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Economic and Environmental Impact Analysis of the Proposed Effluent Limitations Guidelines and Standards for the Concentrated Aquatic Animal Production Industry

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CHAPTER 1

INTRODUCTION

1.1 SCOPE AND PURPOSE

The U.S. Environmental Protection Agency (EPA) proposes and promulgates water effluent discharge limits (effluent limitations guidelines and standards) for industrial sectors. This document summarizes both the costs and economic impacts of technologies that form the bases for the proposed limits and standards for the concentrated aquatic animal production (CAAP) industry and the change in water quality and potential benefits associated with the proposed regulation.

The Federal Water Pollution Control Act (commonly known as the Clean Water Act [CWA, 33 U.S.C. §1251 et seq.]) establishes a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (section 101(a)). EPA is authorized under sections 301, 304, 306, and 307 of the CWA to establish effluent limitations guidelines and standards of performance for industrial dischargers. The standards EPA establishes include:

- Best Practicable Control Technology Currently Available (BPT). Required under section 304(b)(1), these rules apply to existing industrial direct dischargers. BPT limitations are generally based on the average of the best existing performances by plants of various sizes, ages, and unit processes within a point source category or subcategory.
- Best Available Technology Economically Achievable (BAT). Required under section 304(b)(2), these rules control the discharge of toxic and nonconventional pollutants and apply to existing industrial direct dischargers.
- Best Conventional Pollutant Control Technology (BCT). Required under section 304(b)(4), these rules control the discharge of conventional pollutants from existing industrial direct dischargers.[1] BCT replaces BAT for control of conventional pollutants.
- Pretreatment Standards for Existing Sources (PSES). Required under section 307(b). Analogous to BAT controls, these rules apply to existing indirect dischargers (whose discharges flow to publicly owned treatment works [POTWs]).

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[1] Conventional pollutants include biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, pH, and oil and grease. EPA now measures oil and grease as "hexane extractable material."

- New Source Performance Standards (NSPS). Required under section 306(b), these rules control the discharge of toxic and nonconventional pollutants and apply to new source industrial direct dischargers.

- Pretreatment Standards for New Sources (PSNS). Required under section 307(c). Analogous to NSPS controls, these rules apply to new source indirect dischargers (whose discharges flow to POTWs).

Prior to this proposed rule, EPA defined "concentrated aquatic animal production facilities" at 40 CFR 122, Appendix C, and identified the need for them to obtain National Pollutant Discharge Elimination System (NPDES) permits, but had not set national effluent limitations guidelines or standards for these dischargers.

1.2 DATA SOURCES

EPA's economic analysis relied on a wide variety of data and information sources. Data sources used in the economic analysis include:

- EPA's Screener Questionnaire for the Aquatic Animal Production Industry (U.S. EPA, 2001)

- U.S. Department of Agriculture (USDA; particularly the *1998 Census of Aquaculture*, USDA, 2000)

- Joint Subcommittee on Aquaculture (JSA). JSA in an interagency statutory committee established by the National Aquaculture Act of 1980 to encourage the industry.

- Academic literature

- Industry journals

- General economic and financial references

The use of each of these major data sources is discussed in turn below.

EPA collected facility-level production data from individual aquatic animal producers through a screener survey administered under the authority of the CWA Section 308 (U.S. EPA, 2001). EPA used response data from the screener survey to classify and subcategorize facilities by production method, species produced and production level, and water treatment practices in place prior to the proposed regulation. EPA identified the subset of concentrated aquatic animal production facilities deemed to be in scope of the proposed rule.

EPA relied heavily on the USDA *1998 Census of Aquaculture* to profile the industry (USDA, 2000). EPA used the *Census* to identify the approximate number of aquaculture facilities in the U.S., their geographic distribution, species raised and production levels, and the distribution of facilities by revenue classification. EPA developed the production rate thresholds based on 1998 Census of Agriculture data and the screener data that was available prior to proposal. Six production size categories, corresponding to the revenue classifications used in the 1998 Census of Agriculture (i.e., $1,000-$24,999; $25,000 - $49,999; $50,000 - $99,999; $100,000 - $499,999; $500,000 - $1,000,000; and >$1,000,000) were used to group facility production data reported in the screener surveys. EPA used national average product prices taken from the 1998 Census to estimate the production (in pounds) for the dominant species that were reported grown in flow-through (e.g., trout salmon, tilapia), recirculating (e.g., tilapia, hybrid striped bass), and net pen (e.g., salmon) systems.

Based on revenues from aquaculture sales alone (not including other farm-related revenues from other agricultural crops at the facility), more than 90 percent of the facilities have revenues less than $0.75 million annually and thus may be considered small businesses. The Small Business Administration's (SBA) size standard is based on annual revenue at the company level for all products, so using facility revenue from aquaculture sales reported in the 1998 Census of Aquaculture is likely to over-estimate the proportion of small businesses in the industry. The Census data revenue category of $500,000 to $1,000,000 spans the SBA size standard of $0.75 million for this industry. USDA's National Agricultural Statistics Service (NASS) provided a special tabulation of statistics (count, sum, mean, median, standard deviation, and coefficient of variation) by species by revenue class where one of the revenue classes corresponded to SBA size standard ($0.75 million and greater).

JSA formed an Aquaculture Effluents Task Force to assist EPA. The Economics Subgroup provided enterprise budgets, additional references, and articles to EPA. An enterprise budget depicts financial conditions for representative aquaculture facilities. Enterprise budgets are useful tools for examining the potential profitability of an enterprise prior to actually making an investment. To create an enterprise budget, an analyst gathers information on capital investments, variable costs (such as labor and feed), fixed costs (e.g., interest and insurance), and typical yields and combines it with price information to estimate annual revenues, costs and return for a project. By varying different input parameters, enterprise budgets can be used to examine the relative importance of individual parameters to the financial return of the project or to identify breakeven prices required to provide a positive return. The Economics Subgroup of the JSA/AETF provided EPA with enterprise budgets for trout, shrimp, hard clams, prawns, and alligators.

EPA used academic journals and industry sources such as trade journals and trade associations to develop its industry profile, to formulate a better understanding of industry changes, trends, and concerns. As necessary, EPA cites various economic and financial references used in its analysis throughout the EA. These references may be in the form of financial and economic texts, or other relevant sources of information germane to the impact analysis.

1.3 REPORT ORGANIZATION

This report is organized as follows:

- Chapter 2—Industry Profile. Provides background information on the CAAP industry.

- Chapter 3—EPA's Screener Questionnaire for the Aquatic Animal Production Industry. Provides information from EPA's screener survey and focuses on the facilities EPA determined to be within the scope of the proposed rule.

- Chapter 4—Engineering Cost Methodology. Summarizes the engineering cost models and assumptions; a precis of the Development Document accompanying the proposal (U.S. EPA, 2002).

- Chapter 5—Economic Impact Methodology. Summarizes the methodology by which EPA examines incremental pollution control costs and their associated economic impacts.

- Chapter 6—Regulatory Options: Descriptions, Costs, and Conventional Pollutant Removals. Presents short descriptions of the regulatory options considered by EPA. More detail is given in the Development Document (U.S. EPA, 2002).

- Chapter 7—Economic Impacts. Using the methodology presented in Chapter 5, EPA presents the economic impacts associated with the compliance costs, including impacts on commercial and non-commercial facilities.

- Chapter 8—Small Business Analysis. Pursuant to the Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act, EPA examines whether the regulatory options have a significant adverse impact on a substantial number of small entities.

- Chapter 9—Environmental Impacts. Summarizes the issues examined by EPA regarding water quality impacts from nutrients and solids, ecological impacts, aquatic nuisance species, pathogens, drugs, and other potential impacts.

- Chapter 10—Environmental Benefits. Summarizes the methodology by which EPA identifies, qualifies, quantifies, and—where possible—monetizes the benefits associated with reduced pollution from implementing the proposed rule.

- Chapter 11—Cost-Benefit Comparison and Unfunded Mandates Reform Act Analysis. Using the benefits described in Chapter 10, EPA presents an assessment of the nationwide costs and benefits of the regulation pursuant to Executive Order 12866 and the Unfunded Mandates Reform Act (UMRA).

1.4 REFERENCES

USDA. 2000. United States Department of Agriculture. National Agricultural Statistics Service. *1998 Census of Aquaculture*. Also cited as 1997 Census of Agriculture. Volume 3, Special Studies, Part 3. AC97-SP-3. February.

USDA, NASS. 2002. Special tabulation request submitted to USDA NASS. Information relayed to EPA and Eastern Research Group, Inc. March 6.

U.S. EPA. 2002. Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Aquatic Animal Production Industry. EPA-821-R-02-016. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

U.S. EPA. 2001. United States Environmental Protection Agency. Screener Questionnaire for the Aquatic Animal Production Industry. Washington, DC: OMB Control No. 2040-0237. Expiration Date July 26, 2004.

CHAPTER 2

INDUSTRY PROFILE

Aquaculture is broadly defined as the farming or husbandry of fish, shellfish, and other aquatic animals and plants, usually in a controlled or selected environment (Becker and Buck, 1997). EPA is developing effluent limitations guidelines and standards for concentrated aquatic animal production facilities, that is, plant production facilities are not included. In this chapter, the term "aquaculture" has both the extended (aquatic animal and plant) and limited (aquatic animal only) meanings, depending on the context of the word.

An industry profile provides background information necessary to understand and characterize the industry being examined. When completed, it develops a baseline against which to evaluate the economic impacts to the industry as a result of compliance with any proposed requirements developed by the Agency. This chapter briefly describes the range in the entire U.S. aquatic animal production industry. The commercial sector, alone, produced nearly $1 billion in goods in 1998 (USDA, 2000a). The remainder of this document focuses on the subset of concentrated aquatic animal production facilities that EPA considers within the scope of the proposed effluent guideline.

The aquatic animal production industry is one marked by substantial public as well as private activity. This chapter begins with a general discussion of the government and private roles in aquaculture. The economic characteristics of the owner/operator of a production system vary greatly depending on whether it is a non-commercial or commercial venture. Hence, each of the subsequent sections—geographic distribution of facilities, the major species produced, economic value of production organizational structure, small entity definitions, market structure, and international trade—discusses public and private operations separately. Large supporting tables are located in Appendix A.

2.1 PUBLIC/PRIVATE ROLES IN AQUACULTURE

2.1.1 Federal

The National Aquaculture Act of 1980 provides for a national policy to encourage the domestic aquaculture industry and established the interagency Joint Subcommittee on Aquaculture (JSA). JSA is a statutory committee that reports to the National Science and Technology Council (NSTC) committee on science. NSTC, in turn, operates under the White House Office of Science and Technology Policy.[1]

The United States Department of Agriculture (USDA), the Commerce Department, and the Interior Department all have roles in the aquaculture industry. USDA focuses primarily on private aquaculture production, while the other two agencies concentrate more on public aquaculture production for recreational fishing and ecosystem restoration. JSA serves as a federal government-wide coordinating group among these and other agencies.

The Agriculture and Food Act of 1981 authorized USDA to establish regional aquaculture research centers (Title XIV, P.L. 97-98).[2] USDA also collects information (Economic Research Service, National Agricultural Statistics Service), provides assistance under farm lending programs and the Commodity Credit Corporation (CCC) credit guarantee programs, and promotes exports through the market access program.

Two branches within the Commerce Department's National Oceanic and Atmospheric Administration are concerned with aquaculture activities—the National Marine Fisheries Service (NMFS) and the National Sea Grant College Program. NMFS administers the Saltonstall-Kennedy grant program to fund research related to the harvesting, processing, and marketing of fisheries products. NMFS also supports four regional Fisheries Science Centers[3] to help restore depleted fish stocks and

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[1]This description is based on Becker and Buck, 1997.

[2]University of Massachusetts, Mississippi State University, Michigan State University, the University of Washington, and the Oceanic Institute (Hawaii).

[3]Southeast (Galveston, TX), Northwest, Northeast, and Alaska.

establish sustainable fisheries. The National Sea Grant Program funds aquaculture research projects at universities.

The Interior Department's Fish and Wildlife Service (FWS) operates a system of fish hatcheries and conducts fish research. Among its roles and responsibilities, FWS operates six Fish Technology Centers[4] for developing fish culture techniques and recovering endangered species and nine Fish Health Centers for research. FWS also operates the 66-facility National Fish Hatchery System to conserve, restore, enhance, and manage the Nation's fishery resources and ecosystems for the benefit of future generations. Table A-1 lists the FWS facilities (FWS, 2000a-c).

2.1.2 State

Every state has an agency to administer state natural resources, including fisheries. Many states operate fish hatcheries for stocking recreational fisheries. FWS maintains a memoranda of understanding with state fisheries to manage resources on U.S. Forest Service lands within the state (Epifanio, 2000). FWS distributes some of its hatchery production to various states. Many states have agreements with other states and Tribal governments to enable interjurisdictional management of shared resources. Based on Epifanio (2000) and individual state websites, EPA identified 369 coldwater propagation facilities nationwide and 53 warmwater hatcheries in 15 states (see Table A-2). EPA identified a total of 53 warmwater facilities in 15 states. An additional 78 facilities in 12 states could not be classified as coldwater or warmwater because they did not report which species are being raised. The number of warmwater state hatcheries, then, ranges from 53 to 131.

2.1.3 Tribal and Others

Tribal hatcheries support Indian communities' needs and desires for a healthy and abundant fishery for subsistence and cultural heritage. These hatcheries may be funded by the Bureau of Indian

[4]Abernathy, WA; Bozeman, MT; Dexter and Mora, NM; Lamar, PA; San Marcos, TX; and Warm Springs, GA (including the Bear's Bluff, SC field station).

Affairs or the tribal entity (WDNR, 2000). Table 2-1 lists the 17 tribal programs EPA has identified to date. The academic community is very active in aquaculture, with more than 80 institutions that have programs in fisheries, fishing, or fish and game management nationwide (see Table A-3). USDA funds regional aquaculture research centers, while NOAA administers its Sea Grant program to multiple institutions.

2.1.4 Private Aquaculture

Aquaculture's growing economic importance is marked by the 1998 *Census of Aquaculture* (USDA, 2000a). The USDA National Agricultural Statistics Service (NASS) determined that there was a need for a comprehensive snapshot of all aquatic species produced throughout the 50 states and U.S. Territories. The respondent universe for the Census is all farms identified as having sales of $1,000 or more from aquaculture products (USDA, 1998a).[5] As such, the production and revenues from aquatic animals represent a range from some to all of the commercial activities at the facility. The absence of total facility revenues affects the estimates of the number of small businesses in the industry, as discussed in Section 2.7 below.

The 1998 Census forms the basis for the description of commercial activities in this chapter. USDA identified 4,028 facilities that raise aquaculture products, including 20 that raise aquatic vegetables. USDA provided a breakout of facilities by species (e.g., catfish) or groups of related species (e.g., mollusks). Because a facility can raise more than one species, the sum of these individual listings totals about 4,800 operations.

[5]Form OMB 83-1 (Paperwork Reduction Act Submission) box 11 for the 1998 Census identifies the affected public as "farms;" the categories for not-for-profit, federal government, and state, local, or tribal governments are not marked. However, when contacted, USDA mentioned that the survey included commercial and non-commercial facilities but, for the most part, the sales tables do not include noncommercial data (Lang, 2000).

Table 2-1

Tribal Hatcheries

Tribal Program	State(s)	Annual Distributions
Bad River	WI	8,000-10,000 walleye fingerlings 10-14 million walleye fry
Keweenaw Bay	MI	100,000 lake trout yearlings 25,000 brook trout yearlings
Lac Courte Orielles	WI	7 million walleye eggs 140,000 walleye
Lac du Flambeau	WI	~14 million walleye fry 160,000 walleye fingerlings also muskellunge, bass, and trout
Lac Vieux Desert	MI	1.3 million walleye eggs
Leech Lake	MN	8 - 10 million walleye fry 50,000 walleye fingerlings 400,000 lake whitefish fingerlings 20 million white sucker eggs
Menominee	WI	walleye rearing station 400,000 fingerling capacity
Nunns Creek	MI	2-3 million walleye eggs 800,000 walleye fingerlings
Red Cliff	WI	trout and walleye rearing station
Red Lake	MI	capacity for 75 million walleye eggs; walleye and northern pike
Sokaogon	WI	1993 production (under reconstruction) 3 million walleye eggs 2 million walleye fry
St. Croix	WI	walleye
White Earth	MI	200,000 walleye fingerlings
Nez Pierce	ID	
Cherokee	OK	
Navajo Nation	AZ, NM, UT	
Fort Hall Shoshone-Bannock	ID	

Sources: FWS, 2000c; FWS, 2000d.

2.1.5 Aquariums

EPA initially considered aquariums as part of the aquatic animal production industry. Through an Internet search, EPA identified approximately 50 aquariums in the United States (seeTable A-4). Aquariums are part of North American Industry Classification System (NAICS) code 712130. There is no further breakdown of this code. Included in this code are: Animal exhibits, live; Animal safari parks; Aquariums; Arboreta; Aviaries; Botanical gardens; Conservatories, botanical; Gardens, zoological or botanical; Petting zoos; Reptile exhibits, live; Wild animal parks; Zoological gardens; and Zoos. Census data identify 269 non-taxable and 117 taxable establishments in this NAICS code (Census, 2001a and b). The upper bound count for aquariums, then, is 386 establishments.

2.1.6 Observations

Table 2-2 summarizes the estimated facility counts for each of the groups described above. There are between 4,600 to 6,000 facilities within the Agency's definition of the industry.

Table 2-2

Aquatic Animal Production Industry: Estimated Number of Facilities

General Category	Estimated Number of Facilities	
	Lower	**Upper**
Federal Hatcheries/Centers	90	90
State Hatcheries	422	500
Tribal	17	17
Academic/research	80	80
Private/commercial	4,028	4,800
Aquariums	50	386
Total	4,687	5,873

Source: EPA estimates based on information presented in Section 2.1.

2.2 GEOGRAPHIC DISTRIBUTION

2.2.1 Public

FWS operates 66 hatcheries, nine fish health centers, and six fish technology centers in 37 states[6] while USDA funds five regional aquaculture research centers located in Hawaii, Massachusetts, Michigan, Mississippi, and Washington.

A survey of state coldwater fisheries (Epifanio, 2000) found that all but three states—Florida, Mississippi, and Louisiana—actively manage coldwater species.[7] The survey results report 369 coldwater propagation facilities nationwide, with the state of Washington having the largest number (90).

EPA compiled a partial list of state warmwater hatcheries (see Table A-4). EPA identified a total of 53 warmwater facilities in 15 states. An additional 78 facilities in 12 states could not be classified because they did not report which species are being raised (i.e., they may include trout and salmon facilities).

The information provided in Table A-3 indicates that there is at least one academic institution with some type of fisheries-related program in 46 states, potentially operating an aquaculture facility.[8]

In sum, EPA believes that every state has at least one public aquaculture facility.

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[6]States without FWS facilities are: Alabama, Alaska, Connecticut, Delaware, Hawaii, Illinois, Iowa, Kansas, Maryland, Minnesota, Nebraska, Ohio, and Rhode Island.

[7]Indiana did not respond to the survey, hence it does not appear in any of these discussions or tables.

[8]Connecticut, Nevada, Oklahoma, and Utah are the exceptions.

2.2.2 Private

The 1998 *Census of Aquaculture* identified a total of 4,028 private facilities with aquaculture production. Figures 2-1 through 2-5 identify the number of production facilities by state for different species breakdowns. Figure 2-1 illustrates the 1,370 catfish producing facilities (which account for over 30 percent of the total aquaculture facilities) by state. Note that the heaviest concentrations are in Alabama and Mississippi (with a combined total of 654 facilities), with Arkansas and Louisiana having the next heaviest concentration with 156 and 100 facilities respectively. Another 561 facilities raise trout (see Figure 2-2), with North Carolina having the heaviest concentration of facilities (70). Figure 2-3 identifies the 435 facilities that produce food fish (other than catfish or trout); Maryland and Wisconsin have a combined total of 65 facilities. Louisiana dominates crustacean production with nearly 500 crawfish facilities (out of a nationwide total of 837 crustacean facilities), Virginia has 206 of 218 softshell crabs facilities and 33 mollusk facilities, while Florida accounts for 221 of the total 535 mollusk producing facilities (see Figure 2-4). Figure 2-5 illustrates the geographic distribution of other aquatic animal production facilities.[9] A facility that produces more than one type of aquatic animal product is listed under each of the species produced; hence, summing the total facilities by individual species exceeds the 4,028 facility total for the industry. Table 2-3 summarizes the geographic distribution of aquaculture facilities in tabular form. The importance of aquaculture to the southern states is evident; this region is home to two-thirds of the aquaculture facilities in the nation. However, every state has at least one aquatic animal production facility, with several states having marked concentrations, depending on the species.

As shown in Table 2-4, nearly 30 percent of the facilities in the 1998 Census report provide fish and/or eggs for restoration or conservation purposes. Salmon is the largest category with 288 million pounds provided (USDA, 2000a).

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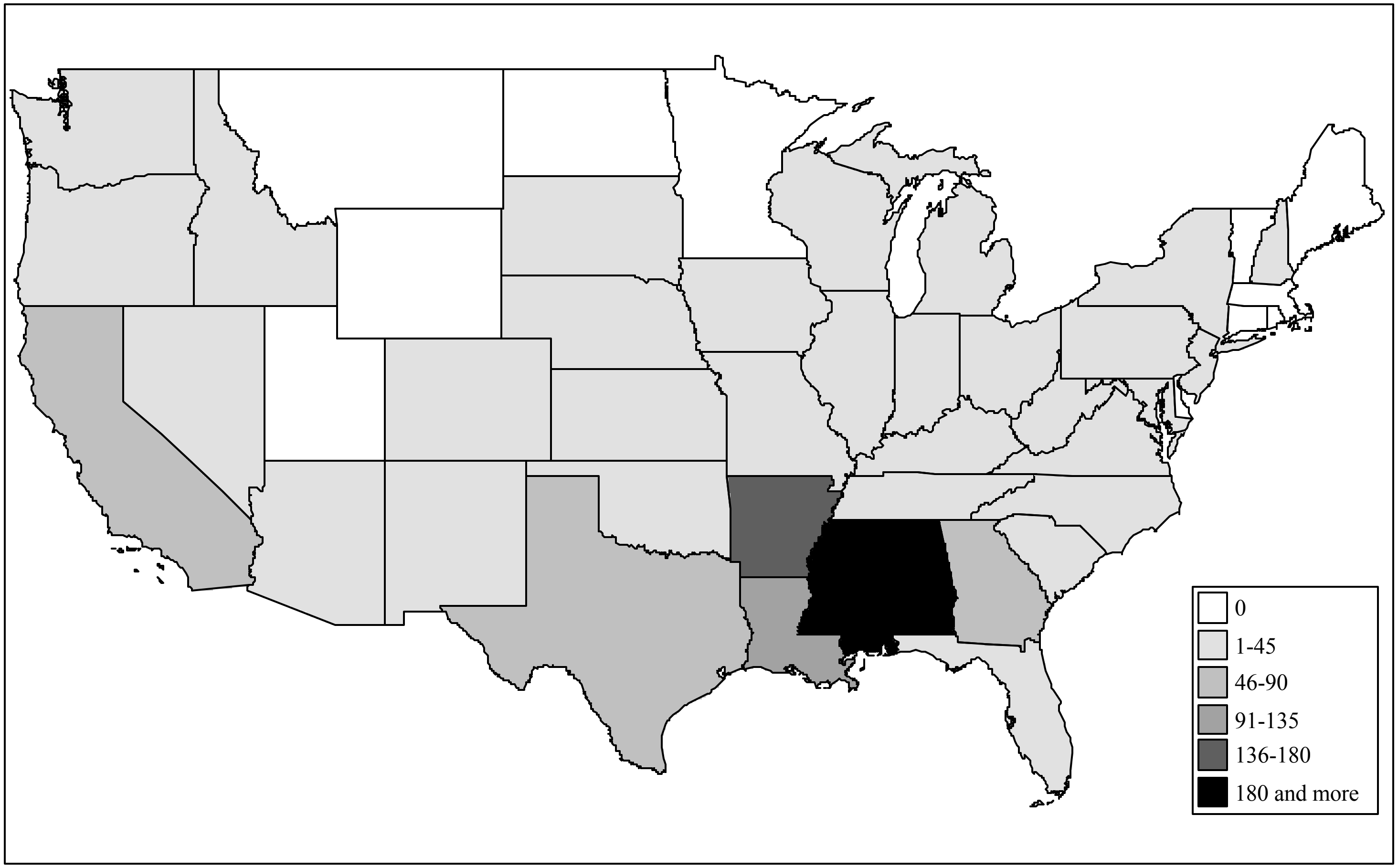
[9]Including baitfish, ornamental fish (171 facilities in FL), sport or game fish, turtles (51 of 56 facilities in LA), alligators, and frogs.

