and Idaho all produced pen-farmed/land based salmon. However, production ceased in California, Oregon and Idaho partly due to disease problems and other factors. The only state that currently produces farmed salmon is Washington.

Table 4. Production Since 1994 with Future Projections of Pen-Farmed/Land-Based Salmon (Estimated Live Weight in Thousands of Pounds)*

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	0	0	0	0	0	0	0
California	0	0	0	0	0	0	0
Colorado	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0
Montana	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0
Oregon	0	195	0	0	0	0	0
Utah	0	0	0	0	0	0	0
Washington	11,184	9,697	12,114	12,781	5,698	12,126	15,000
Wyoming	0	0	0	0	0	0	0
TOTAL	11,184	9,892	12,114	12,781	5,698	12,126	15,000

* Estimates include Pacific Steelhead.

Alaska – The State currently prohibits any type of private farming of fish species. There are currently no commercial farmed salmon operations in Alaska. The bulk of salmon culture is towards enhancement of natural stocks of salmon. This state, with the longest coastline, has altogether prohibited net pen and cage farming on coastal waters. Salmon juveniles, or smolt, are released into the natural environment and harvested as adults when returning to spawn.

This is common for salmon species such as pink and chum salmon, but is not considered under this category.

California – Production of farmed salmon has decreased from 875,000 pounds in 1989 to no production in 1992. Net pen production was limited to physical parameters related to the north coast and politics. Land based culture (fresh and salt water) was based on the availability of water sources. There is currently no production projected through the year 2004.

Idaho – “Pan-sized” coho salmon was being produced through 1991, but currently there is no production in Idaho. Because salmon do poorly in freshwater and are susceptible to disease problems, there are no longer any companies that produce farmed salmon in Idaho.

Oregon – The amount of saltwater pen rearing areas is limited in this state. There was 195,000 pounds of farm-raised salmon in 1995. However, production has ceased with no production of farm-raised salmon reported since that time. There is currently no production estimated through 2004.

Utah – At the present time, Kokanee or land-locked sockeye salmon is reared for sportfishing purposes. However, the State could classify this species as “controlled” and can be reared in an aquaculture facility under the proper direction. The primary constraint is development of a pathogen free (IHN) broodstock. In addition, steelhead trout is currently being reared for fee-fishing and is reported under the trout category.

Washington – Salmon pen rearing in Washington has increased steadily from 3.1 million pounds in 1990 to over 12 million pounds in 1999. Production was relatively stable except for a drop in 1998 to 5.7 million pounds. Production of pen-farmed salmon is projected to increase to over 15 million pounds by 2004. Washington is currently the only producer of pen-reared salmon within WRAC states. There are many political factors that are involved affecting the acquisition of new sites.

Production of Atlantic salmon has remained fairly consistent with Atlantic salmon comprising the majority (99%) of the total salmon production. The average live/whole price averaged \$1.53/pound for Atlantic salmon. Of the Atlantic salmon produced in 1997, 70% are sold gutted and 30% are sold filleted. There is no current breakdown of market products.

The production of coho salmon has decreased substantially. Production of coho salmon in 1996 was over 72,000 pounds. Production has decreased significantly in 1998 with only 4,000 pounds produced. Production is not expected to increase significantly with only 9,000 pounds projected for 2004.

Production of chinook salmon started in 1997, with over 44,000 pounds produced. Production dropped to 30,000 pounds in 1998 and no production in 1999.

In addition to the production of foodfish, eggs and juveniles of chinook, coho, and Atlantic salmon are produced. In total, the value of the 1999 egg and juvenile production in Washington exceeded \$1.78 million.

Although not noted in the commercial production, pen-reared and delayed release of

smolt chinook and coho salmon in Puget Sound has created a very valuable recreational sportfishery. Delayed release of salmon causes them to stay within Puget Sound proper.

2. TROUT CULTURE

Table 5 provides data on trout culture production with future projections for the twelve western states. All states except for Alaska have some trout culture production. As in previous years, Idaho production dwarfed the other states in the western region, producing over 83% of the trout in this region. In most states, trout production has remained fairly stable over the past five years. Production projections indicate that most states will increase their production through the year 2004. All values are reported as wholesale values.

Table 5. Production Since 1994 with Future Projections of Trout Culture (Estimated Live Weight in Thousands of Pounds)

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	290	310	340	300	300	300	350
California	2,470	2,804	2,938	2,966	4,000	4,100	4,400
Colorado	950	976	543	538	960	774	1,008
Idaho	40,000	43,131	40,000	42,000	44,420	46,000	44,000
Montana	160	160	160	160	100	100	100
Nevada	<1	<1	<1	<1	<1	<1	<1
New Mexico*	641	646	600	600	600	600	600
Oregon	152	173	110	170	622	448	400
Utah	1,315	1,884	1,500	1,154	185	217	268
Washington	408	580	811	1,512	1,331	2,562	3,500
Wyoming	<5	<5	<5	<5	57	60	60
TOTAL	46,388	50,670	47,007	49,405	52,573	55,162	54,687

* New Mexico trout primarily for agency restocking.

Alaska – The State prohibition on any type of private farming of fish species mentioned in the previous section, also includes freshwater species.

Arizona – Production has increased slowly over the past several years, with a peak in production of 340,000 pounds in 1996. Production has decreased slightly to 300,000 through 1999 and is projected to reach 350,000 pounds by 2004. The lack of significant growth of the industry is limited due to the lack of new suitable production sites. The 1999 estimated value of trout production was \$600,000. In 1999, rainbow trout makes up 100% of the total

production, with 90% being sold live/whole. Trout are sold primarily to recreational and sportfishing industry. The remaining 10% of the trout production were sold gutted or as fillets. The average price of live/whole trout was \$2.00 per pound in 1999.

California – California was the second highest trout producing state in 1999, with a production of almost 4.1 million pounds of trout at a value of \$6.9 million. The 1998 Census of Aquaculture reported that there were 19 companies producing trout. All were sold live/whole and are sold almost exclusively to live recreational markets. This figure does not include public hatcheries, which produces trout for lake restocking programs. Production has been impacted by drought over the past several years and future consideration over water availability may affect future production. Estimated production in the year 2004 could reach 4.4 million pounds.

In addition to foodfish-sized production, California remains one of the major producers of eyed trout eggs. In 1997, over 100 million rainbow trout eggs were produced at a value of \$1.3 million. There have been no updated numbers since that time. The production of fingerlings and juveniles are negligible.

Colorado – Trout production in Colorado has fluctuated over the past five years with a peak in production of 976,000 pounds in 1995. 1999 trout production remains around 774,000 pounds, with an estimated value of \$2 million. Rainbow trout comprised the complete production and all are sold live/whole, primarily to the recreational market. Rainbow trout are sold to local homeowner associations, fishing clubs, fee fishing operations, and individual landowners. The average price per pound in 1999 was \$2.60/pound.

Trout production is expected to remain steady over the next couple of years. Currently, the biggest constraint facing the industry is whirling disease. The presence of a disease can shut an aquaculture facility down. In addition, over 8,000 fingerlings were sold at an estimated \$64,000 and 180,000 stockers were sold at an estimated \$558,000. It is expected that production of stockers will be around 420,000 fish valued at \$1 million by 2004.

Idaho – This is the leading state in trout culture in the United States with 46 million pounds of rainbow trout produced in 1999. The production value was estimated at over \$37 million in 1999. It is projected that production will remain steady through 2004, with 44 million pounds estimated. Water resources are currently being used near the capacity of the given availability. Economics and current technology also play a role in the future of trout culture. In 1997, approximately 50% of the trout are sold as fillets, 30% are sold gutted, and 20% are sold as other product types. A very small portion is sold live/whole. There is no current breakdown of market products sold. The 1999 wholesale price of live/whole trout averaged \$0.81 per pound.

Montana – In 1989, over 200,000 pounds of trout were produced. In 1990, production decreased to 116,000 pounds in 1990 due to several farm closures and had slowly increased back to 160,000 pounds by 1993. Production decreased slightly with 100,000 pounds of trout produced annually in 1998 and 1999, with latest estimated value of \$200,000 in 1999. Annual production of trout is projected to remain steady through 2004. The average price per

pound for whole/live product is \$2.00. It is projected that there will be no significant increase in production through the year 2004. The potential for increased production is there, but the main problem will be distribution of the product. Water resources are available in many areas but tradition, interpretation of water laws, and lack of education may limit opportunities for expansion. Over 800,000 rainbow trout fingerlings and 1.5 million eggs were produced in 1999.

Nevada – Production has decreased from 10,000 pounds in 1991 to less than 1,000 pounds in 1999. There are only a few remaining producers in Nevada. Production is primary for private sticking of fee fishing or camping facilities. It is estimated that there is minimal commercial production due to lack of water and proximity to markets.

New Mexico – Trout culture is relatively small at present in this state, with only one commercial producer. Water availability continues to be the limiting factor towards growth of the industry. Because there is currently only one commercial operation, the commercial production figures are combined with the state agency production due to confidentiality.

Oregon – Trout culture in the late 1980s and early 1990s remained stable with 750,000 pounds being produced annually. Production decreased to 152,000 pounds in 1994 and remained around 170,000 pounds through 1997. One producer did not produce any product during this time, causing a decline in the overall production. Production increased to 622,000 pounds in 1998 and decreased to 448,000 pounds in 1999. Production is expected to remain relatively stable through 2004, with 400,000 pounds of trout projected. The 1999 estimated value of trout production in Oregon was over \$561,000. The 1997 wholesale price of live/whole trout averaged \$1.25 per pound.

Utah – There are fourteen trout growers in Utah, and production has remained fairly constant. Prior to 1997, the reported figures included fee fishing operations. Starting in 1998, only market production was recorded. In 1999, production of trout was estimated at over 217,000 pounds at a value of \$431,000. It is projected that production will remain fairly consistent through 2004. All of the trout produced were rainbow trout. The average price per pound of whole/live trout was \$2.08. In addition, 101,000 fry and fingerlings are produced at a value of \$13,000.

Washington – Rainbow trout production (including steelhead) has increased over the past four years, from 580,000 pounds in 1995 to over 2.5 million pounds in 1999. The 1999 value of trout production exceeded \$2.8 million. Future production is projected to reach 3.5 million pounds by the year 2004. The average wholesale price for live/whole trout was estimated at \$1.13 per pound in 1999. Although there is no current product breakdown, approximately 90% were sold gutted, 5% were sold live/whole, and 5% were sold as fillets in 1997. In addition to the sale of foodfish-sized trout, there was substantial production of juvenile and trout eggs. It should be noted that Washington is the largest producer of rainbow trout eggs in the world.

Wyoming – Reported figures for trout culture through 1991 was for both restocking purposes by state agencies and for commercial sales. The sale of trout for foodfish and to fee-fishing operations has remained stable and is approximately 60,000 pounds per year. Future projections of the industry production do not project a significant increase in production. Only rainbow trout are sold and the current wholesale market price is \$2.48 per pound.

3. CATFISH CULTURE

Table 6 provides catfish culture production since 1994 with future projections for the twelve western states. In 1999, California remains the largest producer with 87% of the production, followed by Idaho and Arizona with 8% and 6%, respectively. Production in the other states remains small compared with the established states. Future projections for almost all states indicate an increase in production to the year 2004. All values are reported as wholesale values.