Figure 2-1

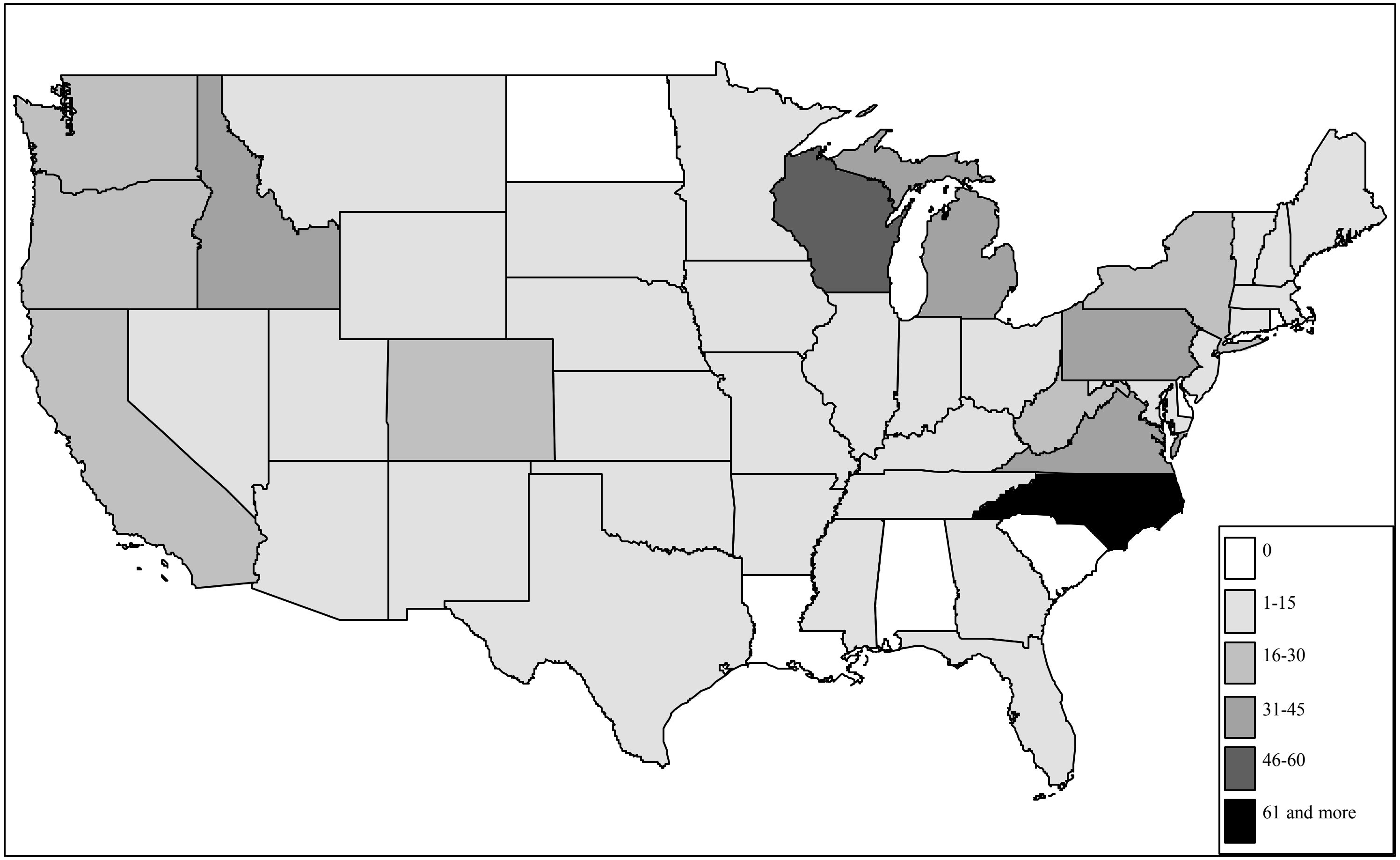
Number of Catfish Producing Facilities By State



Source: USDA, 2000a.

Figure 2-2

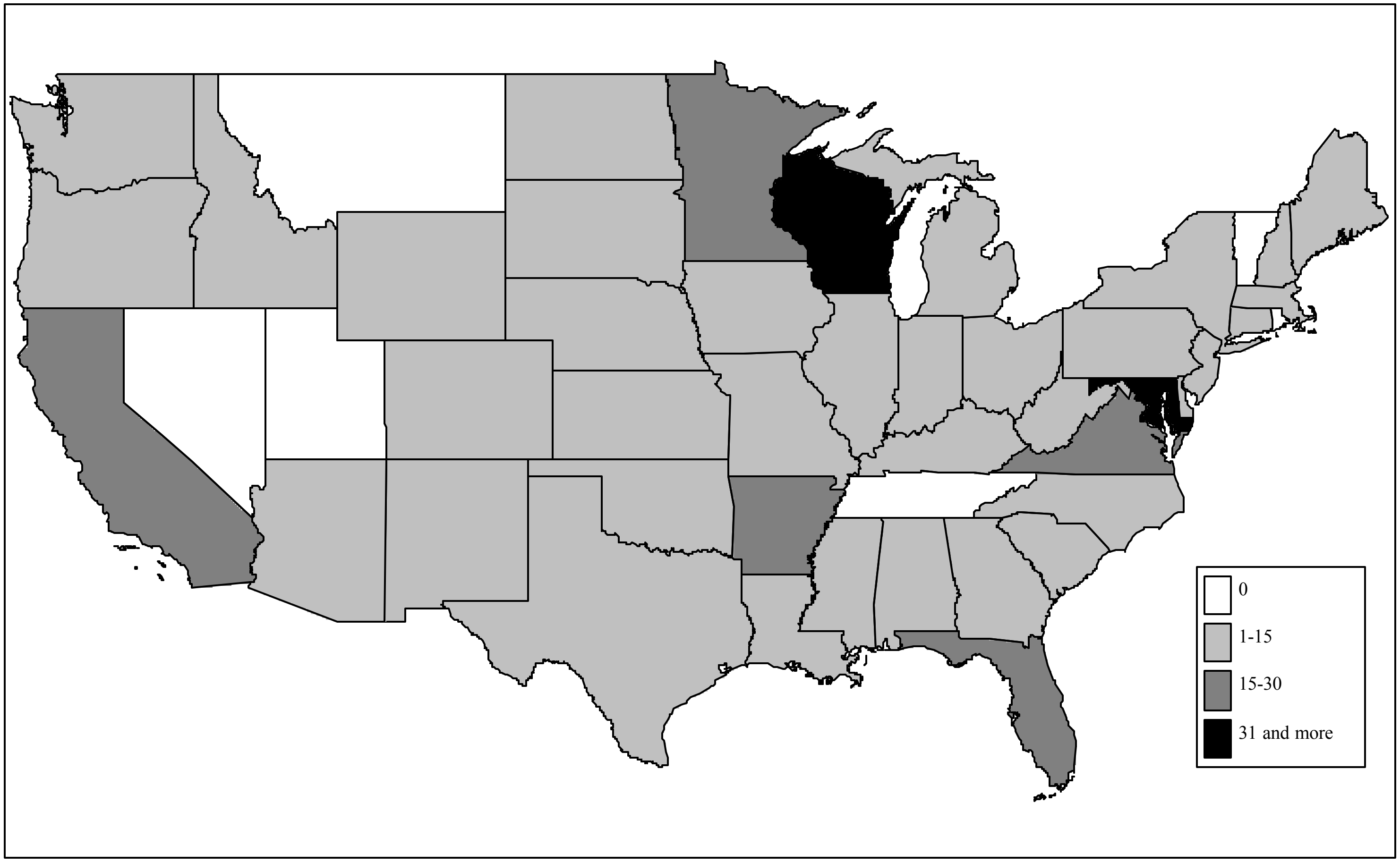
Number of Trout Producing Facilities By State



Source: USDA, 2000a.

Figure 2-3

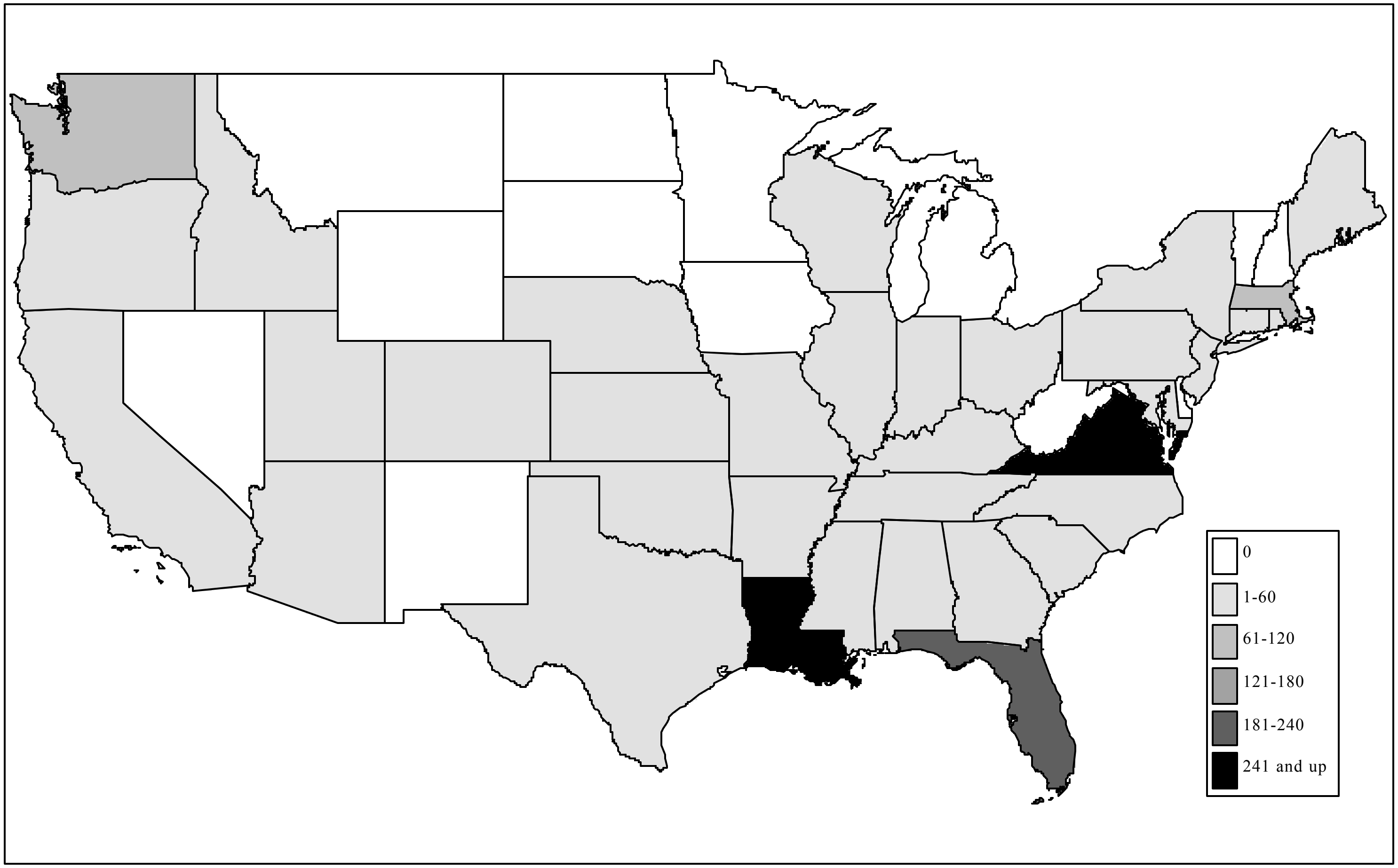
Number of Food Fish Producing Facilities By State



Source: USDA, 2001a.

Figure 2-4

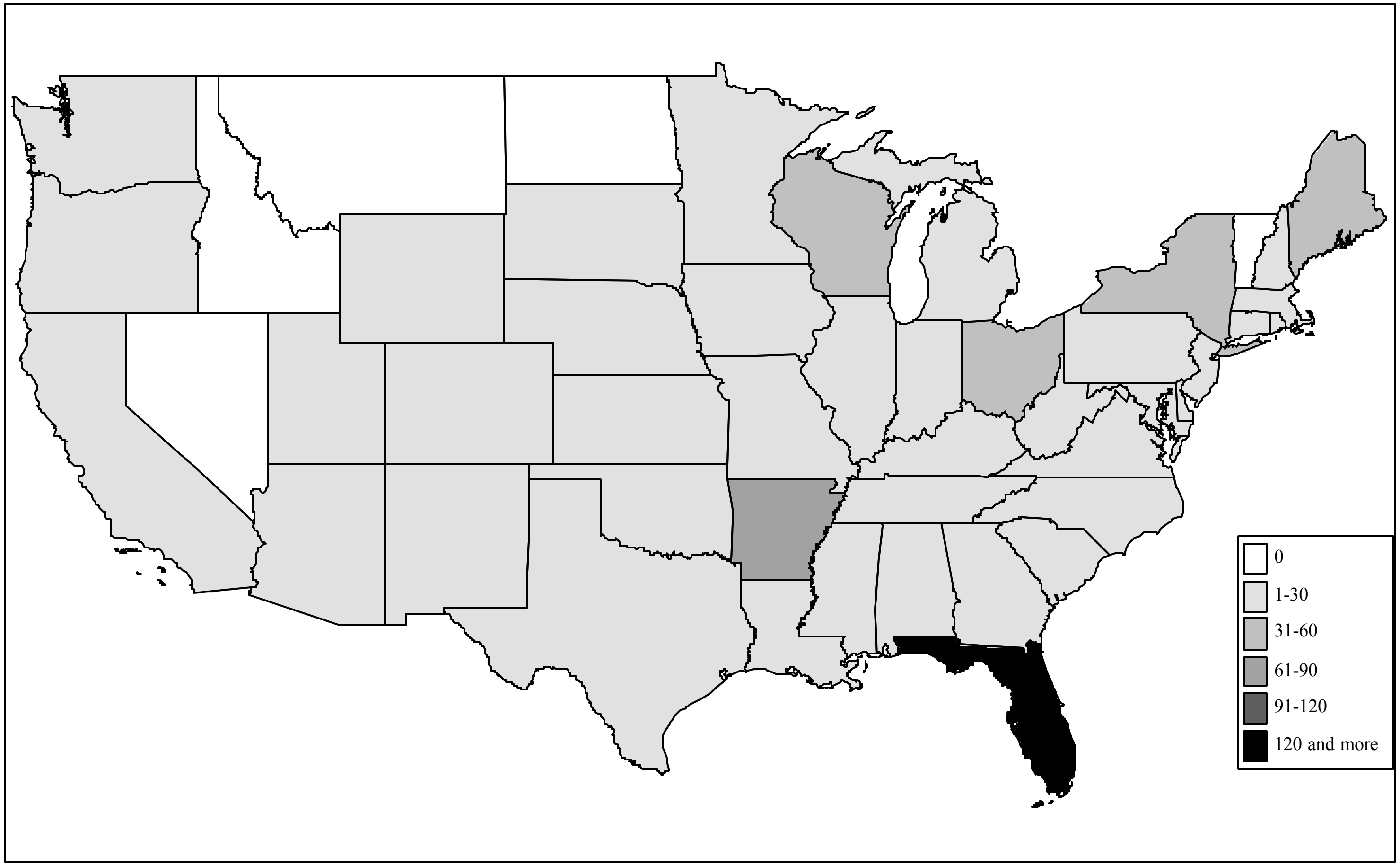
Number of Mollusk and Crustacean Producing Facilities By State



Source: USDA, 2000a.

Figure 2-5

Number of Other Aquatic Animal Producing Facilities By State



Source: USDA, 2001a.

Table 2-3

1998 Aquatic Animal Commercial Facilities

	Total Number of Aquatic Animal Producing Facilities	Number of Trout Producing Facilities	Number of Catfish Producing Facilities	Number of Food Fish Producing Facilities*	Number of Crustacean Mollusk Producing Facilities	Number of All Other Aquatic Animal Producing Facilities
United States	4106	561	1370	435	1372	803
Northeastern Region	465	132	24	81	172	137
Connecticut	24	6	0	1	15	3
Delaware	3	0	0	5	0	3
Maine	56	9	0	12	16	31
Maryland	40	4	7	31	9	20
Massachusetts	115	8	0	2	97	10
New Hampshire	9	5	1	1	0	3
New Jersey	33	2	2	5	18	11
New York	79	30	4	11	12	33
Pennsylvania	65	38	5	6	3	19
Rhode Island	3	0	0	0	2	1
Vermont	7	7	0	0	0	0
West Virginia	31	23	5	7	0	3
Southern Region	2719	136	1152	132	1035	396
Alabama	271	0	250	14	6	15
Arkansas	238	1	156	20	1	80
Florida	429	1	21	19	227	180
Georgia	90	11	55	6	1	23
Kentucky	34	3	20	2	5	6
Louisiana	604	0	100	7	498	6
Mississippi	418	1	404	15	3	10
North Carolina	145	70	36	13	20	19
Oklahoma	27	1	13	2	2	11
South Carolina	25	0	13	5	11	1
Tennessee	45	12	25	0	1	7
Texas	95	1	51	13	17	26
Virginia	298	35	8	16	243	12
North Central Region	488	137	112	116	22	217
Illinois	32	3	15	3	1	13
Indiana	35	3	9	11	5	18

Table 2-3 (cont.)

	Total Number of Aquatic Animal Producing Facilities	Number of Trout Producing Facilities	Number of Catfish Producing Facilities	Number of Food Fish Producing Facilities*	Number of Crustacean Mollusk Producing Facilities	Number of All Other Aquatic Animal Producing Facilities
Iowa	17	2	5	4	0	10
Kansas	36	2	14	8	5	15
Michigan	64	34	12	7	0	18
Minnesota	32	5	0	17	0	27
Missouri	67	10	35	4	3	19
Nebraska	27	10	4	5	2	11
North Dakota	0	0	0	4	0	0
Ohio	60	8	10	15	5	37
South Dakota	8	5	1	4	0	2
Wisconsin	110	55	7	34	1	47
Western Region	371	156	66	54	96	53
Arizona	12	4	5	6	1	2
California	121	22	51	20	18	30
Colorado	37	27	3	6	1	6
Idaho	36	33	2	6	1	0
Montana	10	10	0	0	0	0
Nevada	2	1	1	0	0	0
New Mexico	4	1	1	3	0	2
Oregon	38	21	2	3	10	5
Utah	18	15	0	0	1	2
Washington	84	16	1	9	64	3
Wyoming	9	6	0	1	0	3
Alaska	20	0	0	19	20	0
Hawaii	43	0	16	33	27	0

*Food fish category excludes trout and catfish.
Grand total exceeds 4,028 facilities because a facility may produce in more than one category.
Source: USDA, 2000a.

Table 2-4

1998 Private Aquatic Animal Facilities Providing Stock or Eggs for Restoration or Conservation Purposes

	Total Number of Aquatic Animal Producing Facilities	Number of Trout Producing Facilities	Number of Catfish Producing Facilities	Number of Food Fish Producing Facilities*	Number of Crustacean Mollusk Producing Facilities	Number of All Other Aquatic Animal Producing Facilities
United States	1176	362	113	470	75	156
Northeastern Region	196	70	6	57	44	19
Connecticut	15	4	0	3	8	0
Delaware	1	0	0	1	0	0
Maine	19	10	0	6	2	1
Maryland	15	3	2	3	3	4
Massachusetts	38	6	1	2	28	1
New Hampshire	11	6	0	4	0	1
New Jersey	8	1	1	1	2	3
New York	28	10	0	15	0	3
Pennsylvania	32	14	1	11	1	5
Rhode Island	5	3	0	2	0	0
Vermont	10	4	0	6	0	0
West Virginia	14	9	1	3	0	1
Southern Region	211	32	48	66	23	42
Alabama	9	0	3	3	0	3
Arkansas	23	5	6	7	0	5
Florida	8	0	2	3	0	3
Georgia	25	4	7	8	0	6
Kentucky	9	1	1	3	0	4
Louisiana	23	0	2	3	16	2
Mississippi	3	0	2	0	0	1
North Carolina	9	4	1	3	0	1
Oklahoma	19	1	6	7	0	5
South Carolina	0	0	0	0	0	0
Tennessee	49	11	10	18	0	10
Texas	13	1	5	4	1	2
Virginia	24	5	3	7	6	3
North Central Region	367	81	52	159	2	73
Illinois	5	0	1	1	1	2
Indiana	33	7	7	13	0	6

Table 2-4 (cont.)

	Total Number of Aquatic Animal Producing Facilities	Number of Trout Producing Facilities	Number of Catfish Producing Facilities	Number of Food Fish Producing Facilities*	Number of Crustacean Mollusk Producing Facilities	Number of All Other Aquatic Animal Producing Facilities
Iowa	16	3	1	7	0	5
Kansas	7	0	4	2	0	1
Michigan	10	7	1	0	0	2
Minnesota	170	28	27	85	1	29
Missouri	24	5	5	8	0	6
Nebraska	4	0	1	0	0	3
North Dakota	10	2	0	5	0	3
Ohio	30	7	5	11	0	7
South Dakota	12	4	0	6	0	2
Wisconsin	46	18	0	21	0	7
Western Region	371	179	7	160	6	19
Arizona	0	0	0	0	0	0
California	35	18	0	15	0	2
Colorado	31	18	2	9	0	2
Idaho	56	29	1	24	0	2
Montana	23	11	1	7	0	4
Nevada	11	6	1	3	0	1
New Mexico	11	7	0	3	0	1
Oregon	61	31	0	29	0	1
Utah	15	12	0	1	0	2
Washington	115	36	2	67	6	4
Wyoming	13	11	0	2	0	0
Alaska	28	0	0	28	0	0

*Food fish category excludes trout and catfish.
Source: USDA, 2000a.