Table 6. Production Since 1994 with Future Projections of Catfish Culture (Estimated Live Weight in Thousands of Pounds)

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	380	400	430	450	400	400	500
California	5,503	6,003	6,002	6,102	6,200	6,300	6,600
Colorado	0	0	0	0	0	0	0
Idaho	571	573	580	615	600	550	500
Montana	0	0	0	0	0	0	0
Nevada	10	10	5	5	<1	<1	<1
New Mexico	<1	<1	0	0	0	0	0
Oregon	0	<1	0	0	0	0	0
Utah	0	0	0	0	0	0	0
Washington	3	3	0	<1	0	2	3
Wyoming	0	0	0	0	0	0	0
TOTAL	6,468	6,991	7,017	7,173	7,201	7,253	7,604

Arizona – Production of catfish has been slowly increasing over the past 14 years from 250,000 pounds in 1987 to 450,000 pounds in 1997. There has been a slight decrease in production to 400,000 in 1998 and 1999. This may be due to the fact that several farms have changed ownership. In 1999, the estimated value of the Arizona catfish industry was \$440,000. Channel catfish is currently the only species cultured and 100% are sold live/whole. The average wholesale price is \$1.10 per pound, whole. It is projected that production will increase to 500,000 pounds by 2004, but the exact amount will vary with species mix and management capabilities. Start-up problems in several new farms have

limited the increase in production, but are expected to bring more product to market.

California – Production of all catfish species increased to almost 6.3 million pounds and an estimated value of \$13.8 million in 1999. The production figures include production of food-sized fish sold to stock recreational lakes. Almost all of the catfish produced are being sold live/whole ranging from \$1.50 to \$2.20/pound. Drought conditions negatively impacted the production in the early 1990s and can affect future production. Change in ownership and one farm closing has decreased the growth of catfish production. Production of all catfish species is expected to remain fairly consistent with 6.6 million pounds by the year 2004. In recent years, bird predation has been a major problem with over 10% of the annual production lost to migratory birds.

Colorado – Colorado currently imports catfish from Kansas and Arkansas to supply the sportfishery. There is no in-state production of foodfish size catfish in Colorado. Although the state has high quality geothermal water, there are some environmental problems associated with accessing the water resource.

Idaho – Geothermal water provides intensive catfish culture in raceways. In 1999, an estimated 550,000 pounds of catfish were produced, at an estimated value of \$660,000. Production has remained fairly steady over the past five years and is expected to decrease slightly to 500,000 pounds by 2004. The 1999 average price per pound live/whole was estimated at \$1.20. In 1997, the product breakdown was as follows: less than 1% live/whole, 11% gutted, 80% fillets, and 9% other processed products. The 1999 breakdown of market product is similar.

Nevada – The production of catfish, primarily channel catfish, has declined dramatically since 1993. There is currently only one farm producing any product. There is minimal potential for the production of catfish in the future, but no increases in projection could be given. Production remains dependent on interest in catfish farming and weather conditions that can vary year to year. There are numerous low flow geothermal sites but few large artesian flows. Many artesian sources are remote and/or contain endangered fish species.

New Mexico – There is some experimental catfish production using geothermal water, with less than 1,000 pounds produced in 1995. There is currently no commercial production of food-sized catfish. There is a growing interest, but producers are awaiting information and assistance from the University.

Oregon – In 1995, there was some experimental catfish production with less than 1,000 pounds produced. However, no production was reported since that time. Water temperature and short growing season are the primary constraints to catfish production in Oregon. Geothermal resources may offer some potential, but the supply of water is limited.

Utah – There is growing interest in catfish culture in Utah. However, there is no commercial production at this time.

Washington – Minimal channel catfish production has occurred over the past several years, with 2,000 to 3,000 pounds produced from 1992 through 1999. It is projected that production will not significantly increase through 2004. The average wholesale price was estimated at \$3.00 per pound. In addition to the market production, less than 500,000 juveniles were produced at an estimated value of less than \$500,000.

Wyoming – Geothermal potential for catfish currently exists, however, environmental problems are limiting the potential. The only recorded production of catfish was in 1991, with less than 1,000 pounds produced.

4. TILAPIA CULTURE

Tilapia continues to be the fastest growing agricultural product in the United States, with growing acceptance in most of the traditional markets. Table 7 provides tilapia culture production since 1994 with future projections for the twelve western states. Production in the western region has remained relatively stable since 1994. California produced 63% of the 1999 production. Idaho, Arizona, and Colorado followed California in production. Further, California is the leader in tilapia production nationally, with total U.S. production close to 19 million pounds. Tilapia production should increase over the next several years because of growing acceptance by consumers for this foodfish and through increased production from the farms. Acceptance of tilapia as foodfish is reflected in imports of estimated 90+ million pounds on a product weight basis (See Appendix E).

Table 7. Production Since 1994 with Future Projections of Tilapia Culture (Estimated Live Weight in Thousands of Pounds)

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	400	420	415	450	425	400	550
California	3,650	3,850	3,950	4,500	4,260	3,380	5,000
Colorado	100	100	200	200	300	300	300
Idaho	800	1,008	1,100	1,100	1,200	1,300	1,500
Montana	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0
New Mexico	0	<1	0	0	0	0	0
Oregon	0	0	0	0	0	0	0
Utah	0	0	0	0	0	0	0
Washington	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0
TOTAL	4,950	5,379	5,665	6,250	6,185	5,380	7,350

Arizona – Tilapia production in Arizona has remained between 400,000 and 450,000 pounds over the past seven years after reaching a high of 640,000 pounds in 1988. Production is projected to increase to 550,000 pounds by the year 2004. The 1999 value of the production is estimated at \$500,000. All of the production is from *Oreochromis* hybrids. In 1999, 90% were sold live/whole at an average price of \$1.00 per pound.

California – Many tilapia species are prohibited in California. Only *O. nolitica*, *O. mossambica*, and tilapia hybrids are grown. Production has increased rapidly from 250,000 pounds in 1989 to over 4.5 million pounds in 1997. Production has decreased to 3.4 million pounds in 1999 and is expected to increase to 5 million pounds by the year 2004. The decrease in production is due to closure of one commercial operation. All tilapia production is sold live/whole. The market is also affected by the poor dress-out weight of tilapia. The average price per pound for live markets is \$2.20 per pound, slightly lower than the previous survey.