2.3 MAJOR SPECIES PRODUCED

2.3.1 Public

The U.S. Fish and Wildlife Service provided their 1999 fish and fish egg distribution data (FWS, 2000d). In 1999, the National Fish Hatchery system made over 5,500 distributions of over 50 species to federal, Tribal, state, and local governments; universities; and private entities. Tables A-5 and A-6 summarize the egg and fish distribution respectively. Egg distributions totaled 146 million, most of which were walleye (36 percent) and rainbow trout (26 percent). These eggs were distributed to the following programs:

- Federal—59.4 million (41 percent)
- State and Local—81.7 million (56 percent)
- Tribal—4.8 million (3 percent)
- Universities—0.5 million (less than one percent)

A minuscule amount (less than 0.02 percent) was distributed to private entities. (Percentages do not sum to 100 because of rounding.)

Fish distributions from National Fish Hatcheries totaled 5.5 million pounds, most of which were rainbow trout (40 percent) and steelhead trout (15 percent). These fish were distributed to the following programs:

- Federal—4.2 million (77 percent)
- State and Local—0.7 million (13 percent)
- Tribal—0.5 million (9 percent)

A small amount (less than 0.2 percent) were distributed to private entities, and universities received about 0.03 percent.

Epifanio (2000) lists the 1996 production of trout and salmon from state hatcheries at 23.7 million pounds (see Table 2-5). Most of the state hatcheries for fish other than trout or salmon report releases in terms of the number of fish, not necessarily by weight. Assuming roughly a sixth of a pound per stocked fish,[10] the information in Table A-2 indicates that approximately another 3.8 to 79 million pounds of warmwater fish may be produced at state hatcheries.

Tribal production is at least 1.3 million fish (see Table 2-1). This may be relatively small in relation to nationwide public or private aquaculture, but extremely important in terms of cultural and religious significance and issues related to fishing rights.

EPA identified no estimates for aquaculture production at academic and research institutions. EPA intends to request this information as part of its detailed questionnaire for the aquatic animal production industry.

2.3.2 Private

Figures 2-6 and 2-7 illustrate the distribution of private aquatic animal production by weight and sales, respectively. Catfish accounts for 68 percent of the total pounds sold and 48 percent of the total value produced. Trout accounts for nearly nine percent of the total pounds sold and eight percent of the total value. The relatively high value per pound for mollusks and crustaceans is evident; they account for only five percent of the total pounds produced but account for 13 percent of the total value. Ornamental fish are included in the "all other aquatic animals" category. The specialized crop is less than one percent of production but accounts for 12 percent of the total value.

Aquaculture production has shown a marked increase over the 1985-1997 time period (JSA, 2002). Figure 2-8 and Table 2-6 track the production increase in terms of weight. Catfish is the primary commodity, with production more than doubling from 207 million pounds in 1985 to 600 million pounds in 1999. Clam production increased from 1.6 million pounds to 10.7 million pounds in 1999. Salmon

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[10] Epifanio (2000) reports 136,774,388 trout stocked with an associated biomass of 23,676,004 pounds or, roughly, six trout to a pound.

Table 2-5

Inland Trout Produced and Stocked by Number and Biomass

State	Total Trout Stocked (no.)	Total Trout Biomass (lbs)	Catchables Stocked (no.)	Catchables Biomass (lbs)
Alabama	27,738	11,524	27,738	11,524
Alaska	1,966,646	68,103	245,014	52,952
Arizona	2,970,000	446,220	1,200,000	428,500
Arkansas	2,600,000	788,000	2,100,000	636,000
California	15,357,977	3,895,234	7,041,978	3,722,575
Colorado	13,098,073	1,603,085	3,609,934	1,432,394
Connecticut	857,317	334,000	669,000	321,000
Delaware	30,900	16,200	39,900	16,200
Georgia	1,438,742	472,297	1,278,792	465,810
Hawaii	20,000	NA	10,000	NA
Idaho	11,575,197	1,244,872	2,492,177	908,733
Illinois	342,100	80,000	121,800	60,500
Indiana	55,015	24,394	55,015	24,393
Iowa	438,598	208,853	370,848	207,178
Kansas	94,203	NA	94,203	NA
Kentucky	753,950	251,317	718,800	239,600
Maine	1,203,974	243,107	639,136	186,423
Maryland	600,000	250,000	500,000	200,000
Massachusetts	664,525	505,502	664,525	505,502
Michigan	2,175,192	215,789	7,159	7,779
Minnesota	1,596,689	142,907	408,117	72,999
Missouri	1,754,500	1,209,600	1,754,500	1,209,600
Montana	8,780,317	311,193	145,116	48,179
Nebraska	472,586	115,521	313,607	112,000

Table 2-5 (cont.)

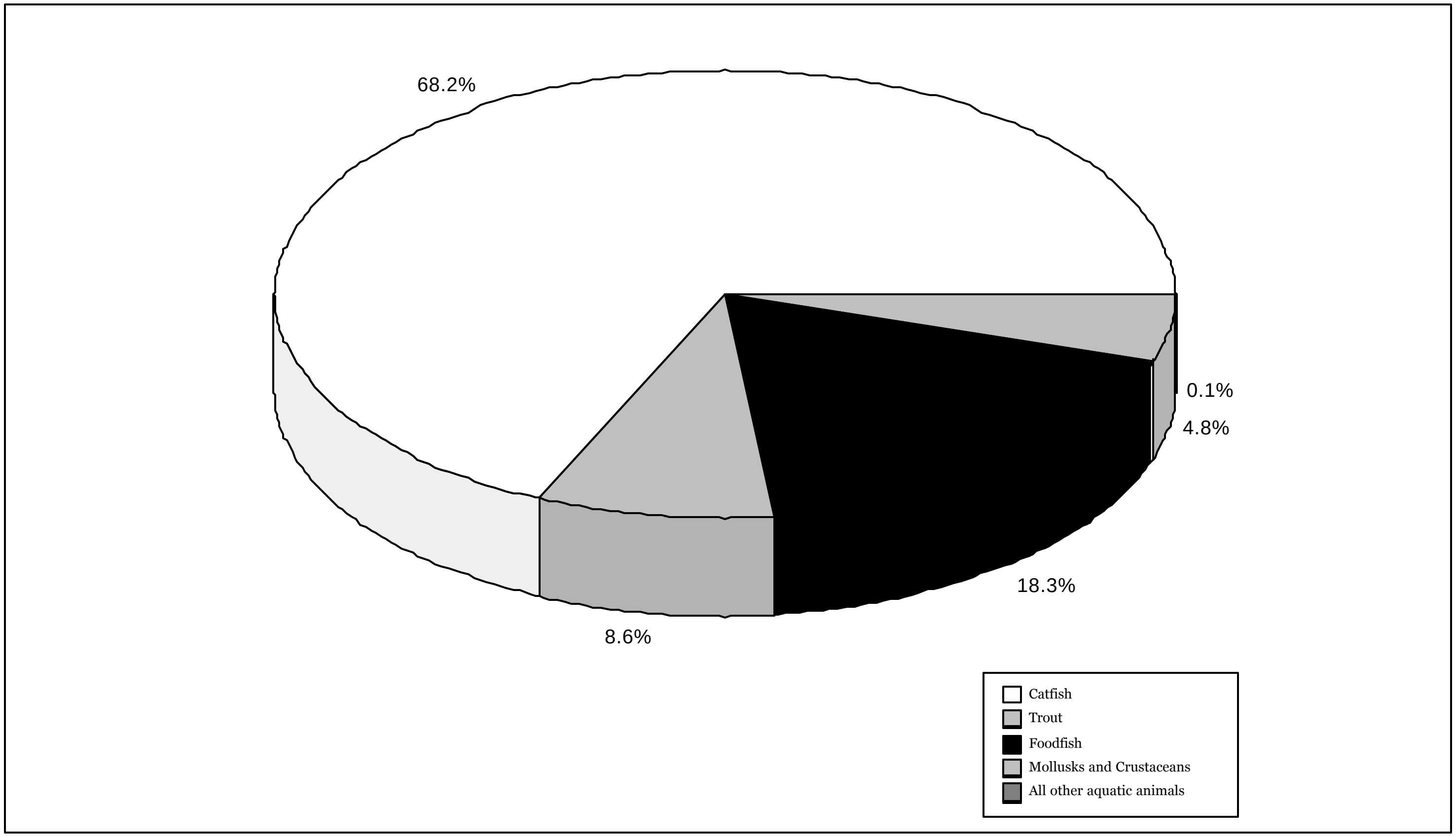
State	Total Trout Stocked (no.)	Total Trout Biomass (lbs)	Catchables Stocked (no.)	Catchables Biomass (lbs)
Nevada	1,971,841	487,784	1,613,000	474,194
New Hampshire	1,671,084	438,382	938,130	426,701
New Jersey	758,310	262,000	687,205	254,000
New York	5,332,865	889,127	3,535,007	?
North Carolina	698,826	286,426	612,747	285,351
North Dakota	372,667	68,202	75,431	41,031
Ohio	363,939	34,991	32,104	18,668
Oklahoma	483,936	NA	408,871	NA
Oregon	7,318,486	887,069	3,428,752	825,478
Pennsylvania	7,929,747	2,701,158	5,216,110	2,543,015
Rhode Island	188,400	155,880	137,400	154,100
South Carolina	418,288	132,518	273,248	91,028
South Dakota	650,000	128,700	174,600	88,440
Tennessee	1,917,498	516,324	1,129,431	486,004
Texas	348,093	70,036	209,862	69,954
Utah	10,137,544	941,788	1,865,721	712,948
Vermont	1,163,938	185,483	612,859	173,448
Virginia	1,541,151	731,766	1,267,054	686,170
Washington	15,770,000	1,169,200	3,517,000	939,900
West Virginia	1,505,667	748,942	1,186,311	743,045
Wisconsin	1,310,675	NA	666,800	NA
Wyoming	6,47,194	402,510	744,246	203,356
Totals	**136,774,388**	**23,676,004**	**52,850,248**	**20,086,672**

Note: Indiana did not reply to the survey. Data for New Mexico not included. Florida, Mississippi and Louisiana do not actively manage cold water species.

Source: Epifanio, 2000.

Figure 2-6

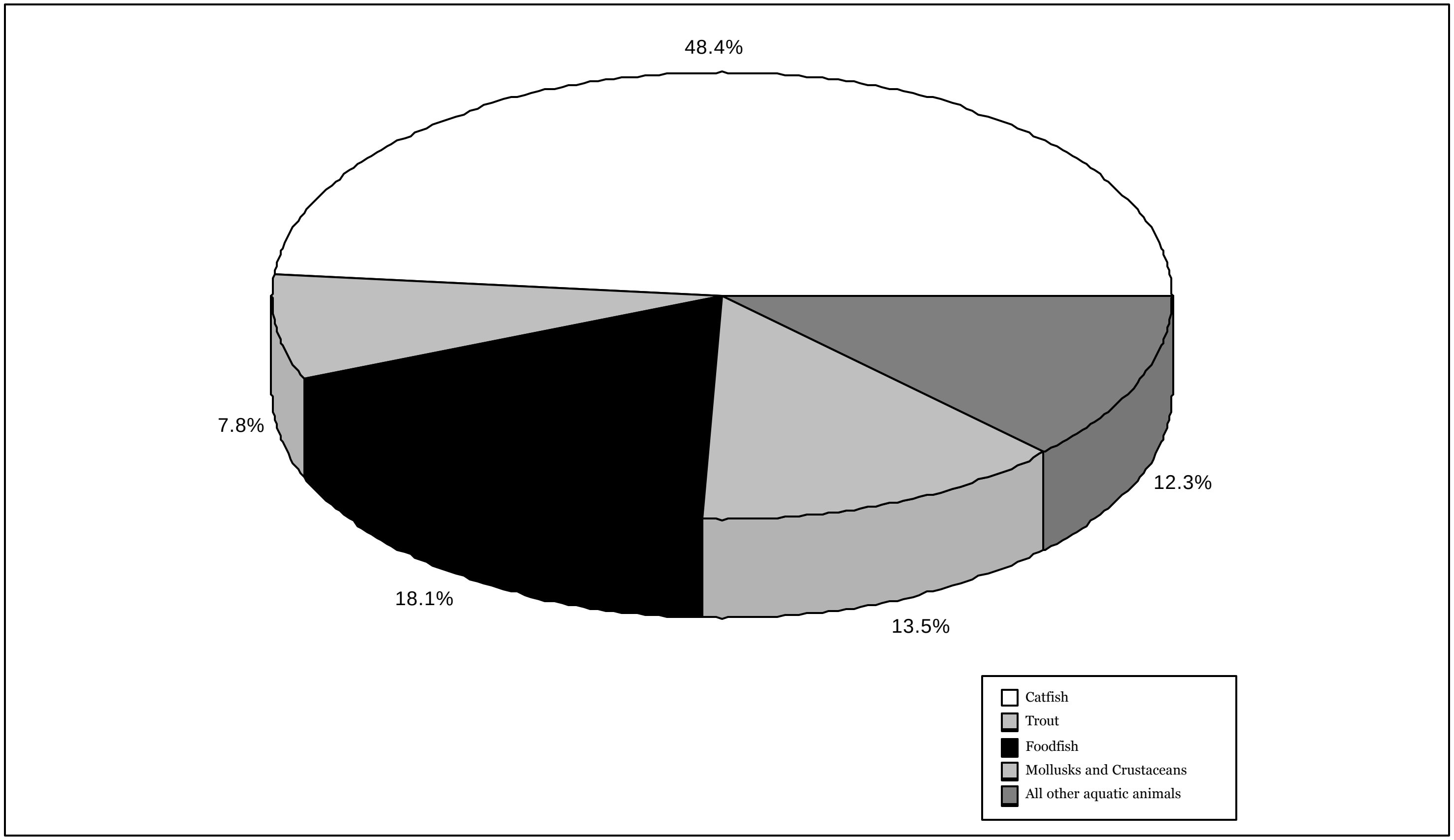
Aquatic Animal Production by Pounds Sold: 1998



Source: USDA, 2000a.

Figure 2-7

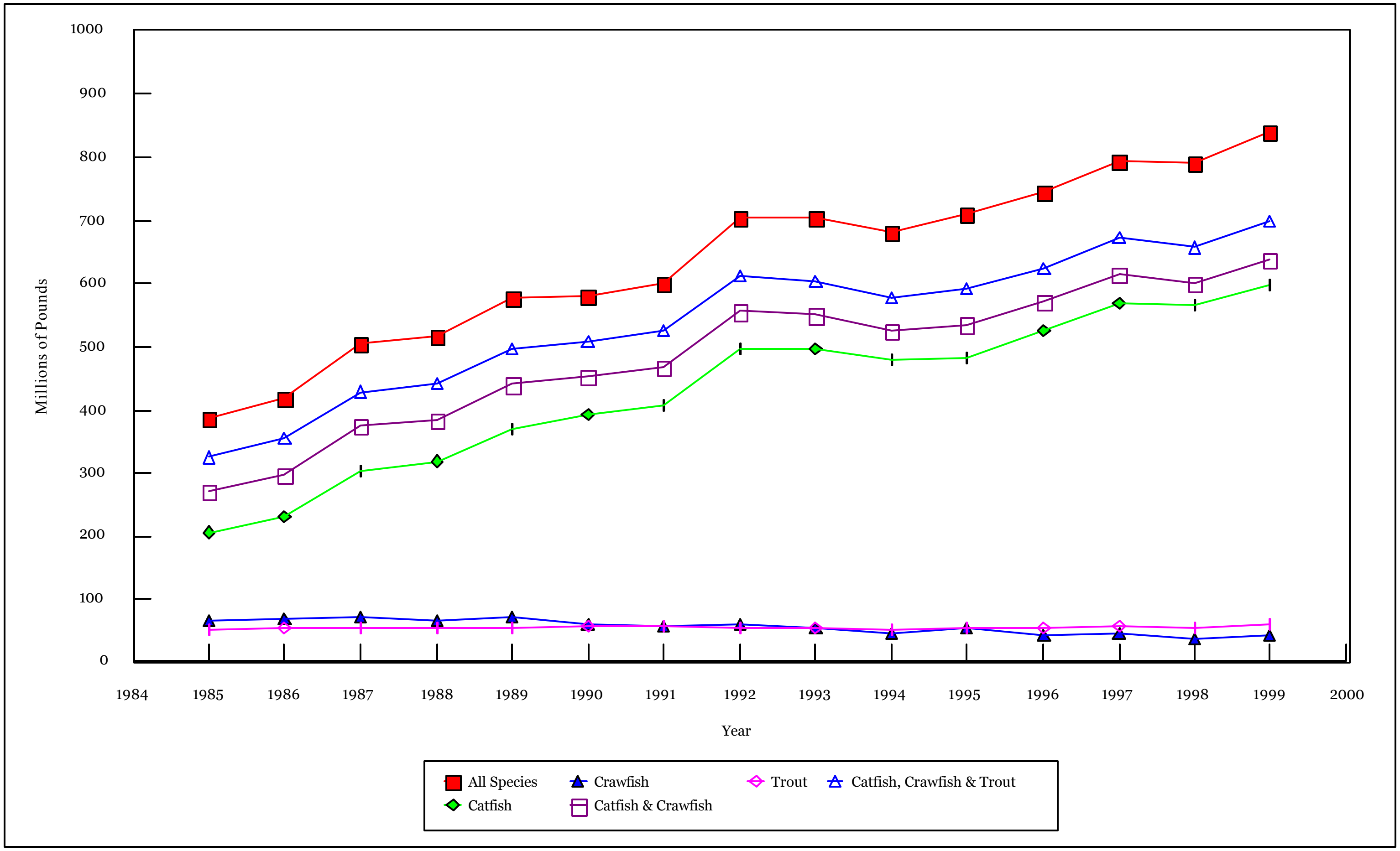
Aquatic Animal Production by Value Sold: 1998



Source: USDA, 2000a.

Figure 2-8

United States Private Aquatic Animal Production By Weight 1985-1999



Source: JSA, 2002.

Table 2-6

U.S. Private Aquaculture Production for 1985-1999
Growth in Time by Weight (1,000 lbs)

Species	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Non-food[1]	24,807	25,247	27,000	28,000	30,000	20,000	20,000	21,000	20,000	20,000	21,000	19,000	19,000	16,369	16,389
Catfish	206,945	230,856	302,936	318,718	369,252	392,429	409,358	497,275	495,758	479,379	481,503	526,276	569,579	564,355	596,628
Clams	1,600	2,500	3,500	4,000	4,200	6,100	6,300	6,600	6,100	7,500	7,800	9,000	8,100	9,735	10,683
Craw fish	65,300	68,400	71,600	67,000	72,400	61,100	57,700	60,000	54,600	46,700	55,400	44,400	46,900	37,945	42,889
Fresh water Prawns	267	178	150	250	250	250	250	250	250	250	250	250	250	----	----
Mussels	800	1,000	950	1,200	1,100	1,000	900	1,100	700	800	1,000	900	600	527	531
Oysters	20,700	21,100	23,100	17,900	18,300	16,500	15,500	17,600	18,600	17,900	19,300	17,700	15,400	18,157	18,662
Salmon[2]	-----	-----	-----	-----	-----	8,000	16,200	24,100	25,600	26,000	32,800	32,600	33,000	32,017	39,114
Shrimp	440	1,354	1,500	2,500	2,500	6,600	4,409	5,200	6,600	4,409	5,200	6,200	5,800	4,409	4,625
Trout	52,000	54,000	55,000	56,000	56,100	56,800	58,900	55,200	54,600	52,000	55,600	53,600	56,900	55,103	60,238
Other Species	14,000	15,500	20,000	22,000	22,000	10,000	12,000	16,000	22,000	27,000	31,000	35,000	37,000	51,071	23,667
Total	386,859	420,135	505,736	517,568	576,102	578,779	601,517	704,325	704,808	681,938	710,853	744,926	792,529	789,708	841,982

Data shown are live weight except for oysters, clams and mussels which are meat weight. Excluded are eggs, fingerlings, etc. which are intermediate products.

1. Baitfish and ornamental fish
2. Salmon estimates are for non-pen production only.

Source: JSA, 2002.

production is tracked only for the time period 1990 to 1999, but increased nearly fivefold from 8 million to 39 million pounds during that time. The only exception to this trend is crawfish production, which shows an overall decline during this period.

Figure 2-9 and Table 2-7 show the increase in production value over the same time period.[11] Catfish is still the primary commodity, with production value ranging from $160 million in 1985 to $439 million in 1999 (nearly 45 percent of the total value tracked in JSA, 2002). Salmon and trout are second and third in terms of production value, with $76.8 million and $65 million, respectively, in 1999. Combined, catfish, trout, and salmon accounted for 60 percent of the total value of aquatic animal production in 1999. The data for total value changes sharply between 1997 and 1998. This is driven primarily by the change in the value of the "Other species" category which jumped from $34 million in 1997 to $209 million in 1998. Although this might be the result of including data in 1998 and 1999 for new species not recorded in earlier years, the web site does not provide any information to this effect.

2.3.3 Observations

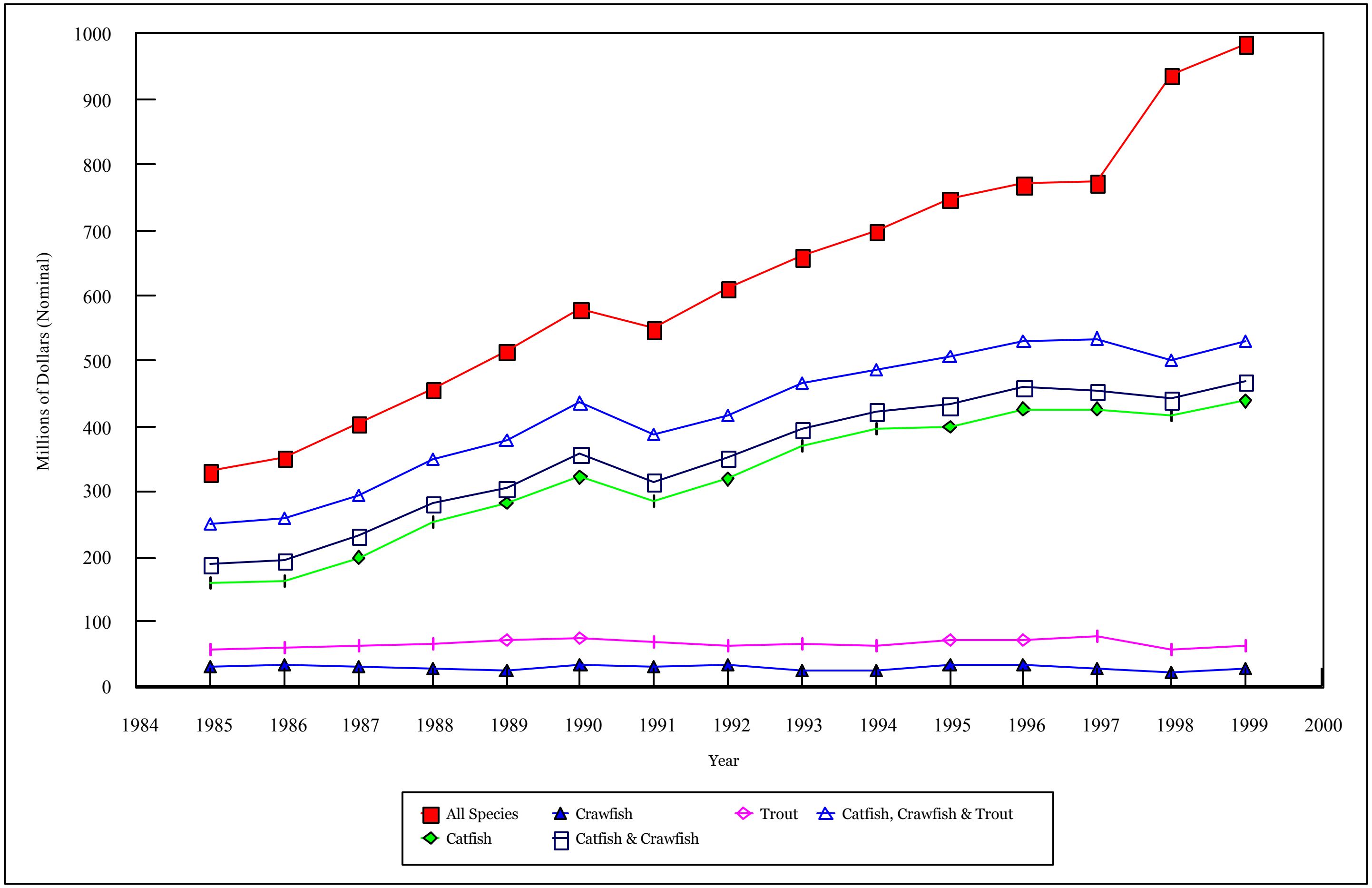
The relative sizes of the public and private aquatic animal production may be coarsely summarized as:

- Public: approximately 35 to 110 million pounds (broken down as follows)
  - Federal: 5.5 million pounds (1999)
  - State: ~28 to 103 million pounds (no date)
  - Tribal: 1.3 million pounds (no date)
  - Academic Institutions: unknown
- Private: approximately 842 million pounds (1999)

[11] Values are presented in nominal dollars.