Colorado – Tilapia culture has increased from no production in 1990 to an estimated 300,000 pounds in 1999. Presently, there is only one major producer of tilapia in Colorado. Tilapia is currently a prohibited species in Colorado, with the one farm “grandfathered”. Production is relatively stable and is not expected to expand through 2004. All of the fish are sold live/whole at an average price of \$1.25 per pound.

Idaho – The production of tilapia in Idaho has significantly increased from 40,000 pounds in 1988 to over 1 million pounds in 1990. This increase in production apparently came from new high density/high technology water re-use systems using geothermal resources. Production has remained stable over the past eight years. In 1999, over 1.3 million pounds of tilapia were produced at an estimated value of \$1.6 million. It is projected that tilapia production will slightly increase to 1.5 million pounds by the year 2004. In 1999, wholesale values for tilapia ranged between \$1.25 and \$1.50/pound, live weight. In 1997, approximately 80% of the tilapia produced was sold live/whole, 15% sold gutted, and 5% fillets. Although the product breakdown was similar, there were more live and less fillets in 1999.

Montana – There is currently no tilapia production in Montana. However, there is reported a potential for future aquaculture production in Montana.

New Mexico – In 1995, there was less than 1,000 pounds of tilapia produced on an experimental basis. However, due to the low dress-out weight, it was determined that juvenile production was more lucrative. There is currently no commercial production of food-sized fish. One company is producing juveniles for sale to companies in other states.

Nevada – Tilapia is currently a prohibited species. Special provisions approved by the State are required.

Oregon – There is currently no tilapia production in Oregon. The cooler water temperature

(short growing season) is the primary constraint to tilapia production. Geothermal resources may offer some potential, but the supply of water is limited with investments being made into other uses. Regulations of exotic species may also limit the potential for tilapia aquaculture.

Utah – Tilapia is currently a prohibited species in Utah. However, some interest in tilapia culture has been expressed.

Washington – There is some interest in starting commercial production of tilapia with one farm being experimentally developed using geothermal water.

5. HYBRID STRIPED BASS

Table 8 provides hybrid striped bass production estimates since 1994 with future projections for the twelve western states. California produces approximately 96% of the hybrid striped bass for this region. Production in Arizona and Colorado are expected to increase by 2004. Total hybrid striped bass is projected to reach 4.2 million pounds by 2004.

Table 8. Production Since 1994 with Future Projections of Hybrid Striped Bass (Estimated Live Weight in Thousands of Pounds)

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	20	40	50	50	40	40	60
California	2,760	3,000	3,325	3,350	2,500	3,200	4,000
Colorado	15	20	50	75	90	98	150
Idaho	0	0	0	0	0	0	0
Montana	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0
Oregon	0	0	0	0	0	0	0
Utah	0	0	0	0	0	0	0
Washington	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0
TOTAL	2,795	3,060	3,425	3,475	2,630	3,338	4,210

Arizona – Production of hybrid striped bass has slowly increased from 10,000 in 1992 to 40,000 pounds in 1999. The estimated value of the 1999 production was \$120,000. All were sold live/whole at an average wholesale price of \$3.00 per pound in 1999.

California – Production of hybrid striped bass has remained fairly consistent with approximately 3.2 million pounds produced in 1999 at a value of \$13 million. It is expected

that production will increase to 4 million pounds by 2004. All products are sold live/whole. The production has rapidly increased to meet the current need.

Colorado – In 1990 and 1991, there was around 250,000 pounds of hybrid striped bass produced in Colorado. The production level dropped for 1992 because of company closures. There is currently only one producer. Production has increased again in recent years, with the 1999 production estimated at 98,000 pounds. Production is expected to increase back up to 150,000 pounds by the year 2004. All hybrid striped bass are processed in the round. The estimated value of production at \$2.00 per pound is \$196,000.

Idaho – Hybrid striped bass are currently illegal in Idaho.

6. OTHER FOODFISH

Other foodfish includes sturgeon, largemouth bass, bluegill, crappie, bullfrogs and other types of foodfish produced through aquaculture. Table 9 provides other foodfish production estimates since 1994 with future projections for the twelve western states. All values are reported as wholesale values.

Table 9. Production Since 1994 with Future Projections of Other Foodfish Culture (Estimated Live Weight in Thousands of Pounds)*

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	200	200	190	150	110	80	100
California	1,100	1,448	1,905	2,875	2,800	2,800	4,950
Colorado	0	0	0	0	0	0	0
Idaho	38	32	100	150	200	200	250
Montana	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0
Oregon	0	0	0	0	0	0	0
Utah	11	11	0	0	0	0	0
Washington	<1	<1	0	27	95	132	251
Wyoming	0	0	0	0	0	0	0
TOTAL	1,350	1,692	2,195	3,202	3,205	3,212	5,551

* Other foodfish include sturgeon and other types of foodfish produced through aquaculture.

Arizona – Production of other foodfish has decreased from 200,000 pounds in 1995 down to 80,000 pounds in 1999 and an estimated value of \$220,000 produced in 1999. Total production of other foodfish is expected to slightly increase to 100,000 by the year 2004. Largemouth bass (*Micropterus salmoides*) comprised 100% of the other foodfish production in 1999. All were sold live/whole at an average wholesale price of \$2.75 per pound in 1999. Largemouth bass production is not expected to increase significantly through the year 2004. In 1997, less than 1,000 pounds of common carp was reported. However, production of carp has ceased under the new ownership.

California – Over 3.5 million pounds of other foodfish were produced in 1999 at an estimated value of \$9 million. Estimated production could reach 4 million pounds by the year 2004.

White sturgeon harvests have steadily increased from 200,000 in 1989 to over 2 million pounds in 1999. Production is estimated to increase to 3 million pounds by the year 2004. The value has been rapidly increasing as the amount of fish grown for caviar has been increasing. The market breakdown is as follows: whole/live 5%, gutted 70%, fillet 25%.