Figure 2-9

United States Private Aquatic Animal Production by Value 1985-1999



Source: JSA, 2002.

Table 2-7

U.S. Private Aquaculture Production for 1985-1999
Growth in Time by Value ($1,000 Nominal)

Species	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Non-food[1]	25,000	26,000	27,500	32,000	34,500	38,000	40,000	44,000	46,000	52,000	59,000	58,000	56,000	57,392	57,392
Catfish	159,800	164,200	199,300	254,300	281,900	323,200	284,700	319,100	370,500	397,400	399,500	425,400	426,800	419,094	438,936
Clams	4,500	8,100	10,300	11,000	12,500	13,500	11,000	11,500	12,000	14,000	18,500	20,000	18,000	29,612	42,051
Craw fish	31,000	33,100	32,300	27,700	24,000	34,100	31,700	33,100	26,600	25,200	33,100	33,200	27,900	23,649	28,287
Fresh water Prawns	1,500	900	750	1,200	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	----	----
Mussels	400	1,000	1,000	,1200	1,150	1,150	1,100	1,500	1,400	1,950	2,500	3,100	1,200	2,801	799
Oysters	33,300	40,900	48,900	41,200	47,100	51,000	43,000	50,000	41,700	47,400	51,000	48,900	46,700	47,951	55,635
Salmon[2]	5,500	4,500	7,500	2,100	24,000	23,000	43,90	62,100	63,300	64,700	79,100	73,500	75,000	62,694	76,778
Shrimp	1,500	1,800	3,000	4,500	3,800	3,000	3,500	5,300	6,600	4,409	5,200	6,200	6,500	17,637	13,706
Trout	58,000	60,500	63,000	66,400	72,600	77,100	70,000	64,900	68,600	65,100	73,900	72,000	79,800	59,710	64,954
Other Species	9,800	10,000	12,000	14,000	13,500	15,000	19,000	20,000	22,000	25,000	28,000	30,000	34,000	218,103	208,562
Total	330,300	351,000	405,550	455,600	516,050	580,050	548,900	612,500	659,700	698,159	750,800	771,300	772,900	938,643	987,080

Data shown are live weight except for oysters, clams and mussels which are meat weight. Excluded are eggs, fingerlings, etc. which are intermediate products.

1. Baitfish and ornamental fish
2. Salmon estimates are for non-pen production only.

Source: JSA, 2002.

In terms of pounds produced, the data indicate that the private sector is about 8 to 24 times larger than the public sector. Aquariums are not reported here because they do not distribute their animals.

2.4 ECONOMIC VALUE

2.4.1 Public

Public aquatic animal production supports a myriad of goals, including helping to restore depleted fish stocks, establishing sustainable fisheries, and recovering endangered species. Pursuit of these goals may also simultaneously support recreational fishing and Tribal fishing rights.

It is extremely difficult to estimate the total economic value to society associated with public aquatic animal production, particularly accounting for the cultural and religious significance of Tribal fishing and helping to re-establish endangered species. However, we can begin to get an idea of the importance of recreational fishing to national, state, regional and local economies by examining what anglers actually spend to fish. FWS' *1996 National Survey of Fishing, Hunting, and Wildlife Associated Recreation* (FWS, 1997) reports that anglers spent $24 billion in trip-related and equipment expenditures for freshwater fishing in 1996.[12] FWS (1997) does not break down other expenditures, such as magazines, memberships, and licences by fresh- or salt-water fishing. However, in 1996 anglers spent approximately $0.6 billion for licenses, stamps, tags, and permits.

Expenditures are not included when estimating societal benefits. Money that is not spent for fishing at a particular site will be spent fishing at a different site or on an entirely different activity. Any change in expenditures is considered a transfer from one subgroup in society to another subgroup.[13] Net economic value or consumer surplus is the value measured as participants' "willingness to pay" above

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[12]Other than salmon, the species listed in Table 5 of FWS (1997) for saltwater fishing are not among those listed in the aquatic animal production lists. Salmon account for only 637,000 of 9,438,000 anglers and 3,976,000 of 103,034,000 fishing days. Hence, the trip-related and equipment expenditures for saltwater fishing are not included in this estimate.

[13]Savings are considered a form of expenditure.

what they actually spend to participate. FWS (1998) examines the economic values for bass, trout, and walleye fishing, and other recreational activities. The goal of the study was to develop net economic value estimates for use in cost-benefit analyses, damage assessments, and project evaluations. The data were analyzed in three different groupings of states, and the decision of which grouping is best for a particular analysis is left to the wildlife manager doing the study. No national estimates are provided. The per-fish marginal values depend on the region and how the states are grouped into regions, but are represented by the following ranges:

- trout - $0.24 to $3.38 per fish caught
- bass - $1.44 to $6.05 per fish caught

Given the 53 million catchable trout stocked by state hatcheries (see Table 2-5), the net economic value for this segment of public aquaculture ranges from $12.7 million to $179 million. Other efforts to restore sustainable fish stocks also contribute to social welfare, so this range represents a lower bound estimate.

2.4.2 Private

In 1998, the value of private aquaculture production was $978 million.[14] The National Marine Fisheries Service presents data for domestic fisheries in its annual *Fisheries of the United States*. In 1997, the value of aquaculture production was nearly one-quarter of the domestic commercial landings (NMFS, 1999). Data for 1998 are available from the *Census of Aquaculture* (USDA, 2000a) and from NMFS, 1999 for domestic commercial landings. Aquaculture is approximately 30 percent of the domestic commercial landings (i.e., $978 million compared to $3.1 billion).

[14]This is within 4 percent of the value presented on the JSA web site (JSA, 2002).

For two states—Maine and Mississippi—aquaculture products were one of the top five agricultural commodities produced in terms of value. Aquaculture ranked fourth in both states, accounting for 10.8 percent of total farm receipts in Maine and 9.0 percent of total farm receipts in Mississippi (USDA, 2000b).

USDA (2000a) categorized facilities by aquaculture revenues. Table 2-8 provides the nationwide data while Table 2-9 disaggregates the information by species. USDA requested information on aquaculture activities only, not on all farm activities. Nearly one-half of the facilities show aquaculture revenues less than $25,000. However, this does not necessarily mean that the total facility income is less than $25,000. Presumably, the 409 facilities with aquaculture revenues in excess of $500,000 represent all-aquaculture entities, while the plethora of smaller facilities represent the range to which an aquaculture enterprise contributes to overall facility revenues. The distinction between aquaculture revenues and total facility revenues is discussed further in Section 2.6.

2.4.3 Aquariums

Revenue data for aquariums represent what people are willing to pay to see and study aquatic animals. Census data are the only source of revenue information for aquariums, however, the information is presented for all of NAICS code 712130 Zoos and Botantical Gardens. Census reports $1.3 billion in revenues for all non-taxable establishments and $0.1 billion for taxable establishments in 1997 form NAICS code 712130 (Census, 2001b).

2.5 ORGANIZATIONAL STRUCTURE

Public entities with aquaculture activities may be separated into four categories:

- Government or Government Agency (Federal, state, or local)
- Not for profit entities, such as Alaskan hatcheries
- Research institutions, such as colleges and universities
- Tribe entities.

Table 2-8

Number of Aquaculture Facilities by Revenue- United States 1998

Revenues		Number of Farms	Percent of Farms
Lower Limit	**Upper Limit**		
$1,000	$24,999	1,977	49.1%
$25,000	$49,999	433	10.8%
$50,000	$99,999	465	11.5%
$100,000	$499,999	743	18.4%
$500,000	$999,999	202	5.0%
$1,000,000	$1,000,000+	208	5.2%
Total		4,028	100.0%

Source: USDA, 2000a.

Table 2-9

Number of Farms by Revenue Category
By Species

	Number of Farms by Size (Revenue)							
Category	**Total**	**$1,000 - $24,999 (No. and Percent)**		**$25,000 to $49,999**	**$50,000 to $99,999**	**$100,000 to $499,999**	**$500,000 and $999,999**	**$1,000,000 and above**
Catfish	1,370	515	38%	112	165	354	121	103
Trout	561	333	59%	56	64	82	17	9
Other food fish	435	244	56%	36	39	62	14	40
Baitfish	275	161	59%	28	22	45	12	7
Ornamental Fish	345	169	49%	44	44	60	16	12
Sport/game fish	204	158	77%	20	6	19	0	1
Other fish	11	9	82%			2	0	0
Crustaceans	837	637	76%	106	45	40	3	6
Mollusks	535	306	57%	63	60	75	14	17
Other animal aquaculture, algea, and sea vegetables	216	96	44%	30	31	42	8	9
Total	4,789	2,628		495	476	781	205	204
Percentage		55%		10%	10%	16%	4%	8%

Note: Total exceeds 4,028 farms because a farm may raise more than one species.

Source: USDA, 2000a.

2.5.1 Public: Government or Government Agency

Table 2-10 indicates the relationship between Federal and state efforts in fisheries management. Federal funds comprise anywhere from zero to 75 percent of a state's fisheries management budget. For eight states, Federal funds make up 70 percent or more of their operating budget. Only Massachusetts and Washington do not receive Federal funds. Table 2-10 also indicates the relative importance of revenue from fishing licenses and fees to a state budget. For 23 states, this source of revenue forms at least 50 percent of the budget.

2.5.2 Nonprofit Organizations

This section primarily focuses on financial organizations unique to Alaskan hatcheries. The farming of salmon, per se, was outlawed in 1990 (Alaska, 2001a). Instead, Alaska permits nonprofit "ocean ranching" where salmon are reared from egg to smolt stage and then released into public waters to be available for harvest by fishermen upon their return to Alaskan waters as adults. Two types of nonprofit organizations are represented in Alaska operations: regional aquaculture associations and private nonprofit corporations. The state promotes increased salmon production through the Fisheries Enhancement Revolving Loan Fund, e.g., long-term, low-interest loans for hatchery planning, construction, and operation. The corporations are permitted to harvest a certain amount of the fish that return to the hatchery area as adults for cost recovery purposes. Regional corporations vote on a self-imposed state tax (from 1 percent to 3 percent) of the ex-vessel value of the fish in the regions where caught. The tax is collected by the Alaska Department of Revenue and disbursed only to the regional corporations through annual grants (Alaska, 2001b and Alaska, 2002).

Census data identify non-taxable establishments in NAICS code 712130. EPA assumes that this count might include non-profit aquariums (Census, 2001b).

Table 2-10
FY 1999 Revenue Sources

State	Budget ($1,000)	GRF * Revenue (%)	Licenses and Fees (%)	Federal Aid (%)	Other Revenue (%)
Alabama	6,200	0	35	65	0
Alaska	10,974	44	17	12	27
Arizona	6,8008	0	25	75	0
Arkansas	6,698	0	81	19	0
California	44,850	0	41	23	36
Colorado	11,894	0	68	28	4
Connecticut	2,292	17	37	46	0
Delaware	270	19	16	51	14
Florida	19,578	NA	NA	NA	NA
Georgia	7,440	0	59	40	1
Hawaii	20	10	15	75	0
Idaho	5,647	NA	NA	NA	NA
Illinois	9,389	10	69	19	2
Iowa	4,685	0	61	38	1
Kansas	4,558	0	54	46	0
Kentucky	7,767	0	30	70	0
Louisiana	8,304	NA	NA	NA	NA
Maine	6,978	0	25	75	0
Maryland	4,762	0	70	30	0
Massachusetts	4,640	0	100	0	0
Michigan	22,103	1	64	28	7
Minnesota	20,319	0	61	39	0
Mississippi	4,877	2	23	75	0
Missouri	10,628	0	9	5	86
Montana	7,678	0	49	45	6
Nebraska	3,156	0	25	75	0

Table 2-10 (cont.)

State	Budget ($1,000)	GRF * Revenue (%)	Licenses and Fees (%)	Federal Aid (%)	Other Revenue (%)
Nevada	2,975	5	25	70	0
New Hampshire	3,571	0	56	44	0
New Jersey	4,705	0	80	20	0
New Mexico	3,900	0	39	61	0
New York	13,568	5	70	25	0
North Carolina	10,989	0	70	30	0
North Dakota	1,176	0	25	75	0
Ohio	16,604	4	74	18	4
Oklahoma	7,760	0	50	30	20
Oregon	12,369	12	27	4	57
Pennsylvania	19,513	0	54	37	9
Rhode Island	422	6	19	75	0
South Carolina	5,455	32	27	33	8
South Dakota	2,937	0	63	37	0
Tennessee	11,548	0	60	40	0
Texas	32,817	NA	NA	NA	NA
Utah	7,454	7	43	39	11
Vermont	2,080	0	56	44	0
Virginia	9,177	0	55	42	3
Washington	13,083	63	0	0	37
West Virginia	4,696	0	80	20	0
Wisconsin	21,517	3	72	20	5
Wyoming	5,999	0	40	41	19
Total	**486,9877**	-	-	-	-

*GRF = State General Revenue (appropriated) Funds

Note: Indiana did not reply to the survey. Florida, Mississippi and Louisiana do not actively manage cold water species.

Source: Epifanio, 2000.

2.5.3 Private

Private entities may be broadly classified as:

- Proprietorship (individual operations)
- Partnership
- Corporations (family and non-family[15])

If facilities with aquacultural activities follow the same pattern as agricultural farms in general, about 90 percent of the facilities are proprietorships. Within the corporation classification, 89 percent are family corporations with more than 50 percent of the stock held by people related by blood or marriage (USDA, 1998b).

2.6 EMPLOYMENT

EPA did not identify a reference or references with industry-wide numbers for employment in aquatic animal production for either the public or private sectors.

[15]EPA searched SEC's *Directory of Companies Required to File Annual Reports with the Securities and Exchange Commission under the Securities Exchange Act of 1934* for industries in Standard Industrial Classification (SIC) codes 0200 (agriculture production, livestock and animal specialties) and 0700 (agriculture services) (SEC, 1999), as well as Internet searches on sites such as Hoovers.com and usinfo.com for publicly held aquatic animal production companies but did not find a sufficient number to develop a representative sample.

2.7 SMALL BUSINESSES

2.7.1 Public

The Regulatory Flexibility Act as Amended by the Small Business Regulatory Enforcement Fairness Act (RFA/SBREFA, Public Law No. 104-121) defines a "small" governmental jurisdiction as the government of a city, county, or town with a population of less than 50,000. For the purposes of the Regulatory Flexibility Act, states and tribal governments are not considered small governments but rather as independent sovereigns (EPA, 1999). Accordingly, EPA has not identified any small governmental jurisdictions for the purpose of a small business analysis.

2.7.2 Private

The Small Business Administration (SBA) sets size standards to define whether a business entity is small and publishes these standards in 13 CFR 121. When making classification determinations, SBA counts receipts or employees of the entity and all of its domestic and foreign affiliates (13 CFR.121.103(a)(4))). As of October, 2000, the size standards are based on NAICS (SBA, 2000). On 21 December 2000, Public Law 106-554 "Small Business Reauthorization Act of 2000" became effective. Section 806(b) of the legislation raised the size standard to $0.75 million for small businesses in the Agriculture Industry. SBA published a direct final rule on 7 June 2001 with this change (SBA, 2001). On 23 January, 2002, SBA adjusted its monetary-based size standards for inflation (SBA, 2002). Table 2-11 summarizes the size standards applicable to the aquatic animal industry.

Table 2-11

Small Business Size Standards

Business Code	Description	Size Standard (Annual Revenues)
NAICS		
112511	Finfish Farming and Fish Hatcheries	$0.75 million
112512	Shellfish Farming	$0.75 million
112519	Other Animal Aquaculture	$0.75 million
712130	Zoos and Botanical Gardens (Aquariums)	$6.0 million

The only readily available source of aquaculture revenue data is USDA *Census of Aquaculture* (2000a). The USDA revenue data are on an individual facility basis while the SBA small business definitions are based on total company revenues. Given that a large percentage of the facilities with aquacultural activities are proprietorships and likely to be single-facility entities (i.e. the facility is the company), this does not necessarily preclude using this data to examine the economic impacts to small businesses. More problematic is the fact that the USDA data reports only revenues from aquaculture, not total facility revenues, while the determination of whether the company (or farm in this case) is a small entity should be done on the basis of total revenues.

Based on these aquaculture revenue data , nearly nine out of every ten facilities would be considered "small" (see Table 2-8). If an individual facility has revenues that exceed the SBA size standard then, by definition, total company revenues must also exceed the size standard. However, if an individual facility has revenues less than the SBA size standard, the total company revenues may or may not exceed the size standard depending on the revenues from the other facilities owned by the company. For example, a company that owns eight facilities, each with $100,000 in annual revenues, would exceed the size standard and hence would not be classified as a small business.

Table 2-9 summarizes the distribution of facilities by revenue category and by species. The individual entries sum to 4,789 facilities while the reported national total is 4,028 facilities, indicating that as many as 761 facilities raise more than one species. Catfish and trout account for approximately 40 percent of the total number of facilities but represent 61 percent of the large facilities. According to this data, about three-quarters of crustacean facilities have revenues below $25,000 (637 out of 837 facilities).

However, this revenue data does not include income from crops that are co-produced with aquaculture. For example, about half the crawfish in Louisiana are raised in rice ponds (Frank, 2000). EPA is aware that classifying operations as "small" solely on the basis of aquaculture revenues at individual facilities will overestimate the number of small entities, but prefers to err by overestimating rather than underestimating that number.

2.8 MARKET STRUCTURE

While the industry profile is organized to present data on the public and private sectors of aquatic animal production, it is in the market structure that the two sectors are inexorably intertwined. In addition, wild catch and imports influence the commercial market and the importance and strength of these influences vary by species. This section summarizes the interplay of these forces and identifies the different markets within the aquatic animal production industry.

2.8.1 Public

Sections 2.1 and 2.3 document the role of public aquatic animal production for ecological restoration, recreation, or fee-fishing. Many of these fish are grown in government fish hatcheries; others are sold to government entities by commercial growers for stocking. Production decisions for these recreationally oriented growers are not governed by the same types of market forces that influence commercial decision-makers. Much of this production is financed by fishing license fees and other taxes. The ultimate consumers are anglers and those who value a natural environment. They do not make consumption decisions based on the price of stocking fish. Hence, there is no market relationship, in the traditional sense for these fish.

Table 2-12 summarizes the uses of aquaculture products and their sources for 1998 combining information from *Census of Aquaculture* and National Marine Fisheries Service (NMFS) documents.[16] Almost half the trout and three-quarters of the salmon raised in U.S. aquaculture are used for ecological restoration, fee-fishing, or recreation. Table 2-13 abstracts information from Table 2-12 to graphically illustrate the variety of market types among the aquaculture products.

2.8.2 Private

The market structure for the private aquaculture industry is characterized by high facility concentration offset by competing sources and substitutes. The Census data indicate a high degree of concentration at the facility level. In the extreme cases, eight facilities in Texas produce 70 percent of the value of shrimp produced by aquaculture in the U.S.; three percent of the ornamental fish facilities (12 facilities) produce 59 percent of the value of the industry. Table 2-14 summarizes the share of production from the top ten percent of facilities. Many of the aquaculture production industries are small and highly concentrated both in terms of the number of firms and geographic area (ornamentals, baitfish, salmon, and shrimp). Commercial production of each aquaculture species also is concentrated geographically (see Figures 2-1 through 2-5).

However, the existence of other sources, namely, wild catch and imports, and close substitutes may limit the exercise of oligopoly power on the part of aquaculture producers. For salmon, shrimp, and most mollusks, the wild catch is greater than domestic aquacultural production. For baitfish, wild catch is not recorded in the fisheries statistics but is an important part of the market and always an option for anglers if farm-raised baitfish prices rise too high. Even when the wild product is only a close substitute for the farm-raised product, prices for the wild product will influence prices for the aquacultural product. If the wild products or imports are setting the price, it is unlikely that changes in costs of aquaculture

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[16] Table 2-12 was assembled from three different sources so the data in each column may not be comparable to neighboring columns and adding them together may be incorrect. The purpose of the table, however, is to show rough scales of contributions of aquaculture (for recreation and food use), wild catch and imports to total U.S. supply for various species.

Table 2-12

Sources and Uses of Aquaculture Species in the United States, 1998

Species	Units	Aquaculture: Total to Recreation, Restoration	Aquaculture: Total to Food/ End use	Wild Catch	Net Imports	Total Use
Catfish	(1,000 lbs)	10,175	563,934	11,590	1,100	586,799
		2%	96%	2%	0%	100%
Trout	(1,000 lbs)	46,341	47,422	789[1]	4,217	98,769
		47%	48%	1%	4%	100%
Salmon	(1,000 lbs)	291,147	107,160	644,434		1,085,072
		27%	10%	59%		100%
Tilapia	(1,000 lbs)	0	11,571	0	60,911	72,482
		0%	16%	0%	84%	100%
Hybrid Striped Bass	(1,000 lbs)	612	8,407	6,715	1,927	17,661
		3%	48%	38%	11%	100%
Ornamentals	($1,000)	414	68,568	0	34,563	103,545
		0%	66%	0%	33%	100%
Baitfish	($1,000)	1,537	35,945	0[1]	0	37,482
		4%	96%	0%	0%	100%
Crawfish	(1,000 lbs)	35	17,426	22,226	4,387	44,074
		0%	39.5%	50.4%	10.0%	100%
Shrimp	(1,000 lbs)	8	4,209	277,757	670,212	952,186
		0%	0%	29%	70%	100%
Crab	($1,000)	21	10,276	473,378	295,518	779,193
		0%	1%	61%	38%	100%
Clam	($1,000)	50	50,026	135,237	31,164	216,477
		0%	23%	62%	14%	100%
Mussel	($1,000)	3	3,177	1,604	29,855	34,639
		0%	9%	5%	86%	100%
Oyster	($1,000)	27	26,985	88,627	29,785	145,424
		0%	19%	61%	20%	100%

[1] Figures shown for wild catch are from NMFS, 1999. Much of the trout and all of the baitfish wild catch is not reported to NMFS. Wild catch will be a substantial factor in both these markets.

Sources: USDA, 2000a; USDA, 2000c; NMFS, 1998; and NMFS 1999.

Table 2-13

Characteristics of Aquaculture Species Markets

			Imports...		Wild catch...	
Species	**Aquaculture is largest source**	**Recreation is a large use**	**dominate domestic aquaculture**	**are a major component**	**dominates domestic aquaculture**	**is a major component**
Catfish	X	-	-	-	-	-
Trout	X	X	-	-	-	(1)
Salmon	-	X	-	-	X	X
Tilapia	-	-	X	X	-	-
Hyb Striped Bass	X	-	-	X	-	X
Ornamentals	X	-	-	X	-	-
Baitfish	X	-	-	-	-	(1)
Crawfish	-	-	-	-	X	X
Shrimp	-	-	X	X	X	X
Crab	-	-	X	X	X	X
Clam	-	-	-	X	X	X
Mussel	-	-	X	X	-	-
Oyster	-	-	X	X	X	X

(1) Much of the trout and all of the baitfish wild catch is not reported. Baitfish wild harvest was reported to be 50 percent of market at JSA Aquaculture Effluents Technical Workshop, 9/20/2000. Wild catch will be a substantial factor in both these markets.

Note: "Recreation is a large use" means ecological restoration, fee-fishing, recreational, and government use is greater than 20 percent of total use. "Dominates domestic aquaculture" means wild catch or net trade provides a greater proportion of total use than aquaculture. "Major component" means more than 10 percent of total use.

Table 2-14

Industry Concentration

Species	Top 10 percent of farms: Number of Farms	Top 10 percent of farms: Produce (Percentage of value)	Total Value ($1,000)
Catfish	137	65%	450,710
Trout	56	72%	72,473
Other Food Fish	44	85%	168,532
Ornamentals	35	75%	68,982
Baitfish	28	67%	37,482
Crustaceans	84	74%	36,318
Mollusks	54	79%	89,128

Source: USDA, 2000a.

Note: Production value categories added together to find top 10 percent.

production will be passed through to consumers and more of the costs of compliance (if not all) will need to be absorbed by the facility.

Like wild catch, a high level of imports reduces the effect of changes in aquacultural production on the market. Imports are discussed in more detail in the next section while the market effects are summarized here. For tilapia, shrimp, and mussels, imports are a much larger share of the market than domestic aquaculture and undoubtedly have more influence on the market price. The situation for salmon is more complex as Tables 2-12 and 2-13 combine Pacific and Atlantic salmon. The U.S. is a large importer of Atlantic salmon and exporter of Pacific salmon so the net trade appears small. Atlantic salmon imports are twice total domestic salmon farm production. There is evidence that Atlantic and

Coho salmon are substitutes in some situations (Clayton and Gordon, 1999). Whatever the precise relationships, trade flows have a large effect on the prices of many aquaculture products.

2.9 INTERNATIONAL TRADE

Import and export codes used by the United States are based on the Harmonized Tariff System (HTS). Import codes (called HTS) are administered by the United States International Trade Commission (ITC) while export codes (called Schedule B) are administered by the U.S. Census (Census 2002a and 2002b; USITC 2002). This means the same product will have different codes depending on whether it is an import or an export. Only three aquatic animal products have export codes that identify them as "farmed"—rainbow trout (0302.11.0010), Atlantic salmon (0302.12.0003), and mussels (0307.31.0010). "Farmed" imports include the rainbow trout (0302.11.00.10), Atlantic salmon (0302.12.00.03), and mussels (0307.31.0010), as well as Chinook salmon (0302.12.00.12), Coho salmon (0302.12.00.53), and oysters (0307.10.00.60). The Census and ITC data, then, provide an incomplete view of trade in aquaculture.

Import and export data for a wider variety of aquaculture products are available from NMFS and USDA. Data on imports and exports of seafood or fishery products include data for both raised (aquaculture) and wild harvested products (confirmed by Harvey, 2000).[17] Hence, data used in this section does not solely reflect aquaculture production. Foreign trade data of certain seafood products and fishery products is provided to portray the overall picture of seafood-related international trade.

In 1999, the world's aquaculture production (inland and marine) equaled 33 million metric tons in live weight (NMFS, 2001). This was 26 percent of the world's total commercial catch. The leading

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[17]Harvey (2000) noted that it might be possible to estimate the percentage of aquaculture products traded into and out of the United States. This estimation would depend on the species, the size of the product, the country of origin, among other factors. Mr. Harvey appears to have done this for the USDA website which states that, in 1999 the total value of aquaculture exports was approximately $30-35 million (Harvey, 2002).

aquaculture and commercial catch countries are China, Peru, Japan, Chile, United States, and India. Of these countries, China has the largest share while the U.S. ranks fifth (NMFS, 2001).

Figure 2-10 demonstrates import and export values of fishery products from 1989 to 2000. The solid pair of lines are for all fishery products, both edible and non-edible, while the dashed pair of lines shows only the value for edible products. For all fishery products, U.S. exports increased from 1989 to 1997 and declined in 1998 (perhaps due to the economic difficulties of the U.S.'s largest market—Asia). The trade gap had been increasing slowly until 1998. The U.S. has a growing net trade deficit in fishery products with a pronounced gap in 1998. Exports of edible fishery products peaked in 1992 with $3.5 billion and have been declining ever since.

2.9.1 Imports

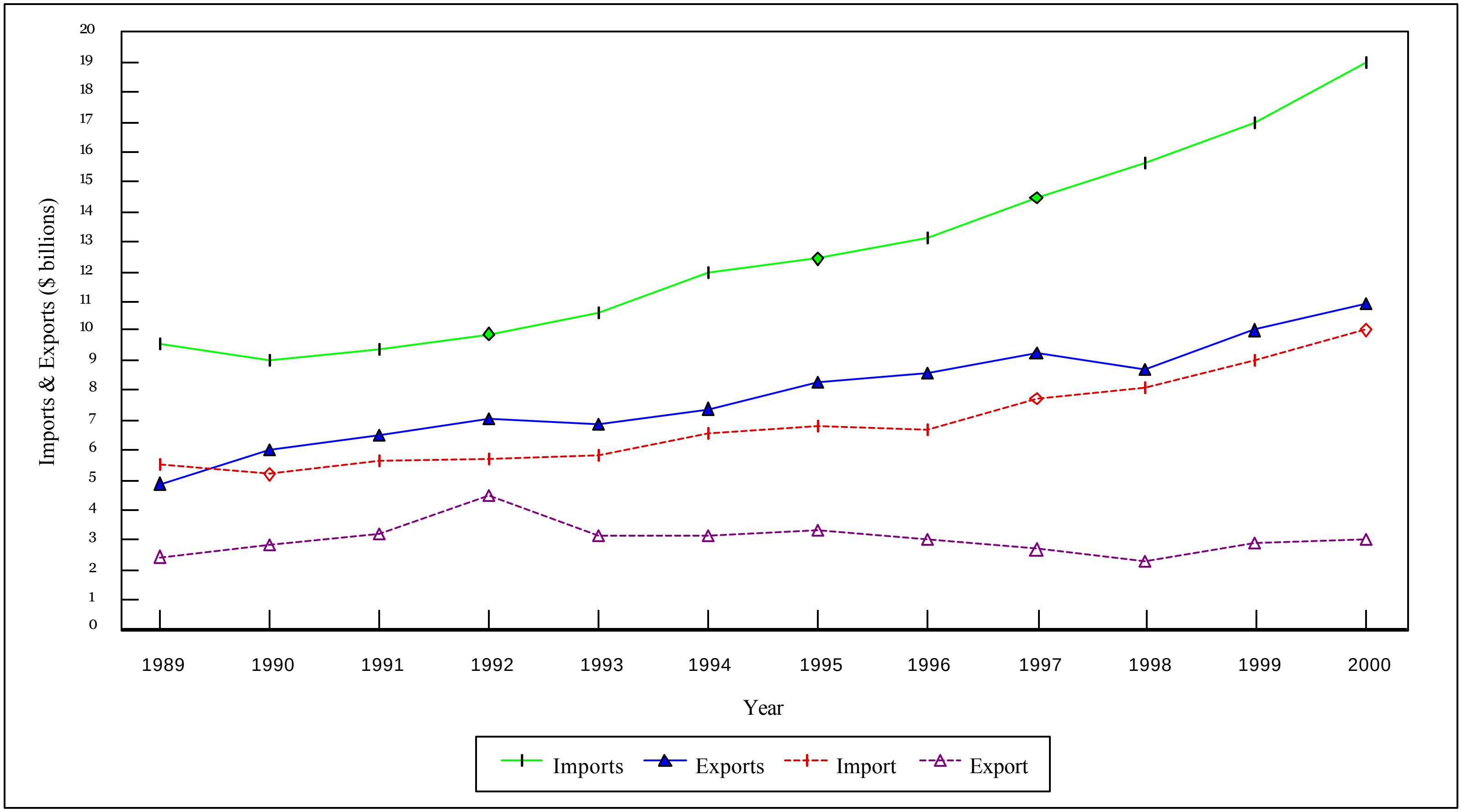
The value of total U.S. imports of edible and nonedible fishery products in 2000 was $19 billion. As a trading region, Asia was the largest source of these imports, accounting for 44 percent of the total tonnage (NMFS, 2001). Canada was the individual country with the largest volume of imports to the U.S. (NMFS, 2001). The value of edible fishery imports has nearly doubled from $5.5 billion in 1989 to $10.1 billion in 2000 (see Figure 2-10).

Switching to USDA data, Tables 2-15 and 2-16 show the value of U.S. imports and exports of selected seafood products for 2000 and 2001, respectively. In both years, the U.S. imported about $4.8 billion worth of these seafood products and exported about $0.6 billion.

Tables 2-15 and 2-16 are rank-ordered from largest net import to largest net export. The largest seafood import for both years was frozen shrimp, accounting for about 62 to 63 percent of the value of all imports. Thailand is the largest exporter of shrimp to the U.S., accounting for 36 percent of shrimp imports in 2000 and 34 percent in 2001 (USDA, 2002a). Mexico, Ecuador, and India are the second through fourth largest shrimp importers to the United States, respectively, in terms of value (USDA, 2002a).

Figure 2-10

Value of U.S. Imports and Exports of Fishery Products 1989-2000 ($1 billion)



Source: NMFS, 1999 and NMFS, 2001.

The value of tilapia imports grew 26 percent from $101.4 million in 2000 to $127.8 million in 2001, while the quantity increase was 39 percent (USDA, 2002a). That is, there was a decrease in the average price of tilapia. Most imports are from Taiwan and China (USDA, 2002a). Although imports of tilapia have been a recent addition to U.S. foreign trade, documented only since 1992, tilapia was the fourth largest seafood product imported in 2001.

The value of Atlantic salmon (both frozen and fresh) imports increased between 2000 and 2001, from $741 million to $773 million. The largest suppliers—Chile and Canada—together account for more than 90 percent of U.S. Atlantic salmon imports (USDA, 2002a).

Table 2-15

2000 Imports and Exports of Selected Seafood Products ($1000)

Product	Imports	Exports	Net
Shrimp, frozen	3,035,173	62,891	2,972,282
Shrimp, fresh & prepared	707,565	52,738	654,827
Atlantic salmon, fresh	654,725	34,471	620,254
Tilipia	101,378	0	101,378
Atlantic salmon, frozen	85,658	583	85,075
Mussels	47,359	1,681	45,678
Oysters	40,763	7,227	33,536
Ornamental Fish	40,761	8,189	32,572
Trout, fresh & frozen	11,291	2,893	8,398
Pacific salmon, fresh	42,633	37,048	5,585
Clams	7,504	5,649	1,855
Trout, live	131	185	(54)
Canned & prepared salmon	32,021	147,127	(115,106)
Pacific salmon, frozen	20,527	273,271	(252,744)
Total	**4,827,489**	**633,953**	**4,193,536**

Table 2-16

2001 Imports and Exports of Selected Seafood Products ($1000)

Product	Imports	Exports	Net
Shrimp, frozen	2,957,944	54,553	2,903,391
Atlantic salmon, fresh	685,289	37,945	647,344
Shrimp, fresh & prepared	678,853	51,481	627,372
Tilipia	127,797	0	127,797
Atlantic salmon, frozen	87,483	139	87,344
Mussels	43,610	1,595	42,015
Ornamental Fish	40,863	6,914	33,949
Oysters	36,914	8,238	28,676
Trout, fresh & frozen	11,507	1,577	9,930
Pacific salmon, fresh	30,462	22,166	8,296
Clams	8,296	6,593	1,703
Trout, live	99	271	(172)
Canned & prepared salmon	36,199	167,825	(131,626)
Pacific salmon, frozen	14,940	236,604	(221,664)
Total	**4,760,256**	**595,901**	**4,164,355**

Source: USDA, 2002a.

2.9.2 Exports

Figure 2-10 portrays the value of U.S. imports and exports of fishery products from 1989 to 2000. The total value of U.S. seafood exports increased slightly, while the export value of edible fish remained relatively constant during the period.

In recent years, however, USDA data show a drop in the value of exports from $634 million to $596 million, see Tables 2-15 and 2-16. Frozen Pacific salmon is the largest U.S. export, comprising between 40 and 43 percent of the total value of U.S. exports.[18] Between 2000 and 2001, the export value of frozen Pacific salmon decreased from $273 million to $237 million. The quantity of exports

[18]Differences between the East and West coasts are obvious for salmon. Fresh Atlantic salmon is the second largest U.S. net import while frozen Pacific salmon is the largest U.S. net export.

increased during this period from 162 million pounds to 168 million pounds. This reflects a decrease in the unit value of Pacific salmon. From 2000 to 2001, only fresh Atlantic salmon, canned and prepared salmon, oysters, and clams showed an increase in the value of exports. All other commodities showed a decline.

2.9.3 Government Intervention

Table 2-17 lists the dramatic rise in reported "catfish" imports from Vietnam from less than 80,000 kilograms in 1995 to 7.8 million kilograms in 2001. In 2001, the value of these imports totaled $21.5 million (NMFS, 2002). Prices paid by catfish processors averaged $0.71/lb in 1997 but dropped to $0.55/lb in December 2001 (USDA, 2002b). The situation was covered in industry news (Fiorillo and McGovern, 2001; McGovern, 2002; Rappaport, 2002; and Rappaport, 2001a and 2001b). In November 2001, President Bush signed a one-year provision declaring that only products from the family *Ictaluridae* could be labeled "catfish." The Vietnamese imports are members of the *Pangasiidae* family. Legislation to make the ban permanent passed the Senate in December (McCain, 2001; Philadelphia, 2002; USDA 2002c).

Table 2-17

"Catfish" Imports 1995-2001

	Imports (kg)			Imports ($)		
Year	**All**	**Vietnam**	**Percent**	**All**	**Vietnam**	**Percent**
1995	1,101,337	79,553	7%	$2,591,161	$263,926	10%
1996	1,119,074	59,096	5%	$3,179,001	$260,847	8%
1997	427,118	54,505	13%	$1,412,010	$233,846	17%
1998	628,354	261,352	42%	$2,135,905	$1,156,550	54%
1999	1,564,631	902,598	58%	$5,674,123	$4,052,524	71%
2000	3,736,242	3,191,068	85%	$12,365,582	$10,695,974	86%
2001	8,201,420	7,765,319	95%	$22,751,433	$21,509,704	95%

Source: NMFS, 2002.

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CHAPTER 3

EPA SCREENER SURVEY

3.1. SURVEY DESCRIPTION

In August 2001, EPA mailed a short screener survey, entitled "Screener Questionnaire for the Aquatic Animal Production Industry" to approximately 6,000 aquatic animal production facilities (EPA, 2001). The screener survey consisted of eleven questions that requested general facility information, including confirmation that the facility was engaged in aquatic animal production, the species and size category produced, type of production system, wastewater disposal method, and the total production at the facility in the year 2000. The Agency used the reported production information combined with price information from the Census to estimate revenues for each facility surveyed.

3.2. DEVELOPMENT OF SURVEY MAILING LIST

The mailing list (sample frame) for EPA's screener survey was developed by synthesizing facility information found in the Dunn and Bradstreet database, EPA's Permit Compliance System (PCS), contacts with EPA regional permit writers, EPA site visits, state aquaculture contacts, assistance from the Bureau of Indian Affairs on tribal facilities, universities, recent issues of *Aquaculture Magazine*, and an extensive collection of web sites with aquaculture references. Additionally, EPA requested but was denied access to the facility identification data associated with the U.S. Department of Agriculture's 1998 Census of Aquaculture (USDA, 2000). The mailing list EPA developed contained approximately 6,000 facilities. This number seemed to compare favorably with the roughly 4,000 facilities found in the 1998 Census of Aquaculture. EPA believes that this mailing population was as current as possible and reasonably complete.

3.3 RESPONSE TO THE SCREENER SURVEY

EPA sent the screener survey to all 6,000 facilities on its mailing list. EPA received responses from 4,900 facilities, with about 2,300 facilities reporting that they do produce aquatic animals. The discrepancy between the number of surveys sent and the number of facilities reporting that they are aquatic animal producers is largely attributed to the fact that the list was compiled from general industry sources and included aquatic animal processors, retailers, etc.

EPA compared the number of direct discharging facilities identified in the NPDES permit compliance (PCS) data base with the number of direct dischargers identified in the EPA screener survey. EPA identified a total of 1,174 aquatic animal production facilities in the PCS database. Based on the NPDES permits found in the PCS database, EPA estimated that there are about 377 facilities with active permits. EPA identified a comparable number of direct discharging aquatic animal production facilities in the screener survey data.

3.4 SUMMARY

The screener survey identified approximately 2,300 facilities in the aquatic animal production industry. This count encompasses the range of public and private ownership, production systems, water pollution control technologies in place prior to the regulation, species, and size (annual harvest). Of these, less than 400 facilities directly discharge wastewater into U.S. water bodies and have sufficiently large production levels to qualify as a "concentrated" aquatic animal production facility, i.e., need an NPDES permit under 40 CFR 122.24 and Appendix C. The screener data, then, provide the foundation for the engineering cost analysis, see Chapter 3 in the Development Document (EPA, 2002) for a more complete description.

3.5 REFERENCES

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CHAPTER 4

TECHNOLOGIES AND ENGINEERING COST ESTIMATES

This chapter provides a brief overview of the treatment practices considered by EPA for the concentrated aquatic animal production industry and the associated engineering cost estimates. More information on EPA's methodology to estimate costs is located in the Development Document for the proposed rulemaking (EPA, 2002a). Section 4.1 discusses the model facility approach used by EPA for the proposed rulemaking. Section 4.2 reviews the treatment practices considered for the rule. Cost estimates are presented in Section 4.3 while frequency factors, used to adjust national costs to reflect treatment practices already in place in the industry, are discussed in Section 4.4.

4.1 MODEL FACILITY APPROACH

Depending on data availability, EPA can develop either *facility-specific* or *model facility* compliance costs and pollutant load reduction estimates. Facility-specific compliance costs and pollutant load reduction estimates require detailed process and geographic information about many, if not all, facilities in an industry. These data typically include production, capacity, water use, wastewater generation, waste management operations (including design and cost data), monitoring data, geographic location, financial conditions, and any other industry-specific data required for the analyses. EPA uses each facility's information to estimate the cost of installing new pollution controls and the expected pollutant removals from these controls.

When facility-specific data are not available, EPA develops model facilities to provide a reasonable representation of the industry. EPA developed model facilities to reflect Concentrated Aquatic Animal Production (CAAP) facilities with a specific production system, ownership (e.g., commercial, Federal, state, and other) and species. EPA developed six models for each production system/ownership/species combination based on the six size classifications in the USDA Census (2000). Each model facility represented all facilities within a size classification and were based on the average production value. These model facilities were developed based on data gathered during site visits, information provided by industry members and their associations, and other publicly available information. EPA estimated the number of facilities that each model represented based on data from the screener survey (EPA, 2001) and the USDA 1998 Census of Aquaculture (USDA, 2000). Compliance costs and pollutant load reductions were estimated for each model facility. Industry-level compliance costs were calculated by multiplying model facility costs by the estimated number of facilities required to implement the treatment practice in each model category. For the proposed rule, EPA used a model-facility approach to estimate compliance costs because detailed information was not available. EPA intends to collect facility level information from a sample of facilities through the detailed survey (EPA, 2002b).

EPA developed the model facilities to capture the key characteristics of individual AAP facilities. Data from the Census of Aquaculture and the screener survey were used to estimate the average values of these key characteristics, which were then used to develop representative model facilities. Using this approach, every model facility was characterized according to the representative values for a set of specific attributes, which included production system type, species, dollar level of production, system inputs (e.g. feed), estimated pollutant loads, discharge flow characteristics, and geographic data. All of these attributes were then linked into options modules using a computing platform to enable changes to model facility assumptions and characteristics.

Control technology options and BMPs used to prevent the discharge of pollutants into the environment were linked in the unit cost modules, which calculated an estimated cost of the component based on estimates of capital (which included elements such as engineering design, equipment, installation, one-time costs, or land) and annual operation and maintenance (O&M). For each model facility, EPA applied combinations of technologies and BMPs, given the model facility configuration characteristics (e.g. system type, size, and species). EPA adjusted the total cost of the component with a frequency factor to account for those CAAP facilities that already have that treatment practice in place. This adjusted cost, which reflects the number of facilities that would incur the costs associated with the treatment practices, is used to estimate national capital and O&M costs from each of the model facility configurations.

4.2 TECHNOLOGY DESCRIPTIONS

This section presents a brief description of treatment practices considered by EPA. See the Development Document (EPA, 2002a) for more detailed descriptions of the treatment practices, their unit cost estimation, and references.

4.2.1 Quiescent Zones

Quiescent zones are a technology control considered in Option 1 for all flow-through CAAP facilities as a part of primary solids removal. Quiescent zones are a practice used in raceway flow-through systems that use the last approximately 10% of the raceway to serve as a settling area for solids. It is important to note that flow-through system raceways are typically sized according to loading densities (e.g., 3-5 pounds of fish per ft^3), but the flow rate of water through the system drives the production levels in a particular raceway. Thus, EPA evaluated the impacts of placing quiescent zones in the lower 10% of raceways and found no adverse impacts on the production capacity of a facility. The goal of quiescent zones (QZ) and other in-system solids collection practices is to reduce the TSS (and associated pollutants) in the effluent.

Quiescent zones usually are constructed with a wire mesh screen, which extends from the bottom of the raceway to above the maximum water height, to prohibit the cultured species from entering the quiescent zone. The reduction in turbulence, usually caused by the swimming action of the cultured species, allows the solids to settle in the quiescent zone. Then, the collected solids are available to be efficiently removed from the system. The quiescent zones are usually cleaned on a regular schedule, typically once per week in medium to large systems to remove the settled solids. The Idaho BMP Manual recommends minimal quiescent zone cleaning of once per month in upper raceways and twice per month in lower units. The settled solids must be removed regularly to prevent breakdown of particles and leaching of pollutants such as nutrients and BOD.

Quiescent zones placed at the bottom or end of each rearing unit or raceway allow for the settling of pollutants before they are discharged to other production units (when water is serially reused in several rearing units) or receiving waters.

4.2.2 Sedimentation Basins (Gravity Separation)

Sedimentation basins are a technology control considered in Option 1 for all flow-through and recirculating CAAP facilities as a part of primary solids removal. Sedimentation basins at flow-through facilities can be in the form of offline or full-flow. Offline settling treats a portion of the flow-through effluent volume in which solids have been concentrated. When offline settling is used, treatment technologies to concentrate solids (e.g., quiescent zones) are also used. Full-flow settling treats the entire flow-through effluent volume. For recirculating systems, sedimentation basins are used to treat the waste stream that is discharged from the recirculating system.