Hybrid carp, including bronze goldfish, production has increased from 105,000 in 1993 to 410,000 in 1995, then decreased to 350,00 by 1997, then increased to 500,000 pounds in 1999. All of the carp are sold live/whole at an average price per pounds of \$2.00. There is an increasing demand to provide carp to supply the ethnic market with production projected to reach 1 million pounds by 2004.

Largemouth bass production was 200,000 pounds in 1999. It is expected to increase to 750,000 pounds by 2004. All of the production is sold live/whole at an average price of \$6.00 per pound.

There are various other sunfish that are produced for sale to the recreational fishery. Production was approximately 100,000 pounds at a value of \$300,000 in 1999 and is expected to remain fairly stable through 2004. The average price per pound was \$3.00 in 1999.

Although there is no reported production of Sacramento blackfish in 1999, it is expected to increase to 100,000 by 2004.

Idaho – Commercial sturgeon culture began slowly and remained at approximately 3,000 pounds until 1991. Production has quickly increased over the past eight years. In 1999, 200,000 pounds of sturgeon were produced at an estimated value of \$350,000. It is projected that the production of sturgeon will continue to increase to over 250,000 pounds by the year 2004. The wholesale price per pound was projected at \$1.50 per pound live/whole in 1999. There is currently no market breakdown available for sturgeon.

Montana – There is currently no production of other foodfish. Interest remains in sturgeon and walleye culture. Walleye culture is still in an early experimental stage with applications in for pilot studies.

New Mexico – There is currently no other foodfish grown on site other than in fee fishing situations.

Utah – Production of largemouth bass and sturgeon was estimated at 11,000 pounds annually in 1994 and 1995. However, there was no production recorded since 1996.

Washington – Production of other foodfish was estimated at 132,000 pounds in 1999. This consisted primarily of arctic char. There was 131,000 pounds of arctic char produced at a value of \$300,000 in 1999. Production of arctic char is expected to expand to 250,000 by 2004. Largemouth bass production was less than 500 pounds at a value of \$3,000. Production is not expected to increase significantly.

B. Shellfish Production

This section has been divided into four main categories: oysters, mussels, Manila clams, and others. Other types of cultured shellfish include crustaceans, clams, scallops and abalone culture. Most are marine species that are cultured only in coastal states. Crawfish and other species of crustaceans grown in freshwater have the potential to be grown in the inland states.

1. OYSTER CULTURE

Table 10 provides oyster culture production as live weight in pounds since 1994 with future projections for the twelve western region states. Washington remains the leader in oyster production of the coastal states, with 79.8% of the total production. This is followed by followed by California, Oregon and Alaska, respectively. Production of oysters is expected to increase in all states through the year 2004. All values are reported as wholesale values.

Alaska – The primary shellfish cultured in Alaska is the Pacific oyster. Information was reported in the number of individuals cultured. A conversion of 200 oysters/gallon x 8.25 was used to calculate the number of pounds of oyster meat produced (Glude & Chew 1982). The value is then converted to live weight (in the shell) by multiplying the value by seven. In 1999, production of pacific oysters was calculated to be 255,000 pounds of oysters. The 1999 value of oyster production exceeded \$327,000. The total production of pacific oysters in Alaska increased in the early 1990s, but has remained relatively stable over the past three years, with some farms closing and other farms starting production. All oysters are sold live, unshucked for the half-shell market. Depending on the success of these new farms, oyster production is projected to increase to 323,000 pounds by 2004. The markets remain strong with hanging culture the primary culture method. The permitting process is cumbersome and lengthy. The primary factor is the availability of seed. There is currently one hatchery and two seed nurseries in Alaska. Timing and size of seed continue to be the overriding factors. Finally, overall interests are accelerating in regard to the south-central and southeastern Alaska shellfish efforts, but it was noted much still needs to be done to promote change in regulations in order to realize any significant expansion for the growers.

California – Oyster production has been fairly stable over the past five years, with a slight decline in 1996 and 1997 production. Although California cultures a variety of oysters

Table 10. Production Since 1994 with Future Projections of Oyster Culture (Estimated Live Weight in Thousands of Pounds)*

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska**	217	250	251	249	235	255	323
Arizona	0	0	0	0	0	0	0
California	11,336	9,775	8,647	7,719	7,595	5,642	7,000
Colorado	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0
Montana	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0
Oregon	4,039	3,178	2,065	2,187	3,109	4,200	5,000
Utah	0	0	0	0	0	0	0
Washington	51,751	55,601	50,840	37,204	45,094	49,329	77,000
Wyoming	0	0	0	0	0	0	0
TOTAL	67,343	68,804	61,803	47,359	56,033	59,426	89,323

* Live weight estimated as 7 times the meat weight.

** Reported as individuals with conversion of 200 oysters/gallon x 8.25 x 7 = Live Weight (in Shell)

(including the Pacific oyster, triploid Pacific oyster, Kumamoto oyster and European oyster), the Pacific oyster comprises the majority (99%) of the harvest. Approximately 5.6 million pounds of live/whole oysters were harvested in 1999 at an estimated value of \$3 million. Estimated production could reach 7 million pounds of oysters by the year 2004. Humboldt Bay is still the major producing area in California. Recent moves to accommodate off-bottom longline culture in this bay is being done, as bed culture may be less available for future considerations.

Pacific oyster mortalities in Tomales Bay have raised concerns and investigations are currently being conducted to determine the cause. There are currently no hatcheries in the state of California. However, there are setting facilities for one major oyster and another company, which sets and sells a variety of shellfish seed. Both of these operations operate out of Humboldt Bay in northern California.

Oregon – Oyster production in Oregon has grown dramatically since 1990, with a peak in production of 4.9 million pounds in 1993. Since that time, production has slowly decreased to 2.1 million pounds in 1997 and then increased to 4.2 million pounds in 1999. The increase in production is due to increased seed investment and production in Coos Bay. The Pacific oyster is the primary oyster harvested in Oregon. While the amount of growing area is limited, production is projected to increase to 5 million pounds by the year 2004. One major

commercial shellfish hatchery is located near Tillamook Bay and sells mainly eyed-larvae.