Sedimentation, also known as settling, separates solids from water using gravity settling of the heavier solid particles. In the simplest form of sedimentation, particles that are heavier than water settle to the bottom of a tank or basin. Sedimentation basins (also called settling basins, settling ponds, sedimentation ponds, or sedimentation lagoons) are used extensively in the wastewater treatment industry and are commonly found in many flow-through and recirculating aquatic animal production facilities (EPA, 2001). Most sedimentation basins are used to produce a clarified effluent (for solids removal), but some sedimentation basins remove water from solids to produce a more concentrated sludge. Both of these applications of sedimentation basins are used and are important in aquatic animal production systems.

Periodically, when accumulating solids exceed the designed storage capacity of the basin, the basin is cleaned of the accumulated solids. EPA found that cleaning frequencies of sedimentation basins used at CAAP facilities ranged from two to twelve times per year depending on the size of the facility. For estimating costs, EPA used a cleaning frequency of nine times per year to capture some of the variation in cleaning frequencies used by the industry. By sizing sedimentation basins for a cleaning frequency of nine times per year, the basin volume will be larger than for a cleaning frequency of twelve times per year. The extra storage will also provide a safety factor to accommodate facilities that cannot use a solids disposal method, such as land application, which requires year round access to application sites.

The primary advantages of sedimentation basins for removing suspended solids in effluents from aquatic animal production systems are the relative low cost of designing, constructing, and operating sedimentation basins; the low technology requirements for the operators; and the demonstrated effectiveness of their use in treating similar effluents. In many aquatic animal production systems, most of the solids from feces and uneaten feed are of sufficient size to settle efficiently in most moderately sized (i.e., 37 ft^3 to 741 ft^3) sedimentation basins, without using chemical addition. Many of the pollutants of concern in aquatic animal production system effluents can be partly or wholly removed with the solids captured in a sedimentation basin. Much of the phosphorus tends to bind with the solids, BOD and organic nitrogen are in the form of organic particles in the fish feces and uneaten feed, and some other compounds, such as oxytetracycline, were found in the sediments captured in sedimentation basins in EPA's sampling data.

Disadvantages of sedimentation basins include the need to clean out accumulated solids, the potential odor emitted from the basin under normal operating conditions, and the inability of the basins to remove small-sized particles without chemical addition. Accumulated solids must be periodically removed and properly disposed of through land application or other sludge disposal methods. For the purpose of costing, EPA assumed no cost associated with the disposal of collected solids in flow-through and recirculating systems. EPA based this assumption on the observation that there are several alternatives for CAAP facilities that collect solids, which offer a no cost impact to the facility. Collected solids can be used as a valuable fertilizer taken for free by local farmers and gardeners. System operators should maintain or increase the efficiency of sedimentation basins by cleaning quiescent zones as frequently as possible and attempt to minimize the breakdown of particles (into smaller sizes) by avoiding cleaning methods that tend to grind up the particles. Industry representatives report that existing aquatic animal production systems might have limited available space for the installation of properly sized sedimentation basins. Therefore included in the cost for sedimentation basins is a cost for the purchase of land.

4.2.3 Solids Control Best Management Practices (BMP) Plan

Solids control BMP plans are considered as a management practice for all CAAP facilities under Option 1. All requirements and costs associated with the solids control BMP Plans are assumed to be equal for all species and culture systems.

Evaluating and planning site-specific activities to control the release of solids from CAAP facilities is a practice currently required in several EPA Regions as part of individual and general NPDES permits (e.g., shrimp pond facilities in Texas, net pens in Maine, and flow-through facilities in Washington and Idaho). BMP plans in these permits require the facility operators to develop a management plan for removed solids and prevention of excess feed from entering the system. The BMP plan also ensures planning for proper operation and maintenance of equipment, especially treatment control technologies. Implementation of the BMP plan results in a series of pollution prevention activities, such as ensuring that employees do not waste feed and planning for the implementation of other O&M activities, which are costed under each technology control or BMP.

4.2.4 Compliance Monitoring

Compliance monitoring is a management practice considered under Option 1 for all flow-through and recirculating systems. In addition, for flow-through and recirculating facilities that would be subject to compliance with numeric limitations, EPA proposed an alternative compliance provision that would allow facilities to develop and implement a BMP plan to control solids provided the permitting authority determines the plan will achieve the numeric limitations (see proposed 40 CFR 451.4). For the purpose of estimating costs, EPA assumed compliance monitoring for CAAP facilities was a function of the production level on production system used at the facility. EPA assumed that all costs related to compliance monitoring would be included under operation and maintenance costs. The O&M costs for monitoring consist of two components, 1) the labor associated with sampling (e.g., collecting the sample and preparing it for transport) and transport of the sample to the lab and 2) sampling materials (e.g., bottles) and analysis.

4.2.5 Feed Management

Feed management is a management practice considered under Option 1 for all net pen operations. Feed management recognizes the importance of effective, environmentally sound use of feed. Net pen operators should continually evaluate feeding practices to ensure that feed placed in the production system is consumed at the highest rate possible. Observing feeding behavior and noting the presence of excess feed can be used to adjust feeding rates to ensure minimal excess. An advantage of this practice is that proper feed management decreases the costs associated with the use of excess feed that is never consumed by the cultured species. Excess feed distributed to net pens breaks down, and some of the resulting products remain dissolved in the receiving water. More importantly, solids from the excess feed usually settle and are naturally processed along with feces from the aquatic animals. Excess feed and feces accumulate under net pens, and if there is inadequate flushing this accumulation can overwhelm the natural benthic processes resulting in increased benthic degradation.

The primary operational factors associated with proper feed management include development of precise feeding regimes based on the weight of the cultured species and constant observation of feeding activities to ensure that the feed offered is consumed. Other feed management practices include using high quality feeds, proper storage and handling (which includes keeping feed in cool, dry places, protecting feed from rodents and mold conditions, and handling gently to prevent breakage of the pellets), and feeding pellets of proper size. Feed management is a practice required in net pen facility permits issued by EPA Regions 1 and 10. Feed management costs are O&M costs for the extra time required will be used to observe feeding behavior and perform additional record keeping (i.e., amount of feed added to each net pen, along with records tracking the number and size of fish in the pen). The record keeping duties involve filling in a logbook.

4.2.6 Drugs and Chemical Management

The drugs and chemical BMP plan proposed under Option 2 for large flow-through systems (producing 475,000 pounds or more annually), net pens and recirculating systems. All requirements and costs associated with the Drugs and Chemical BMP Plan are estimated to be equal for all species and culture systems. The purpose of the BMP plan is to avoid spillage or inadvertent release of drugs and chemicals, and ensure the proper disposal of mortalities. Facilities producing non-native species must also develop and implement practices to minimize the potential escape of the non-native species. BMP plans must be prepared and certified by the facility owner or operator. Employees of the facility must be familiar with the BMP plan and be adequately trained in the specific procedures that the BMP plan requires. Facilities must also report the use of any drug not used according to the label and investigational new animal drugs. Oral reports are required within 7 days after initiating treatment with drugs not used according to the label and written reports within 30 days after completion of the treatment for drugs not used according to the label and investigational new animal drugs.

4.2.7 Additional Solids Removal (Solids Polishing)

Additional solids removal is considered under Option 3 for flow-through systems and recirculating systems. The term "solids polishing" refers to the use of a wastewater treatment technology to further reduce solids discharged from sedimentation basins used to treat flow-through and recirculating systems. Several technologies are available, including microscreen filters and polishing ponds. For the purpose of cost analysis, EPA assumed that microscreen filters were used. Microscreen filters consist of fine mesh filters that are usually fitted to a rotating drum. The wastewater stream is pumped into the inside of the drum and solids are removed from the effluent as the water passes through the screen. The screen size usually varies between 60 and 90 microns. The filters are equipped with automatic backwash systems that remove collected solids from the screen and direct them to further treatment or solids storage.

4.2.8 Active Feed Monitoring

Active feed monitoring is considered as a management practice in Option 3 for all net pen facilities. Active feed monitoring is a relatively new (but proven and used by some facility operators in the salmon industry) technology that uses some type of remote monitoring equipment such as an underwater video camera lowered from the surface to the bottom of a net pen during feeding to monitor for uneaten feed pellets as they pass by the video camera. The goal of active feed monitoring is to further reduce pollutant loads associated with feeding activities. A variety of technologies have been reported, including video cameras with human or computer interfaces to detect passing feed pellets. A new NPDES permit issued in Maine (USEPA, 2002b) also suggests that ultrasonic equipment may be available. Most facilities that use this technology use a video monitor at the surface that is connected to the video camera. An employee watches the monitor for feed pellets passing by the video camera and then stops feeding activity when a predetermined number of pellets (typically only two or three) pass the camera.

4.3 COMPLIANCE COST ESTIMATION

EPA estimated compliance costs based on the implementation of the practices or technologies to meet particular requirements. EPA developed computer cost equations to estimate compliance costs for each model facility and regulatory option based on information collected during the site visits, sampling events, published information, vendor contacts, and engineering judgment. Costs were calculated for each technology or practice that make up each regulatory option for each model facility. EPA based cost estimates on model facility characteristics, including system type, species, feeding strategy, size, and system specific characteristics. (The options are described in Chapter 6 of this document.)

The cost estimates generated contain the following types of costs: (1) Capital costs—costs for facility upgrades (e.g., construction projects), including land costs and other capital costs (equipment, labor, design, etc.); (2) one-time non-capital costs—one-time costs for items that cannot be amortized (e.g., consulting services or training); and (3) annual operating and maintenance (O&M) costs—annually recurring costs, which may be positive or negative. A positive O&M cost indicates an annual cost to operate, and a negative O&M cost indicates a benefit to operate, due to cost offsets. The term "unit cost" refers to the capital, one-time, and O&M costs for a technology.

Tables 4-1 through 4-3 summarize the unit costs developed for each option for each model facility in the Lower 48 States. Tables 4-4 through 4-6 summarize the costs developed for each option for each Alaska facility. Alaska provided facility-level information to EPA; hence, EPA could develop cost estimates for each individual facility. Chapter 8 in the Technical Development Document contains a more detailed discussion on the derivation of these costs (EPA, 2002a).

4.4 FREQUENCY FACTORS

EPA recognizes that some individual facilities have already implemented some treatment technologies or best management practices that were described in Section 4.2. EPA uses the term "frequency factor" to describe the portion of the regulated universe that already had a particular technology or treatment practice in place. Facilities that already have the component in place would not incur additional costs for that component as a result of the proposed regulation. If a cost component has frequency factor value of 0, the cost for that component is incurred by all facilities. If a cost component has a frequency factor of 1, the cost for that component is incurred by none of the facilities.

EPA estimated frequency factors based on sources such as those listed below. (Each source was considered along with its limitations.)

- EPA site visit information was used to assess general practices of CAAP operations and how they vary between regions and size classes.
- Screener survey data were used to assess general practices of CAAP operations and how they vary between regions and size classes.
- Observations on CAAP operations by industry experts that were contacted to provide insight into operations and practices, especially where data were limited or not publicly available.
- USDA National Agricultural Statistical Service (NASS)—The data currently available from 1998 Aquaculture Census were used to determine the distribution of AAP operations across the regions by size class.
- USDA APHIS National Animal Health Monitoring System (NAHMS)—This source provides information on catfish production.
- State Compendium: Programs and Regulatory Activities Related to Aquatic Animal Production was used to estimate frequency factors, based on current requirements for treatment technologies and BMPs that already apply to CAAP facilities in various states. For example, BMP plans are required for all facilities with permits in Idaho and Washington, so the facilities from these states were assumed to have solids control BMP plans in place.

Tables 4-1 through 4-6 also contain the associated frequency factors for each technology by model facility. Section 5.1.4 explains how EPA uses these frequency factors in evaluating the range of compliance costs that a facility might incur under each option while Section 5.2 describes how EPA uses these frequency factors when calculating the national industry costs for each option.

4.5 REFERENCES

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USDA. 2000. United States Department of Agriculture. National Agricultural Statistics Service. *1998 Census of Aquaculture*. Also cited as 1997 Census of Agriculture. Volume 3, Special Studies, Part 3. AC97-SP-3. February.

Table 4-1
Non-Alaska Model Facilities
Unit Costs—Regulatory Option 1

			Regulatory Option 1 Unit Costs and Frequency Factors					
Species	Model	Count	Feed Management Capital	Feed Management O&M	Feed Management Frequency	Quiescent Zone Capital	Quiescent Zone O&M	Quiescent Zone Frequency Factor
Trout- Flow-through	Medium	22	--	--	--	$7,195.56	$4,339.28	0.91
Trout- Flow-through	Large	8	--	--	--	$53,367.07	$28,974.66	1.00
Trout- State Flow-through	Medium	<5	--	--	--	$7,795.19	$4,659.22	1.00
Trout- State Flow-through	Large	<5	--	--	--	$11,992.60	$6,898.80	1.00
Trout Stockers-Flow-through	Medium	5	--	--	--	$6,595.93	$4,019.34	1.00
Trout Stockers-Flow-through	Large	0	--	--	--	$0.00	$0.00	0.00
Trout Stockers- Federal FT	Medium	7	--	--	--	$7,195.56	$4,339.28	0.57
Trout Stockers- Federal FT	Large	<5	--	--	--	$29,381.87	$16,177.06	0.50
Trout Stockers- State FT	Medium	44	--	--	--	$7,195.56	$4,339.28	0.91
Trout Stockers- State FT	Large	<5	--	--	--	$10,793.34	$6,258.92	1.00
Trout Stockers- Other FT	Medium	<5	--	--	--	$12,592.23	$7,218.74	1.00
Trout Stockers- Other FT	Large	<5	--	--	--	$10,193.71	$5,938.98	1.00
Tilapia- Flow-through	Medium	<5	--	--	--	$8,394.82	$4,979.16	0.67
Tilapia- Flow-through	Large	<5	--	--	--	$21,586.68	$12,017.84	1.00
Tilapia- Recirculating	Large	5	--	--	--	--	--	--
Striped Bass-FT	Medium	<5	--	--	--	$3,911.33	$2,586.94	1.00

Table 4-1 (continued)
Non-Alaska Model Facilities
Unit Costs—Regulatory Option 1

Regulatory Option 1 Unit Costs and Frequency Factors (continued)								
Species	**Model**	**Count**	**BMP Plan Capital**	**BMP Plan O&M**	**BMP Plan Frequency Factor**	**Monitoring Capital**	**Monitoring O&M**	**Monitoring Frequency Factor**
Trout- Flow-through	Medium	22	$1,076.80	$918.36	0.32	$0.00	$2,731.92	0.32
Trout- Flow-through	Large	8	$1,076.80	$918.36	1.00	0.00	$2,731.92	1.00
Trout- State Flow-through	Medium	<5	$1,076.80	$918.36	0.00	0.00	$2,731.92	0.00
Trout- State Flow-through	Large	<5	$1,076.80	$918.36	0.00	0.00	$2,731.92	0.00
Trout Stockers-Flow-through	Medium	5	$1,076.80	$918.36	0.60	0.00	$2,731.92	0.60
Trout Stockers-Flow-through	Large	0	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
Trout Stockers- Federal FT	Medium	7	$1,076.80	$918.36	0.14	0.00	$2,731.92	0.14
Trout Stockers- Federal FT	Large	<5	$1,076.80	$918.36	0.50	0.00	$2,731.92	0.50
Trout Stockers- State FT	Medium	44	$1,076.80	$918.36	0.02	0.00	$2,731.92	0.02
Trout Stockers- State FT	Large	<5	$1,076.80	$918.36	0.00	0.00	$2,731.92	0.00
Trout Stockers- Other FT	Medium	<5	$1,076.80	$918.36	1.00	0.00	$2,731.92	1.00
Trout Stockers- Other FT	Large	<5	$1,076.80	$1,381.32	1.00	0.00	$2,731.92	1.00
Tilapia- Flow-through	Medium	<5	$1,076.80	$918.36	0.00	0.00	$2,731.92	0.00
Tilapia- Flow-through	Large	<5	$1,076.80	$918.36	0.00	0.00	$2,731.92	0.00
Tilapia- Recirculating	Large	5	$1,076.80	$918.36	0.40	0.00	$2,731.92	0.40
Striped Bass-FT	Medium	<5	$1,076.80	$918.36	0.00	0.00	$2,731.92	0.00
Striped Bass-FT	Large	0	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
Striped Bass-Recirculating	Large	<5	$1,076.80	$918.36	0.00	0.00	$2,731.92	0.00
Salmon-Other Flow-through	Medium	0	$0.00	$0.00	$0.00	$0.00	$0.00	0.00
Salmon-Other Flow-through	Large	<5	$1,076.80	$918.36	0.00	0.00	$2,731.92	0.00
Salmon-Net Pen	Large	8	$1,076.80	$253.80	0.13	--	--	--

Table 4-2
Non-Alaska Model Facilities
Unit Costs—Regulatory Option 2

Regulatory Option 2 Unit Costs and Frequency Factors								
Species	**Model**	**Count**	**Drugs & Chemical BMP Plan Capital**	**Drugs & Chemical BMP Plan O&M**	**Drugs & Chemical BMP Plan Frequency Factor**	**Monitoring Capital**	**Monitoring O&M**	**Monitoring Frequency Factor**
Trout- Flow-through	Medium	22	$1,076.80	$253.80	0.00	$0.00	$2,731.92	0.32
Trout- Flow-through	Large	8	$1,076.80	$253.80	0.00	0.00	$2,731.92	1.00
Trout- State Flow-through	Medium	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.00
Trout- State Flow-through	Large	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.00
Trout Stockers-Flow-through	Medium	5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.60
Trout Stockers-Flow-through	Large	0	$0.00	$0.00	0.00	$0.00	$0.00	0.00
Trout Stockers- Federal FT	Medium	7	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.14
Trout Stockers- Federal FT	Large	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.50
Trout Stockers- State FT	Medium	44	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.02
Trout Stockers- State FT	Large	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.00
Trout Stockers- Other FT	Medium	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	1.00
Trout Stockers- Other FT	Large	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	1.00
Tilapia- Flow-through	Medium	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.00
Tilapia- Flow-through	Large	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.00
Tilapia- Recirculating	Large	5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.40
Striped Bass-FT	Medium	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.00
Striped Bass-FT	Large	0	$0.00	$0.00	0.00	$0.00	$0.00	0.00
Striped Bass-Recirculating	Large	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.00
Salmon-Other Flow-through	Medium	0	$0.00	$0.00	0.00	$0.00	$0.00	0.00
Salmon-Other Flow-through	Large	<5	$1,076.80	$253.80	0.00	0.00	$2,731.92	0.00

Table 4-3
Non-Alaska Model Facilities
Unit Costs—Regulatory Option 3

Regulatory Option 3 Unit Costs and Frequency Factors									
Species	**Model**	**Count**	**Solids Polishing Capital**	**Solids Polishing O&M**	**Solids Polishing Frequency Factor**	**Monitoring Capital**	**Monitoring O&M**	**Monitoring Frequency Factor**	**Active Feed Monitoring Capital**
Trout- Flow-through	Medium	22	$8,052.91	$1,861.32	0.09	--	--	--	--
Trout- Flow-through	Large	8	$8,574.86	$1,861.32	0.00	0.00	4171.92	1.00	--
Trout- State Flow-through	Medium	<5	$8,052.91	$1,862.32	0.00	--	--	--	--
Trout- State Flow-through	Large	<5	$8,052.91	$1,861.32	0.00	0.00	4171.92	0.00	--
Trout Stockers-Flow-through	Medium	5	$8,052.91	$1,861.32	0.00	--	--	--	--
Trout Stockers-Flow-through	Large	0	$0.00	$0.00	0.00	0.00	4171.92	0.00	--
Trout Stockers- Federal FT	Medium	7	$8,052.91	$1,861.32	0.00	--	--	--	--
Trout Stockers- Federal FT	Large	<5	$8,052.91	$1,861.32	0.00	0.00	4171.92	0.50	--
Trout Stockers- State FT	Medium	44	$8,052.91	$1,861.32	0.05	--	--	--	--
Trout Stockers- State FT	Large	<5	$8,052.91	$1,831.32	0.00	0.00	4171.92	0.00	--
Trout Stockers- Other FT	Medium	<5	$8,052.91	$1,861.32	0.00	--	--	--	--
Trout Stockers- Other FT	Large	<5	$8,052.91	$1,861.32	0.00	0.00	4171.92	1.00	--
Tilapia- Flow-through	Medium	<5	$8,052.91	$1,861.32	0.00	--	--	--	--
Tilapia- Flow-through	Large	<5	$8,052.91	$1,861.32	0.00	0.00	4171.92	0.00	--
Tilapia- Recirculating	Large	5	$8,052.91	$1,861.32	0.40	0.00	4171.92	0.40	--
Striped Bass-FT	Medium	<5	$8,052.91	$1,861.32	1.00	--	--	--	--

Table 4-4
Alaska Facilities
Unit Costs—Regulatory Option 1

Regulatory Option 1 Unit Costs and Frequency Factors										
Facility	**Harvest**	**Quiescent Zone Capital**	**Quiescent Zone O&M**	**Quiescent Zone Frequency Factor**	**Settling Basin Capital**	**Settling Basin O&M**	**Settling Basin Frequency Factor**	**Monitoring Capital**	**Monitoring O&M**	**Monitoring Frequency Factor**
Facility 1	201,052	6,378.67	5,933.51	0	24,884.00	5,071.32	0	0	2,731.92	0
Facility 2	204,139	6,476.61	6,016.94	0	25,252.76	5,075.47	0	0	2,731.92	0
Facility 3	144,436	4,582.44	4,403.44	0	17,862.69	4,995.29	0	0	2,731.92	0
Facility 4	135,510	4,299.25	4,162.21	0	16,796.40	4,983.30	0	0	2,731.92	0
Facility 5	403,515	12,802.10	11,405.15	0	49,715.01	5,343.22	0	0	2,731.92	0
Facility 6	150,822	4,785.05	4,576.02	0	18,625.54	5,003.87	0	0	2,731.92	0
Facility 7	125,720	3,988.65	3,897.63	0	15,626.91	4,970.16	0	0	2,731.92	0
Facility 8	207,649	6,587.97	6,111.80	0	25,672.06	5,080.18	0	0	2,731.92	0
Facility 9	985,194	31,256.71	27,125.26	0	121,265.81	6,124.40	0	0	2,731.92	0
Facility 10	116,636	3,700.45	3,652.13	0	14,541.75	4,957.96	0	0	2,731.92	0
Facility 11	366,030	11,612.83	10,392.11	0	45,108.09	5,292.88	0	0	2,731.92	0
Facility 12	244,543	7,758.48	7,108.87	0	30,208.38	5,129.73	0	0	2,731.92	0
Facility 13	571,095	18,118.82	15,934.07	0	70,378.97	5,568.28	0	0	2,731.92	0
Facility 14	145,089	4,603.16	4,421.09	0	17,940.69	4,996.17	0	0	2,731.92	0
Facility 15	222,290	7,052.47	6,507.48	0	27,421.04	5,099.85	0	0	2,731.92	0
Facility 16	250,047	7,933.10	7,257.62	0	30,865.88	5,137.12	0	0	2,731.92	0
Facility 17	104,738	3,322.97	3,330.59	0	12,991.40	4,941.98	0	0	2,731.92	0
Facility 18	153,371	4,865.92	4,644.91	0	19,059.08	5,007.29	0	0	2,731.92	0

Table 4-4 (continued)
Alaska Facilities
Unit Costs—Regulatory Option 1

Regulatory Option 1 Unit Costs and Frequency Factors (continued)							
Facility	Harvest	BMP Plan Capital	BMP Plan O&M	BMP Plan Frequency Factor	Monitoring Capital	Monitoring O&M	Monitoring Frequency Factor
Facility 1	201,052	1,710.40	1,277.64	0	0	2,731.92	0
Facility 2	204,139	1,710.40	1,277.64	0	0	2,731.92	0
Facility 3	144,436	1,710.40	1,277.64	0	0	2,731.92	0
Facility 4	135,510	1,710.40	1,277.64	0	0	2,731.92	0
Facility 5	403,515	1,710.40	1,277.64	0	0	2,731.92	0
Facility 6	150,822	1,710.40	1,277.64	0	0	2,731.92	0
Facility 7	125,720	1,710.40	1,277.64	0	0	2,731.92	0
Facility 8	207,649	1,710.40	1,277.64	0	0	2,731.92	0
Facility 9	985,194	1,710.40	1,277.64	0	0	2,731.92	0
Facility 10	116,636	1,710.40	1,277.64	0	0	2,731.92	0
Facility 11	366,030	1,710.40	1,277.64	0	0	2,731.92	0
Facility 12	244,543	1,710.40	1,277.64	0	0	2,731.92	0
Facility 13	571,095	1,710.40	1,277.64	0	0	2,731.92	0
Facility 14	145,089	1,710.40	1,277.64	0	0	2,731.92	0
Facility 15	222,290	1,710.40	1,277.64	0	0	2,731.92	0
Facility 16	250,047	1,710.40	1,277.64	0	0	2,731.92	0
Facility 17	104,738	1,710.40	1,277.64	0	0	2,731.92	0
Facility 18	153,371	1,710.40	1,277.64	0	0	2,731.92	0

Table 4-5
Alaska Facilities
Unit Costs—Regulatory Option 2

Regulatory Option 2 Unit Costs and Frequency Factors							
Facility	**Harvest**	**Drugs & Chemical BMP Plan Capital**	**Drugs & Chemical BMP Plan O&M**	**Drugs & Chemical BMP Plan Frequency Factor**	**Monitoring Capital**	**Monitoring O&M**	**Monitoring Frequency Factor**
Facility 1	201,052	1,710.40	1,277.64	0	0	2,731.92	0
Facility 2	204,139	1,710.40	1,277.64	0	0	2,731.92	0
Facility 3	144,436	1,710.40	1,277.64	0	0	2,731.92	0
Facility 4	135,510	1,710.40	1,277.64	0	0	2,731.92	0
Facility 5	403,515	1,710.40	1,277.64	0	0	2,731.92	0
Facility 6	150,822	1,710.40	1,277.64	0	0	2,731.92	0
Facility 7	125,720	1,710.40	1,277.64	0	0	2,731.92	0
Facility 8	207,649	1,710.40	1,277.64	0	0	2,731.92	0
Facility 9	985,194	1,710.40	1,277.64	0	0	2,731.92	0
Facility 10	116,636	1,710.40	1,277.64	0	0	2,731.92	0
Facility 11	366,030	1,710.40	1,277.64	0	0	2,731.92	0
Facility 12	244,543	1,710.40	1,277.64	0	0	2,731.92	0
Facility 13	571,095	1,710.40	1,277.64	0	0	2,731.92	0
Facility 14	145,089	1,710.40	1,277.64	0	0	2,731.92	0
Facility 15	222,290	1,710.40	1,277.64	0	0	2,731.92	0
Facility 16	250,047	1,710.40	1,277.64	0	0	2,731.92	0
Facility 17	104,738	1,710.40	1,277.64	0	0	2,731.92	0
Facility 18	153,371	1,710.40	1,277.64	0	0	2,731.92	0

Table 4-6
Alaska Facilities
Unit Costs—Regulatory Option 3

Regulatory Option 3 Unit Costs and Frequency Factors							
Facility	**Harvest**	**Solids Polishing Capital**	**Solids Polishing O&M**	**Solids Polishing Frequency Factor**	**Monitoring Capital**	**Monitoring O&M**	**Monitoring Frequency Factor**
Facility 1	201,052	8,052.91	2,320.48	0	0	5,405.04	0
Facility 2	204,139	8,052.91	2,320.48	0	0	5,405.04	0
Facility 3	144,436	8,052.91	2,320.48	0	0	5,405.04	0
Facility 4	135,510	8,052.91	2,320.48	0	0	5,405.04	0
Facility 5	403,515	8,052.91	2,320.48	0	0	5,405.04	0
Facility 6	150,822	8,052.91	2,320.48	0	0	5,405.04	0
Facility 7	125,720	8,052.91	2,320.48	0	0	5,405.04	0
Facility 8	207,649	8,052.91	2,320.48	0	0	5,405.04	0
Facility 9	985,194	8,052.91	2,320.48	0	0	5,405.04	0
Facility 10	116,636	8,052.91	2,320.48	0	0	5,405.04	0
Facility 11	366,030	8,052.91	2,320.48	0	0	5,405.04	0
Facility 12	244,543	8,052.91	2,320.48	0	0	5,405.04	0
Facility 13	571,095	8,052.91	2,320.48	0	0	5,405.04	0
Facility 14	145,089	8,052.91	2,320.48	0	0	5,405.04	0
Facility 15	222,290	8,052.91	2,320.48	0	0	5,405.04	0
Facility 16	250,047	8,052.91	2,320.48	0	0	5,405.04	0
Facility 17	104,738	8,052.91	2,320.48	0	0	5,405.04	0
Facility 18	153,371	8,052.91	2,320.48	0	0	5,405.04	0

CHAPTER 5

ECONOMIC IMPACT METHODOLOGY

This section provides an overview of the methodology used in the economic impact analysis. Section 5.1 discusses EPA's facility impact analysis using a revenue test while Section 5.2 describes each step in the analysis. Section 5.3 summarizes the approach used to calculate the incremental industry compliance costs while Section 5.4 describes the adjustment to the commercial cost estimate to obtain the national industry compliance costs for the rule. Section 5.5 discusses the structure of EPA's Best Conventional Technology (BCT) cost test.

5.1 FACILITY ANALYSIS

5.1.1 Revenue Test

EPA used the facility production data from the screener survey, combined with available price data from the Census and other sources, to estimate revenues for the model facilities for which the Agency estimated costs. EPA calculated model facility impacts using the test measure of the ratio of the estimated annual compliance costs to revenue from aquacultural sales (hereafter referred to as a "revenue test"). EPA calculated the revenue test as:

$$\frac{\text{Pre-tax annualized compliance cost}}{\text{Estimated revenues from aquaculture sales}}$$

for each model facility configuration. The costs were annualized over a ten-year period with a seven percent real discount rate and included a mid-year convention for putting any new equipment into operation (i.e., six months between purchase, installation, and operation). EPA calculated pre-tax annualized costs for two reasons: these costs are compared to pre-tax revenue and EPA had no data or information on which to estimate a post-tax cost.

5.1.2 Alternative Approaches Considered

No financial data were collected in EPA's screener survey and the USDA Census collected only revenue data. Neither the *1998 Census of Aquaculture* (USDA, 2000; hereafter referred to as "the Census") nor EPA's screener survey collected data on farm-level operating costs. This absence of matched pairs of cost and revenue limited EPA's efforts in developing the economic analysis for proposal. The Census collected information on revenues from aquaculture sales (not including other farm-related revenues from other agricultural crops at the facility) while the screener survey collected aquatic animal production data at the facility. EPA could not calculate the test measure of the ratio of the estimated annual compliance costs to facility profit (otherwise known as a "profit test") due to the absence of corresponding cost data. EPA is currently in the process of collecting detailed facility-level economic data on concentrated aquatic animal producers, including matched pairs of cost and revenue data, and intends to perform a detailed financial analysis on this real-world data for final promulgation.

EPA considered alternative approaches to the revenue test used to examine economic impacts to the industry, including developing representative model facilities based on enterprise budget data. EPA determined these alternative approaches to be infeasible given the lack of information on the distribution of profits among aquatic animal producers. EPA's examination of the feasibility of using an enterprise budget approach to analyze economic impacts is summarized in the rulemaking record (DCNs 20146-20150 and 20152-20155).

5.1.3 Revenue Estimates for Non-Commercial Facilities

While some non-commercial facilities—Federal and state hatcheries, academic and research facilities, and tribal facilities— might sell some of their production, most fish and egg distribution from these facilities have no market transaction (that is, they are not sold). The industry profile (Chapter 2) stresses the differences between commercial and non-commercial facilities, but the economic analysis is constrained by the absence of cost and/or funding data for non-commercial facilities until detailed survey data are available. Given the data available at this time—production level from the screener survey and market value from the Census—the only measure by which to evaluate impacts is to impute a value to their production based on annual harvest and commercial prices.

5.1.4 Revenue Estimates for Alaskan Facilities

Alaskan non-profit facilities have a unique financial structure (see Section 2.5.3 for further discussion). Alaskan facilities practice ocean ranching where the salmon smolts are released to the sea. A non-profit corporation is allowed to harvest adult salmon that return to the region. In addition, reginal corporations vote on a self-imposed tax of 1, 2, or 3 percent of the ex-vessel value of fish in the region caught. Alaska provided operator-reported revenues and enhancement tax revenues for each facility (Alaska, 2002). For these facilities, EPA compared the annualized compliance costs to the sum of operator-reported revenues and enhancement tax revenues (Alaska, 2002).

5.2 STEPS IN THE FACILITY ANALYSIS

The analysis of economic impacts includes the following steps: (1) assessing the number of facilities that could be affected by this rule; (2) estimating the annualized incremental compliance costs for model facilities to comply with the different requirements identified in the rule; (3) calculating model facility impacts using the revenue test; and (4) extrapolating from the individual model facility results to estimate facility impacts at the national level (i.e., in the regulated universe) using the revenue test. Each of these steps is discussed below.

5.2.1 Calculation of Annualized Costs for Individual Option Components

EPA's engineering staff developed estimates of the capital, one-time non-equipment[1], and operating and maintenance (O&M) costs for incremental pollution control in the aquatic animal production industry. The capital cost, a one-time cost, is the initial investment needed to purchase and install the equipment. The one-time non-equipment cost is incurred in its entirety in the first year of the

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[1]A one-time non-equipment cost is best explained by example, such as an engineering study that recommends improved operating parameters as a method of meeting effluent limitations guidelines. One-time non-equipment costs cannot be depreciated because the product is not associated with property that wears out, nor is it an annual expense.

model. The O&M cost is the annual cost of operating and maintaining the equipment; the site incurs it each year.

There are two reasons for the annualization of capital, one-time non-capital, and O&M costs. First, the capital cost is incurred only once in the equipment's lifetime; therefore, initial investment should be expended over the life of the equipment. Second, money has a time value. A dollar today is worth more than a dollar in the future; expenditures incurred 10 years from now do not have the same value to the firm as the same expenditures incurred tomorrow. The model develops a time series for cash flows involving pollution control capital, one-time non-capital, and annual O&M costs. The cash outflows are then discounted to calculate the present value of future cash outflows in terms of dollars for the first year of the model. This methodology evaluates what a business would pay in constant dollars for all initial and future expenditures. Finally, the model calculates the annualized cost for the cash outflow as an annuity that has the same present value of the cash outflows and includes the cost of money or interest. The annualized cost is analogous to a mortgage payment that spreads the one-time investment of a home into a defined series of monthly payments.

Because EPA is evaluating only pre-tax annualized costs at this time, only three additional parameters are needed for the cost annualization model:

- Interest rate, discount rate, or opportunity cost of capital
  EPA uses the Office of Management and Budget (OMB) recommendation of seven percent real discount rate for the opportunity cost of capital and three percent for discounting benefits (OMB, 1992).

- Time period for annualization
  EPA uses a 10-year period for cost annualization in the rulemakings for animal feeding operations and aquatic animal production industry. The time period coincides with equipment lifetime for major equipment expenditures and Internal Revenue Service (IRS) definitions that place single-purpose agricultural structures as 10-year property (IRS, 1999).

- Mid-year convention for putting equipment in service, that is, a six-month lag between the time the initial monetary outlay is made and when the enterprise goes into operation.

EPA intends to use a more complex cost annualization model for final promulgation which takes into account depreciation schedules, differentiation between non-depreciable items such as land and one-time non-capital expenditures and depreciable costs, tax shields, and tax rates that differ earnings level for corporate and individuals to calculate post-tax annualized costs.

5.2.2 Identification of Possible Facility Option Costs

EPA identified several technologies and treatment practices that reduce pollutant loadings to a water body from a concentrated aquatic animal enterprise. The following is a selected list of technologies that EPA reviewed as part of the rulemaking process:

- Solids Control Best Management Practices (called solids control BMP or "B" in the example below).
- Drugs & Chemical Best Management Practices.
- Quiescent Zone (called "Quiescent" or "Q"). This is a zone with lower currents or water activity (usually at the end of a raceway) that allows solids to settle out of the water column.
- Active feed monitoring. This involves watching the fish in net-pens (e.g., salmon) while they feed. The fish are fed until satiation but no more. The purpose is to minimize the amount of uneaten feed in the water column and settling below the pen.
- Settling Basin (called "Settling" or "S"). This is an area not in line with any raceway or other part of the aquaculture system. The purpose of the basin is to allow the water to stand for some period of time to let solids drop out of the water column.
- Solids Polishing (called "Polish" or "P"). Effluent is discharged to a pond where it is held for a longer period of time to allow natural processes to treat the effluent.

Not all cost components are considered for each production system. Some components are restricted to certain production systems for technical reasons. EPA considers active feed management for net-pen systems where it can affect the amount of uneaten feed accumulating beneath the pens, and not other systems. Quiescent zones, settling basins, and the subsequent management of the collected nutrients are associated with flow-through and recirculating systems.

EPA calculated the range in possible costs incurred by a facility to comply with the proposed or evaluated option. For example, suppose an option has three components: (1) solids control BMP plan

[B], (2) quiescent zone [Q], and (3) settling basin [S]. A facility might incur any one of eight cost combinations:

- B, Q, S (i.e., all three costs are incurred)
- B, Q (site has a settling basin, only BMP plan and quiescent zone cost components apply)
- B, S (site has quiescent zone, only BMP plan and settling basin cost components apply)
- B (site has quiescent zone and settling basin, only solids control BMP cost component applies)
- Q, S (site has BMP plan, only settling basin and quiescent zone cost components apply)
- Q (site has BMP plan and settling basin, only quiescent zone cost component applies)
- S (site has BMP plan and quiescent zone, only settling basin cost component applies)
- no cost (site has all three components in place prior to the rulemaking)

EPA calculated the total cost to a facility to implement and operate a technology or treatment practice. These costs differed according to the production system and annual harvest (pounds) for each model facility.

5.2.3 Calculation of the Likelihood of a Facility Incurring Particular Costs

On the basis of screener survey data, EPA characterized the industry by production system, species, operator (commercial and non-commercial; the latter includes federal, state, tribal, academic/research, and other operators), and size. All costs are reported in 2000 dollars unless otherwise noted.

EPA also used the screener information to calculate "frequency factors" to account for the portion of the regulated population that already had a particular treatment practice in place. For example, if three of every ten flow-through facilities already had a quiescent zone in place prior to the regulation, the quiescent zone frequency factor is 0.30. This means that seven of ten facilities might incur the cost of installing and operating a quiescent zone if it is part of the proposed option. Frequency factors differ by production system, species, operator, and size (see Tables 4-1 and 4-2).

In the example given in Section 5.1.3, the probability of a site incurring a cost is the product of (1 minus the frequency factor) for the three components. Likewise, the likelihood of a site incurring **no** costs is the product of the three frequency factors. If a cost component has a frequency factor value of 0 or 1, the cost for that component is incurred by either all or none of the facilities, respectively. Under these conditions, the number of possible cost combinations is reduced. That is, depending on the value of the frequency factors, the revenue test needs to examine 1, 2, 4, or 8 possible configurations. The number of cost combinations for which probabilities must be calculated therefore differs for each production system/ species/ owner/ size configuration.

For example, using the information in Table 4-1, a medium commercial trout flow-through facility has an 0.0848 probability of incurring no costs to meet Option 1 requirements and an 0.0037 probability of incurring costs for all components of Option 1 (i.e., the frequency factors are .91 x .91 x .32 x .32 for quiescent zone, settling basin, BMP plan, and monitoring, respectively). The frequency factors for large commercial trout flow-through facilities are all 1.0, hence, none of the eight facilities in this model category are anticipated to incur costs to meet Option 1 requirements.

5.2.4 Calculation of Facility Counts Showing Impacts at a Given Revenue Test Threshold

EPA calculated the possible cost combinations for each option for each model facility and compared these costs to the model facility and evaluated whether a revenue test showed impacts. As mentioned in Section 5.1.1, EPA used the average annual production from the screener survey and national average price from Census data to estimate revenues for each commercial model facility. For non-commercial facilities, EPA used an imputed revenue based on average production from the screener survey and national average commercial price from Census data for reasons given in Section 5.1.3. For Alaskan non-profit corporations, EPA used the sum of operator-reported revenues and enhancement tax revenues for each facility (see Section 5.1.4).

EPA used revenue test thresholds of one, three, five, and ten percent. EPA used the full pre-tax annualized cost in the revenue test; that is, EPA did not assume that any portion of the cost could be passed through to the consumers in terms of higher prices. EPA is not associating any particular threshold of the revenue test with facility failure; such a determination will be made on the basis of facility-specific information collected in the detailed survey. For purposes of the proposed regulation, EPA believes that a large percentage of facilities experiencing impacts greater than 5% and/or a small percentage experiencing impacts greater than 10% indicate disproportionate economic burden.

For each model facility, EPA calculated the range in costs that potentially could be incurred by the facility under an option and the likelihood of incurring those costs. In the example given in Section 5.2.3, the hypothetical option consists of three components. Say a model facility has a 50-50 chance of having each technology or treatment in place. Each of the eight cost combinations identified in Section 5.2.3 has a 1/8 or 0.125 chance of occurring (that is, .5 x .5 x .5 = .125). Say that only two cost combinations have a cost that exceed x percent of revenues where x is the test threshold. In this case, 0.25 (i.e., the sum of the probabilities of those costs) of the facilities represented by this model facility are assumed to show impacts under this option. EPA then multiplies the percentage showing impacts by the number of facilities in the screener survey represented by the model facility to estimate the number of facilities showing impacts on the revenue test. To continue with the example, say the model facility represents 40 facilities in the screener survey data. EPA would estimate that 10 facilities would show impacts at the x percent threshold for that option .

5.2.5 Sample Calculations

To illustrate the process discussed in Sections 5.2.1 through 5.2.4, suppose an option has three components: A with a cost of $10 and a frequency factor of 0.9, B with a cost of $100 and a frequency factor of 0.5, and C with a cost of $1000 and a frequency factor of 0.1. In the example, these are annualized costs that take into account capital, annual, and the cost of capital (Section 5.2.1). A facility could incur any cost from $0 (all control practices are in place) to $1110 (none of the control practices are in place, Section 5.2.2).

EPA used the frequency factors to calculate the probability of a facility incurring a particular control practice cost combination (Section 5.2.3). Table 5-1 summarizes the probabilities of a facility incurring the example costs:

Table 5-1

Calculation of Sample Costs and Their Probabilities

Cost Combination	Frequency Factor (or inverse)			Facility Cost	Probability of Facility Cost
	A	B	C		
ABC	0.1	0.5	0.9	$1,110	0.045
AB	0.1	0.5	0.1	$110	0.005
AC	0.1	0.5	0.9	$1,010	0.045
A	0.1	0.5	0.1	$10	0.005
BC	0.9	0.5	0.9	$1,100	0.405
B	0.9	0.5	0.1	$100	0.045
C	0.9	0.5	0.9	$1,000	0.405
no cost	0.9	0.5	0.1	$0	0.045
Sum of probabilities					1.000

From Table 5-1, we see that the example model facility has a 90 percent probability of incurring a cost of $1,000 or more. If the example model facility represents 50 facilities and the $1,000 cost shows impacts at the 1 percent level, EPA estimates that 50 x 0.9 or 45 facilities would show impacts at the 1 percent revenue test.

5.3 INDUSTRY COSTS

EPA used the following approach to calculate national industry compliance costs. For each model facility, EPA calculated the weighted average cost for each component (that is, the cost of the component times (1 minus the frequency factor) for that component), multiplied the weighted-average cost by the number of facilities represented by that configuration, and summed over the components that comprise a given option. In the example given in Section 5.2.3, the industry capital cost for each model facility configuration is calculated as:

(N x UA x [1-FFA]) + (N x UB x [1-FFB]) + (N x UC x [1-FFC])

where:

N	=	number of facilities represented by the model facility configuration (taken from EPA screener survey data)
UA	=	capital cost for component A (e.g., solids control BMP plan)
UB	=	capital cost for component B (e.g., quiescent zone)
UC	=	capital cost for component C (e.g., settling basin)
FFA	=	frequency factor for component A
FFB	=	frequency factor for component B
FFC	=	frequency factor for component C

EPA then summed the estimated costs for all the model facility configurations to estimate the industry compliance cost associated with each option. The industry costs are used in the cost-reasonableness and nutrient cost-effectiveness calculations. EPA estimated costs for three size groups based on production: less than 100,000 pounds/year, between 100,000 and 475,000 pounds/year, and greater than 475,000 pounds/year. Appendix C discusses EPA's determination of the production thresholds.

5.4 NATIONAL INDUSTRY COMPLIANCE COSTS

In order to estimate the national pre-tax annualized compliance costs attributed to the proposed rule, EPA multiplied the compliance costs for commercial facilities identified by the screener by a factor of 2.5. This factor was estimated by calculating the ratio of the number of potentially regulated commercial facilities identified in the Census to the number of potentially regulated commercial facilities identified in the screener survey results. EPA evaluated this comparison by system type and found, for those potentially regulated facilities, that the ratio was fairly consistent (approximately 2.5). A more detailed explanation of this analysis can be found in the rulemaking record (Tetra Tech, 2002). EPA believes it was able to identify all public facilities in the screener, so these compliance costs did not need to be adjusted.

5.5 COST-REASONABLENESS AND BCT COST TESTS

EPA is evaluating technology options for the control of only conventional parameters at BPT.[2] CWA Section 304(b)(1)(B) requires a cost-reasonableness assessment for BPT limitations. In determining BPT limitations, EPA must consider the total cost of treatment technologies in relation to the effluent reduction benefits gained by such technology. This inquiry does not limit EPA's broad discretion to adopt BPT limitations that are achievable with available technology unless the required additional reductions are wholly out of proportion to the costs of achieving such marginal reduction.

The cost reasonableness ratio is the average cost per pound of pollutants removed by a BPT regulatory option. The cost component is measured as total pre-tax annualized costs in 2000 dollars. In this case, the pollutants removed are conventional pollutants although, in some cases, removals may include priority and nonconventional pollutants.

In July 1986, EPA explained how it developed its methodology for setting effluent limitations based on BCT (EPA, 1986). EPA evaluates the reasonableness of candidate technologies considered for BCT—those that remove more conventional pollutants than BPT—by applying a two-part cost test: a POTW test and an industry cost-effectiveness test.