Washington – Washington is one of the top producers of oysters in the United States. Production of oysters has consistently been at or over 50 million pounds each year. The 1999 oyster production was over 49 million pounds, valued at \$15 million. Oyster production is estimated to expand to around 77 million pounds, live weight by the year 2004. There are four main types of oysters cultured: Pacific, Olympia, Kumamoto, and European flat. The Pacific oyster comprises approximately 99% of the cultured oysters and 90% of those are sold as a shucked product. The remaining 10% are sold live/whole. Olympia oysters are also sold primarily shucked (95%), while the European flat oysters are primarily sold live for the half-shell market (90%).

In addition to the harvestable oysters, over 35 million oyster seed were produced at an estimated value of \$372,000 in 1995. Although there remains significant production of oyster seed, no information is available for 1999. Eyed larvae are also produced for sale to growers for remote setting. The largest oyster larvae producer in Washington alone produces over 28 billion larvae for use and sales. This facility is the largest producer in the world, with approximately 50% of the production being triploid oysters. Several other commercial shellfish hatcheries are located throughout this state. Growers acquire enough oyster seed for production, which was the primary constraint in the past.

Projections for future production indicate that the industry will remain fairly stable. However, future projections are difficult. Problems with low condition oysters greatly effected production in figures in Willapa Bay/Grays Harbor areas that normally provide over 60% of the state's production. Hopefully this situation will turn around. Also, recent problems affecting the industry are Pacific oyster mortalities, coupled with pollution and subsequent reclassification of growing areas and other losses of growing areas are of concern in the Puget Sound region. Pollution problems related to increasing human population growth and encroachment into adjacent shellfish growing areas are recognized. Finally, the aggravating losses of growing areas due to increasing infestation of the burrowing shrimp and potential spread of the cordgrass, *Spartina*, in Willapa Bay are pressing issues for the growers.

2. MUSSEL CULTURE

Table 11 provides production of cultured mussels since 1994 with future projections. Washington is the leader among the coastal states for cultured mussels. Production has remained fairly stable over the past five years, with slight increases and decreases in the overall production. Production is expected to increase in all states through the year 2004. All relative values presented in the following states are reported as wholesale values.

Table 11. Production Since 1994 with Future Projections of Mussel Culture (Estimated Live Weight in Thousands of Pounds)

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	3	4	7	2	5	4	5
Arizona	0	0	0	0	0	0	0
California	221	259	308	344	259	300	300
Colorado	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0
Montana	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0
Oregon	0	0	0	0	0	0	0
Utah	0	0	0	0	0	0	0
Washington	1,106	995	1,634	1,364	1,480	1,659	2,000
Wyoming	0	0	0	0	0	0	0
TOTAL	1,330	1,258	1,949	1,710	1,744	1,963	2,335

Alaska – Culture of blue mussels over the past 10 years has been inconsistent. In 1989, a new permitting program was followed by an increase in new farms. Production quickly increased to 17,000 pounds in 1991 and has fluctuated between 2,000 to 7,000 pounds over the past several years. In 1999, approximately 4,000 pounds of blue mussels were harvested at an estimated value of \$9,000. All seed are currently caught from wild set or incidental to other species. All production is through hanging culture in nets or baskets, due to predation by otters and birds. If farmers can deal with the equipment and labor-intensive processing this species requires, it holds promise. Markets are strong and it is expected that production will remain stable through the year 2004.

California – The primary species of culture is the Mediterranean mussel, *Mytilus galloprovincialis*. No production was reported for the large wild harvest of mussels from oil platforms in Southern California. Production was estimated to be 300,000 pounds in 1999 at an estimated value of \$270,000. Production is projected to remain stable through the year 2004. All of the products are sold to the live market.

Oregon – The historic culture of mussels in Oregon was minimal, with 5,000 pounds being produced in 1991. However, there is no recorded production starting from 1992. There remain many companies (not covered in this survey) that harvest wild mussels, *Mytilus californianus*. The low price of mussels and difficult regulations may be the limiting factor on the potential for mussel aquaculture in Oregon.

Washington – In 1999, it was estimated that over 1.6 million pounds of live mussels (*M. trossulus* and *M. galloprovincialis*) were produced at an estimated value of \$1.6 million. Production has increased substantially over the past seven years. It is projected that production will increase to 2 million pounds by the year 2004. All of the harvested mussels were sold live.

Production problems associated with the native (*M. trossulus*) mussel include the presence of a hemic neoplasia disease, which causes mortalities in market-sized product. The transfer of Mediterranean mussels (*M. galloprovincialis*) is also finding some resistance due to lack of information on the interaction on the native mussel species.

3. MANILA CLAM CULTURE

Table 12 provides a picture of production since 1994 of Manila clams. Washington has been the major producer of Manila clams over the past five years. This is followed by California. Restrictions on introduced species have limited the growth of the industry in other western states. All values are reported as wholesale values.

Alaska – There is currently no production of clam species in Alaska. There were two applications to modify existing licenses to allow farming of native littleneck clams, but not for Manila clams.

Table 12. Production Since 1994 with Future Projections of Manila Clam Culture (Estimated Live Weight in Thousands of Pounds)*

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	0	0	0	0	0	0	0
California	3	6	8	25	15	11	15
Colorado	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0
Montana	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0
Oregon	0	0	0	0	0	0	0
Utah	0	0	0	0	0	0	0
Washington	4,547	5,234	5,352	5,209	4,283	4,662	6,000
Wyoming	0	0	0	0	0	0	0
TOTAL	4,550	5,240	5,360	5,234	4,298	4,673	6,015

California – Manila clam production was estimated at 11,000 pounds in 1999 at an estimated value of \$26,000. It is projected that clam production can increase to 15,000 pounds by the year 2004.

Oregon – Current Oregon statutes do not provide for the culture of non-native clams, such as the Manila clam.

Washington – In 1999, it was estimated that over 4.6 million pounds of Manila clams were produced at an estimated value of \$9.4 million. Production of Manila clams has remained fairly steady over the past 10 years. It is projected that production of clams could increase to 6 million pounds by the year 2004. It should be recognized that only small portions of the total clams are harvested through planted seed. However, most of the Manila clam beds are carefully worked and prepared for the new natural catch or hatchery seed plantings of Manila clams after each harvest. All clams were sold live or whole.

The impact of the recent federal court decision regarding Western Washington Treaty Indian shellfish rights allowing Native American tribes access to 50% of the harvestable resource (excluding artificial beds) is not known. The decision and implementation of the decision could impact present practices. There are currently discussions for a negotiated settlement, which would put the issue to rest.

4. OTHER SHELLFISH CULTURE

Other shellfish includes crustaceans, clams, scallops, abalone, and other types of shellfish cultured. Table 13 provides a picture of production since 1994 of this group of cultured shellfish. All values are reported as wholesale values.

Alaska – There is currently no production of other species in Alaska. There were two applications to modify existing licenses to allow farming of native littleneck clams in 1995. Because of lack of management funds by the State of Alaska, no new commercial clam harvesting permits were issued in 1995 and all were to be phased out in 1996. Therefore all clam harvest will be restricted to permitted aquatic farms. Hatchery seed for native littleneck clams are not yet available on a commercial scale. Other work is being conducted on geoduck and cockles. Therefore, commercial potential of this species is currently limited to naturally occurring reseeding. It is estimated that up to 10,000 pounds of native littleneck clams will be produced by the year 2002. Major constraints are the slow process of permitting new sites and development of public planting programs and regulations.

Arizona – Several farmers have stocked *Panaeus vannemei* into brackish ponds for trial grow-out. Production from these tests increased from less than 1,000 pounds in 1994 to 217,000 pounds in 1999. Several of the tilapia farms have been converted to shrimp production. The 1999 production was valued at over \$1 million. 20% of the production was sold live/whole. Specific pathogen free broodstock are grown in brackish water and sold to farms in Mexico.

Table 13. Production Since 1994 with Future Projections of Other Shellfish Culture (Estimated Live Weight in Thousands of Pounds)*

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	10
Arizona	<1	<1	<1	6	187	217	500
California	246	248	293	301	300	300	400
Colorado	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0
Montana	0	0	0	0	0	0	0
Nevada	0	<1	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0
Oregon	0	0	0	0	0	0	0
Utah	0	0	0	0	<1	<1	<1
Washington	341	364	279	211	234	151	330
Wyoming	0	0	0	0	0	0	0
TOTAL	588	614	573	518	698	669	1,241

* Other shellfish includes shrimp, crawfish, clams, scallops, abalone and other types of shellfish cultured.

California – California produces one of the largest varieties of shellfish and includes abalone, rock scallop, shrimp and crayfish. Abalone comprised over 99% of the total production in this category. The market is very strong and projected to expand quickly. The average wholesale price per pound was \$10.00 in 1997. 1997 estimates indicate that over 1 million seed abalone was produced at a worth of \$488,000. There is also substantial production of abalone larvae and seed, but there have been no updated larvae and seed production figures for 1999. Most of the cultured abalone is sold live, but there is some processing.

Several companies are testing grow-out of wild caught purple hinge rock scallop (*Crassadoma gigantea*) seed. Rock scallop production was less than 1,000 pounds. Production is not expected to increase considerably by the year 2004. Although there are several farms in the San Joaquin Valley that produce crawfish and freshwater prawn, *Macrobrachium*, there were no reported production values.

Nevada – There is currently only the experimental production of crawfish. Less than 1,000 pounds were produced in 1995. No data have been reported since that time.

New Mexico – There is growing interest in shrimp production. Growers are awaiting information from extension agents.

Oregon – Current Oregon statutes do not provide for the culture of non-native clams, such as the Manila clam. There is no culture of the native species of clam or other types of shellfish at this time.

Utah- Crawfish are currently cultured for exportation as broodstock. There was less than 1,000 pounds produced in 1999, with an estimated value of less than \$1,000. The average price per pound in 1999 ranged between \$4 to \$10 per pound. Although it is estimated that the production will increase through 2004, it is still considerably less than 1,000 pounds.

Washington – In 1999, it was estimated that over 151,000 pounds of other shellfish were produced at an estimated value of \$127,000. The primary type of other shellfish is the native (common) littleneck clam, butter clam, cockle, horse and mud clams. Production of clams steadily declined from 429,000 pounds in 1992 down to 151,000 pounds in 1999. It should be recognized that all commercial clams harvests are recorded on aquaculture reports. However, most of the native littleneck clam beds are carefully worked and prepared for the new recruitment of clams after each harvest. All clams were sold live or whole.

Production of the rock scallop was recorded in 1999, with less than 1,000 pounds produced.

Geoducks are currently being grown in Washington. However, there have been no harvests of the clams to date. Over the past several years, thousands of geoduck seed have been planted intertidally throughout Puget Sound and harvests will start after 1999. Geoducks are the largest burrowing clam in the world and command a high price in the Asian market. Seed are being produced in the hatchery and planted on intertidal beaches for harvest in 3 –5 years as a two pound clam.

The impact of the recent federal court decision regarding Western Washington Treaty Indian shellfish rights allowing Native American tribes access to 50% of the harvestable resource (excluding artificial beds) is not known. The decision and implementation of the decision could impact present practices. There are currently discussions for a negotiated settlement, which would put the issue to rest.

C. Aquatic Plant Production

This section takes into account large edible marine seaweed and unicellular freshwater algae culture. While microalgae production is concentrated in inland states, several coastal states are currently producing macroalgae. Table 14 provides algal production in dry weight since 1994. All values are reported as wholesale values.

Alaska – There are licenses to raise bull kelp (*Nereocystis leutkana*) and *Porphyra* species. However, there is no recorded harvest of aquatic plants through aquaculture.

Arizona – There is research on *Gracilaria* sp. culture across the border in Mexico, but no culture is anticipated in Arizona at the present time. Two ornamental plant farms have opened recently, but do not have any production. They have plans for local production in the future.

California – Total aquatic plant production was estimated at 1.1 million pounds and an estimated value of \$9 million in 1999. The 1999 figures include both food grade and animal grade production. The figures for microalgae are reported in dry weight since it is their common market form. The dry weight is calculated to be 1/10th of the wet weight. The microalgae, *Spirulina*, comprises the majority of the microalgae production with 620,000 pounds (dry weight) produced in 1999 at a value of \$4 million. The macroalgae, such as *Grassalaria*, was approximately 10,000 pounds (wet weight) in 1999. The other aquatic plants produced was approximately 481,000 pounds at a value of \$4.4 million. Other types of aquatic plants being produced include marine algae, aquarium plants, potted aquatic plants, and floating ornamentals.

Nevada – Culture of aquatic plants is regulated by the Department of Agriculture. There is currently no production.

Table 14. Production Since 1994 with Future Projections of Aquatic Plants (Estimated Weight in Thousands of Pounds)*

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	0	0	0	0	0	0	0
California	523	829	1,024	1,037	1,025	1,111	1,599
Colorado	0	0	0	0	0	0	0
Idaho	0	0	0	0	0	0	0
Montana	0	0	0	0	0	0	0
Nevada	0	0	0	0	0	0	0
New Mexico	0	0	0	0	0	0	0
Oregon	0	0	0	0	0	0	0
Utah	0	0	0	0	0	2	N/A
Washington	0	0	0	0	0	0	0
Wyoming	0	0	0	0	0	0	0
TOTAL	523	829	1,024	1,037	1,025	1,113	1,599

N/A Data not available.

* Aquatic plants refer to cultured edible seaweed and freshwater algae. Microalgae is reported in dry weight and macroalgae in wet weight

Oregon – Macroalgae culture is of interest with pre-production culture evaluation at the Hatfield Marine Science Center in Newport, OR. There is currently no commercial production in Oregon.

Utah – There was less than 2,400 pounds of aquatic plants produced in 1999. Products

produced include hyacinth, water celery, watercress, papyrus, and other aquatic ornamentals. There is room for growth of the industry in the future.

Washington – Nori is no longer cultured in Puget Sound. There was great interest in the early 1980s for nori culture and potential of other marine species of algae. Unfortunately, permit and fee requirements did not encourage the development of this culture. Harvests had significantly decreased from 1988 where over 62,000 pounds were produced to no production today.

D. Non-Foodfish Production

This section can be divided into tropical fish cultured for aquarium trade and baitfish. In several states, there are well-established industries. California cultures many types of tropical fish for the aquarium trade. Problems with bird predation, disease and lack of culture expertise are noted. Production figures are shown in Table 15. All values are reported as wholesale values.

Table 15. Production Since 1994 with Future Projections of Non-Edible Fish (Estimated Live Weight in Thousands of Pounds)*

	1994	1995	1996	1997	1998	1999	2004 (Est.)
Alaska	0	0	0	0	0	0	0
Arizona	10	12	12	12	<1	<1	<1
California	515	545	877	1,008	1,749	1,825	1,921
Colorado	0	0	0	0	0	0	0
Idaho	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Montana	0	0	0	0	0	0	0
Nevada	<1	<1	<1	<1	<1	<1	<1
New Mexico	<1	<1	0	0	0	0	0
Oregon	<1	<1	0	0	<10	<10	<10
Utah	<1	<1	0	0	0	0	0
Washington	0	0	1	1	1	1	1
Wyoming	0	0	0	0	0	0	0
TOTAL	529	561	891	1,022	1,762	1,838	1,933

N/A Data not available.

* Non-edible fish include tropical fish, baitfish and other aquatic animals that are cultured for non-consumptive purposes.

Arizona – There is a well-established baitfish industry. Tropical fish culture is just beginning. The main types of baitfish cultured are fathead minnows, golden shiners, and

goldfish. Approximately 12,000 pounds of baitfish are produced at an estimated value of \$300,000. There are currently two koi producers rearing for ornamental markets, with less than 1,000 pounds being produced in 1999. Several producers started to import juvenile triploid grass carp for rearing to adult size for stocking. Production of grass carp was also less than 1,000 pounds in 1999.

California – Non-edible fish produced in California includes brine shrimp, koi, fancy goldfish, baitfish, and various aquarium/tropical fish. Total production was 1.8 million pounds in 1999 at a value of \$7.3 million. Brine shrimp production comprises over 71% of the non-foodfish production. This is followed by feeder fish, baitfish and worms. In 1998 there were 6 companies producing koi, three producing goldfish, 2 tropical and six ornamental fish (1998 Census). In addition, there were several companies producing baitfish.

Colorado – There is one reported producer that is producing alligators for their own personal use. However, there are no reported commercial production figures available at this time.

Idaho – Although Idaho reported a small tropical fish industry in the past report, no current information was provided. In addition, one producer is also producing alligators. However, no production figures were reported.

Nevada – There may be several producers of ornamental fish for the California aquarium trade, however, there is no mandatory reporting of production to the Nevada Department of Conservation and Natural Resources. Production is estimated at less than 1,000 pounds. State production is low because many suitable geothermal sites are remote.

New Mexico – There is some culture of baitfish recorded through 1995. However, there was no reported production since 1996. The main constraints are the lack of local markets, lack of infrastructure support, and lack of culture expertise.

Oregon – There is some production of non-edible fish for 1999, with less than 10,000 pounds of koi being produced. It is estimated that the value of koi production is less than \$100,000. It is projected that there will be little to no growth of the industry through 2004.

Utah – There is growing interest in tropical fish farming using geothermal water. There was less than 1,000 pounds produced in 1994 and 1995. However, there was no production recorded since that time.

Washington - Minimal non-edible fish production of approximately 1,000 pounds produced in 1999. This was primarily koi for the ornamental fish market. There are currently two producers of ornamental fish and the production of koi is not projected to increase through the year 2004.