EPA first calculates the cost per pound of conventional pollutant removed by industrial dischargers in upgrading from BPT to a BCT candidate technology, and then compares this cost to the cost per pound of conventional pollutants removed in upgrading Publicly Owned Treatment Works (POTWs, also called sewage treatment plants) to advanced secondary treatment (i.e., "the POTW test"). The upgrade cost to industry must be less than the POTW benchmark of $0.25 per pound in 1976 dollars or $0.65 per pound in 2000 dollars. In the industry cost-effectiveness test, the ratio of the cost per

[2]Conventional pollutants considered in the aquatic animal production industry include biological oxygen demand (BOD) and total suspended solids (TSS). EPA also evaluated option cost-effectiveness for nutrients as measured by total nitrogen and total phosphorus.

pound to go from BPT to BCT divided by the cost per pound to go from raw wastewater to BPT for the industry must be less than 1.29 (that is, the cost increase must be less than 29 percent).

5.6 REFERENCES

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CHAPTER 6

REGULATORY OPTIONS:
DESCRIPTIONS, COSTS, AND CONVENTIONAL REMOVALS

6.1 PROPOSED SUBCATEGORIES AND OPTIONS

Table 6-1 summarizes the options evaluated for each subcategory. The Best Management Practices (BMP) plan listed for Option 1 addresses solids control. The drugs and chemicals BMP listed for Options 2 and 3 addresses general reporting requirements for drug and chemical use.

Table 6-1
Regulatory Options

Option	Subcategory		
	Flow-through	**Recirculating**	**Net Pens**
1	Sedimentation Basin Quiescent Zone BMP plan Compliance Monitoring	Sedimentation Basin Quiescent Zone BMP plan Compliance Monitoring	Feed Management BMP plan
2	Option 1 plus Drugs & Chemical BMP	Option 1 plus Drugs & Chemical BMP	Option 1 plus Drugs & Chemical BMP
3	Option 2 plus Solids Polishing	Option 2 plus Solids Polishing	Option 2 plus Active Feed Monitoring

6.2 SUBCATEGORY COSTS

EPA first examined subcategory costs for all facilities meeting the definition of "concentrated aquatic animal production facilities" that need an NPDES permit under 40 CFR 122.24 and Appendix C. These are summarized in Table 6-2. The annual operating and maintenance (O&M) costs are comparable in order of magnitude to the combined capital and one-time costs, such as equipment, for all subcategories. Total pre-tax annualized costs for Options 1 to 3 are estimated to be: $510,000 to $930,000 for flow-through systems excluding Alaska; $440,000 to $510,000 for flow-through systems in Alaska; $31,000 to $45,000 for recirculating systems; and $6,200 to $34,000 for net pen systems.

Table 6-2
Option Costs by Subcategory ($2000)

Subcategory	Option	Capital and One time cost	Annual O&M Cost	Pre-tax Annualized Costs
Flow-through	1	$750,000	$418,000	$506,000
	2	$860,000	$444,000	$545,000
	3	$1,653,000	$727,000	$925,000
Flow-through Alaska Nonprofits	1	$765,000	$350,000	$441,000
	2	$796,000	$358,000	$453,000
	3	$941,000	$400,000	$513,000
Recirculating	1	$6,000	$31,000	$30,000
	2	$15,000	$33,000	$34,000
	3	$47,000	$40,000	$45,000
Net Pens	1	$7,000	$5,000	$6,000
	2	$16,000	$7,000	$9,000
	3	$66,000	$26,000	$34,000

Note: Numbers rounded to nearest $1,000.
Source: 30 May costs for Flow-through Medium facilities.
16 May costs for Large Flow-through facilities, Recirculating, and Net Pen Systems.
23 May 2002 costs for Alaska facilities.

EPA performed several rounds of costing analysis as it developed the effluent guideline. In March 2002, EPA developed compliance cost estimates for the six revenue size categories used by USDA in its *Census* (see Chapter 2, Table 2-8 and USDA, 2000). Based on the estimated impacts for each category using the revenue tests, EPA set three production levels:

- below 100,000 pounds per year
- 100,000 to 475,000 pounds per year
- more than 475,000 pounds per year

Appendix C provides more details on this early analysis. EPA is not proposing effluent limitations guidelines for CAAP facilities with production below 100,000 pounds per year.

The flow-through subcategory has the largest number of facilities (120 including Alaskan nonprofit facilities, 102 excluding Alaska). EPA estimated the compliance costs for two different size groups within the subcategory: (1) from 100,000 to 475,000 pounds of annual production, and (2) 475,000 pounds or greater of annual production. Table 6-3 summarizes the cost information by size.

Table 6-3
Flow-through Systems:[1] Cost by Annual Production ($2000)

Size	Option	Capital and One Time Cost	Annual O&M	Pre-tax Annualized Costs
100,000 to 475,000 Pounds	1	$558,000	$372,000	$435,000
	2	$652,000	$394,000	$469,000
	3	$1,319,000	$649,000	$805,000
475,000 Pounds and Greater	1	$192,000	$46,000	$70,000
	2	$208,000	$50,000	$76,000
	3	$333,000	$78,000	$120,000

[1] Excluding Alaskan facilities.
Note: Numbers rounded to nearest $1,000.

6.3 COST OF PROPOSED OPTIONS

EPA is proposing the following options:

- Flow-through systems (BPT/BCT/BAT/NSPS)
  - Facilities with less than 100,000 pounds annual production: no regulation
  - Facilities with annual production with 100,000 pounds or more and less than 475,000 pounds: Option 1
  - Facilities with 475,000 pounds and greater annual production: Option 3

- Recirculating systems (BPT/BCT/BAT/NSPS)
  - Facilities with less than 100,000 pounds annual production: no regulation
  - Facilities with 100,000 pounds and greater annual production: Option 3

- Net Pen systems (BPT/BCT/BAT/NSPS)
  - Facilities with less than 100,000 pounds annual production: no regulation
  - Facilities with 100,000 pounds and greater annual production: Option 3

An analysis of potential costs and impacts to CAAP facilities producing less than 100,000 pounds per year is located in Section 8.4.1

Table 6-4 summarizes the pre-tax annualized compliance costs associated with the proposed options based on the screener survey facility counts. The data are divided in terms of commercial and non-commercial groups and annual production category. (Non-commercial facilities include Federal and state hatcheries, Tribal facilities, and academic/research facilities). EPA did not identify any non-commercial facilities with more than 100,000 pounds of annual production in the recirculating and net pen system subcategories. EPA estimates that the total pre-tax annualized compliance costs attributed to the proposed rule are $1.1 million for the facilities in the screener survey data.

Table 6-4

Estimated Pre-Tax Annualized Cost for Proposed Options (Screener Survey Facility Counts)

Subcategory	Owner	Number of Regulated CAAPs	Pre-tax Annualized Cost (Millions, 2000 dollars)
100,000 - 475,000 Pounds Production			
Flow-through	Commercial	31	$0.16
Flow-through	Non-Commercial	57	$0.30
Flow-through	Alaska Non-Profit	15	$0.32
Recirculating	Commercial	5	$0.03
Net Pen	Commercial	0	$0.00
475,000 Pounds Production and Above			
Flow-through	Commercial	9	$0.04
Flow-through	Non-Commercial	6	$0.09
Flow-through	Alaska Non-Profit	2	$0.11
Recirculating	Commercial	3	$0.02
Net Pen	Commercial	8	$0.03
Total		**136**	**$1.10**

Note: Count for Flow-through Non-commercial includes one Alaska state-owned facility.

In order to estimate the **national** pre-tax annualized compliance costs attributed to the proposed rule, EPA multiplied the commercial facilities by a factor of 2.5 (see Section 5.4 and Tetra Tech, 2002). These results are presented in Table 6-5. EPA believes it was able to identify all public facilities in its screener survey mailing list, so these compliance costs did not need to be adjusted. EPA estimates that the total pre-tax annualized compliance costs attributed to the proposed rule are **$1.5 million** for the industry. More than half of the estimated cost ($0.82 million) is projected to be borne by non-commercial and non-profit facilities. Among commercial facilities, those with flow-through systems will incur the greatest share of the cost ($0.49 million annually).

Table 6-5

Estimated Pre-Tax Annualized Cost for Proposed Options

Subcategory	Owner	Number of Regulated CAAPs	Pre-tax Annualized Cost (Millions, 2000 dollars)
100,000 - 475,000 Pounds Production			
Flow-through	Commercial	78	$0.40
Flow-through	Non-Commercial	57	$0.30
Flow-through	Alaska Non-Profit	15	$0.32
Recirculating	Commercial	13	$0.06
Net Pen	Commercial	0	NA
475,000 Pounds Production and Above			
Flow-through	Commercial	23	$0.09
Flow-through	Non-Commercial	6	$0.09
Flow-through	Alaska Non-Profit	2	$0.11
Recirculating	Commercial	8	$0.05
Net Pen	Commercial	20	$0.09
Total		**222**	**$1.51**

Note: Count for Flow-through Non-commercial includes one Alaska state-owned facility.

6.4 COST-REASONABLENESS

EPA compared the removals of the higher of BOD or TSS with the cost of the proposed BPT option for each subcategory. Cost-reasonableness is calculated on the basis of the screener survey facility counts. The results are summarized in Table 6-6 where the $/lb ranges from $0.04/lb for net pen systems to $0.39/lb for flow-through systems producing between 100,000 to 475,000 pounds per year. The industry average for all four regulated subcategories is $0.18/lb.

Table 6-6
Cost-reasonableness of Proposed BPT Options

Subcategory	Annual Production Level (lbs)	Number of Facilities	Removals (lbs, BOD or TSS)	Pre-tax Annualized Costs (2000$)	Cost per Pound Removed ($/lb)
Flow-through	100,000 to 475,000	103	1,974,210	$777,688	$0.39
	>475,000	17	2,476,255	$226,675	$0.09
Recirculating		8	638,365	$45,071	$0.07
Net Pens		8	868,899	$34,345	$0.04
Industry Totals		136	5,957,729	$1,083,779	$0.18

Note: Screener survey facility counts. 18 Alaska facilities include one state-owned facility (the rest are non-profit).

EPA also has calculated the cost-effectiveness of the removal of nutrients for the options considered in today's proposal. As a benchmark for comparison, EPA has estimated that the average cost-effectiveness of nutrient removal by POTWs with biological nutrient removal is $4/lb for nitrogen and $10/lb for phosphorus. Table 6-7 summarizes the nutrient cost-effectiveness by production system for the proposed options. The removals are given for total nitrogen (TN) and total phosphorus (TP) individually and on a combined basis. On the basis of nutrient removal, the proposed options are within the $4/lb benchmark for recirculating and net pen systems, but not for flow-through systems. For flow-through systems, nutrient CE exceeds $10/lb threshold for phosphorus (even looking at the combined TN and TP removals) suggesting that the requirements are not very cost-effective for removing nutrients at flow-through systems.

6.5 REFERENCE

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USDA. 2000. United States Department of Agriculture. National Agricultural Statistics Service. *1998 Census of Aquaculture*. Also cited as 1997 Census of Agriculture. Volume 3, Special Studies, Part 3. AC97-SP-3. February.

Table 6-7
Nutrient Cost-effectiveness of Proposed Options

Subcategory	Pre-tax Annualized Costs (2000$)	Nutrient Removals (lbs)			Cost per Pound Removed ($/lb)		
		TN	TP	TN + TP	TN	TP	TN + TP
Flow-Through	$1,004,363	50,273	15,830	66,103	$19.98	$63.45	$15.19
Recirculating	$45,071	25,090	7,363	32,453	$1.80	$6.12	$1.39
Net Pens	$34,345	74,477	12,413	86,890	$0.46	$2.77	$0.40
Industry Totals	$1,083,779	149,840	35,606	185,446	$7.23	$30.44	$5.84

Note: 18 Alaska facilities include one state-owned facility (the rest are non-profit).

CHAPTER 7

ECONOMIC IMPACT RESULTS

Chapter 7 describes the economic impacts that may result from the costs of complying with the proposed concentrated aquatic animal production industry rule. The impacts are estimated using the revenue test described in Chapter 5 and the compliance costs presented in Chapter 6 of this report. The results are presented for each proposed subcategory. Because EPA projects the costs for new sources to be equal to, or less than, those for existing sources and because limited impacts are projected for these existing sources, EPA does not expect significant economic impacts (or barrier to entry) for new sources. EPA is not proposing standards for indirect dischargers, hence, this Chapter does not include a discussion for PSES and PSNS.

7.1 FLOW-THROUGH SYSTEMS (BPT, BCT, BAT, and NSPS)

7.1.1 BPT and BAT

EPA evaluated the impacts on 181 flow-through systems from the estimated costs of implementing Option 1, 2, or 3. Section 7.1.1.1 contains the discussion for the 164 commercial and non-commercial flow-through facilities in the lower 48 states. The remaining seventeen facilities are non-profit establishments in the state of Alaska; these facilities are discussed in Section 7.1.1.2. Table 7-1 summarizes the findings for commercial and non-commercial ownership and for nonprofit facilities in the state of Alaska.[1]

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[1] Non-commercial facilities include Federal hatcheries, state hatcheries, Tribal facilities, academic/research facilities, and any other nonprofit facilities.

Table 7-1

Flow-through Systems
Facilities Showing Impacts at 3%, 5%, and 10% Revenue Test Thresholds

Size	Number of Facilities	Option 1 3%	Option 1 5%	Option 1 10%	Option Proposed	Option 2 3%	Option 2 5%	Option 2 10%	Option Proposed	Option 3 3%	Option 3 5%	Option 3 10%	Option Proposed
100,000 - 475,000 pounds Annual Production													
Commercial	78	**25**	**8**	**0**	*	25	15	0		35	23	23	
Non-Commercial[1]	57	**0**	**0**	**0**	*	0	0	0		4	0	0	
Alaska Nonprofit	15	**0**	**0**	**0**	*	0	0	0		0	0	0	
Greater than 475,000 pounds Annual Production													
Commercial	23	0	0	0		0	0	0		**0**	**0**	**0**	*
Non-Commercial	6	0	0	0		0	0	0		**0**	**0**	**0**	*
Alaska Nonprofit	2	0	0	0		0	0	0		**1**	**0**	**0**	*
Total	181	25	8	0		25	15	0		40	23	23	

[1] EPA found one state-owned hatchery in Alaska produces between 100,000 and 475,000 pounds annually. Impacts to this facility were tabulated with other non-commercial facilities in this table.

7.1.1.1 Non-Alaskan Facilities

Of the 164 non-Alaskan facilities identified through the screener survey, 135 produce between 100,000 and 475,000 pounds per year (78 commercial and 57 non-commercial) and 29 facilities produce more than 475,000 pounds annually (23 commercial, six non-commercial).

For facilities with annual production ranging from 100,000 to 475,000 pounds, the largest impacts are expected to be incurred by commercial facilities. For non-commercial facilities, only four of 57 facilities (about 7 percent) incur costs exceeding three percent of revenues for the most stringent option, Option 3. The results indicate that non-commercial facilities are unlikely to incur compliance costs that exceed three percent of revenues for Option 1 or Option 2. In contrast, nearly half of the commercial facilities are expected to incur costs exceeding three percent of revenues under Option 3 (35 of 78 facilities). About one-third of the commercial facilities show impacts at the three-percent-of-revenues threshold for both Option 1 and Option 2 (25 of 78 facilities). However, the number of commercial facilities incurring costs in excess of five percent of revenues drops from 15 under Option 2 to eight under Option 1. (No facility incurs costs in excess of 10 percent of revenues under Option 1 or Option 2.) EPA is proposing Option 1 for flow-through facilities with annual production between 100,000 pounds and 475,000 pounds.

The effects of economies of scale in the costing models are evident for facilities with production of 475,000 pounds or more per year. The results indicate that these facilities are not likely to incur impacts at the three-percent threshold even under the most stringent option, Option 3. EPA is proposing Option 3 for flow-through facilities with an annual production of 475,000 pounds or greater.

7.1.1.2 Alaskan Facilities

EPA used information provided by the state on production and revenues to evaluate impacts on nonprofit facilities in the state of Alaska. Production level was used to determine those facilities within scope of the proposed rule and to estimate facility-level compliance costs. EPA identified 15 nonprofit

Alaskan facilities that produce between 100,000 pounds and 475,000 pounds annually, and two nonprofit facilities that produce more than 475,000 pounds annually.[2]

Alaskan facilities perform ocean ranching where salmon smolts are released to the ocean. The members of the nonprofit corporation are allowed to harvest adult fish that return to that region. These are reported as operator revenues. In addition, nonprofit hatcheries may allow region permit holders to vote for a self-imposed "enhancement tax" on the value of fish caught in that region (i.e., by member and non-member fishermen). EPA used the sum of operator-reported revenues and the enhancement tax (where applicable) income as the revenues against which compliance cost impacts are measured. Revenues and enhancement tax income are reported at the level of the nonprofit association, which may own more than one hatchery. EPA estimated facility level revenues based on the facility's percentage of total association production. The 17 nonprofit facilities that exceed 100,000 pounds in annual production are owned by nine associations.

The projected impacts on the 17 Alaskan nonprofit facilities are reported in Table 7-1. No facilities with annual production ranging from 100,000 to 475,000 pounds are expected to incur costs exceeding three percent of revenues. One facility with annual production in excess of 475,000 pounds is projected to incur costs exceeding the three percent threshold under Option 3.

7.1.2 BCT

EPA's methodology for evaluating candidate BCT technologies is discussed in Section 5.3 of this report. EPA is establishing BPT limitations for flow-through facilities with an annual production of 100,000 pounds. A BCT test can be performed for the category with 100,000 to 475,000 in annual production. (EPA is proposing the most stringent option for facilities with 475,000 and greater in annual production. Hence, there is no more stringent option to be considered for BCT for this group.) For purposes of this analysis, EPA is assuming that the proposed BPT limits are the baseline. Thus, EPA is considering only Options 2 and 3 as BCT candidate options.

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[2] In addition, EPA found one state-owned hatchery in Alaska produces between 100,000 and 475,000 pounds annually. Impacts to this facility were tabulated with other non-commercial facilities in Table 7-1.

Table 7-2 presents the calculations for the BCT cost test. The cost per pound to upgrade from secondary to advanced secondary treatment is less than $0.65 for Option 3, so Option 3 passes the first of the two-part test. However, the cost per pound to go from raw wastewater to BPT is $0.20; therefore, the ratio of the cost per pound to go from BPT to BCT divided by the cost per pound to go from raw wastewater to BPT for the industry is 2.08 and Option 3 fails the second part of the test. Based on these results, EPA is proposing that BCT be set equal to BPT.

Table 7-2
POTW Cost Test Calculations for Flow-through Systems
(100,000-475,000 Pounds in Annual Production)

Option	Incremental Conventional Pollutants Removed (lbs.)	Incremental Pre-tax Total Annualized Costs (Millions, 2000$)	Ratio of Costs to Removals (POTW Test)	Pass POTW Test?	BPT-BCT Raw-BPT Ratio (Industry Test)	Pass Industry Test?
2	0	$0.03	undefined	no	NA	NA
3	874,136	$0.37	0.42	yes	2.08	no

7.1.3 NSPS

EPA is proposing new source performance standards that are identical to those proposed for existing dischargers that meet the 100,000 pound production threshold. Thus, new facilities with annual production ranging from 100,000 to 475,000 pounds will be required to meet Option 1 standards, and new facilities with annual production in excess 475,000 pounds will be required to meet Option 3 standards. Engineering analysis indicates that the cost of installing pollution control systems during new construction is no more expensive than the cost of retrofitting existing facilities and is frequently less expensive than the retrofit cost. Because EPA projects the costs for new sources to be equal to or less than those for existing sources and because limited impacts are projected for these existing sources, EPA does not expect significant economic impacts (or barrier to entry) for new sources that meet the 100,000 pound production threshold.

7.2 RECIRCULATING SYSTEMS (BPT, BCT, BAT, and NSPS)

EPA evaluated impacts on 21 recirculating systems, all of which are commercial and have annual production in excess of 100,000 pounds. EPA found 13 facilities with annual production ranging from 100,000 to 475,000 pounds, and eight facilities with annual production in excess of 475,000 pounds. No recirculating facilities are projected to incur costs exceeding three percent of revenues under any option. EPA is proposing Option 3 for recirculating facilities with production of 100,000 pounds per year or greater for BPT.

EPA is proposing the most stringent option for facilities with recirculating systems. Hence, there is no more stringent option to be considered for BCT, so BCT is set equal to BPT. The technology options EPA considered for BAT are identical to those it considered for BPT. Because EPA projects limited economic impacts associated with the BPT requirements, EPA does not expect significant economic impacts for BAT. Because EPA projects the costs for new sources to be equal to or less than those for existing sources and because limited impacts are projected for these existing sources, EPA does not expect significant economic impacts (or barrier to entry) for new sources that meet the 100,000 pound production threshold.

7.3 NET PEN SYSTEMS (BPT, BCT, BAT, and NSPS)

EPA evaluated impacts on 20 facilities with net pen systems, all of which are commercial and have annual production in excess of 475,000 pounds. None of the facilities shows impacts under the most stringent combination of technologies and thresholds, i.e., 3 percent with Option 3. EPA is proposing Option 3 for net pen facilities as BPT.

EPA is proposing the most stringent option for facilities with net pen systems. Hence, there is no more stringent option to be considered for BCT, so BCT is set equal to BPT. The technology options

EPA considered for BAT are identical to those it considered for BPT for existing dischargers. Because EPA projects limited economic impacts associated with the BPT requirements, EPA does not expect significant economic impacts for BAT. Because EPA projects the costs for new sources to be equal to or less than those for existing sources and because limited impacts are projected for these existing sources, EPA does not expect significant economic impacts (or barrier to entry) for new sources that meet the 100,000 pound production threshold.

7.4 OTHER ECONOMIC IMPACTS

7.4.1 Firm-Level Impacts

For the final rule, EPA intends to conduct an analysis of firm-level impacts with the detailed survey data. No firm-level analysis is possible at this time due to data constraints that arise from the predominance of privately-held (i.e. firm not required to file financial information with the Securities and Exchange Commission) and foreign-held firms. The salmon industry, for example, is predominantly foreign-held. Due to differences in accounting standards, EPA does not routinely consider foreign firms in its financial analysis. EPA also intends to examine the potential cumulative impacts on non-commercial concentrated aquatic animal production facilities, such as state and Federal hatcheries, using information collected in the detailed survey.

7.4.2 Community-level Impacts

EPA did not identify any data source with detailed employment information for the aquatic animal production industry. Given that the scope of the proposed regulation is focused on a limited number of larger facilities, EPA believes that is not likely to cause severe community impacts. EPA intends to examine community-level impacts based on detailed survey data.

7.4.3 Foreign Trade Impacts

EPA believes that proposed regulations will have little, if any, impact on foreign trade. Several species, including striped bass, tilapia, trout, and salmon, face significant foreign competition. However, no facilities in the striped bass sector are expected to incur compliance costs that exceed the 1 percent revenue threshold, and no tilapia or salmon facilities are expected to incur compliance costs that exceed the 3 percent revenue threshold. EPA used its regulatory flexibility and proposed different options for different levels of production for the system most commonly used to raise trout (i.e., flow-through) to mitigate potential adverse impacts.

CHAPTER 8

SMALL BUSINESS FLEXIBILITY ANALYSIS

8.1 INTRODUCTION

This chapter analyzes the projected effects of incremental pollution control costs on small entities. This analysis is required by the Regulatory Flexibility Act (RFA) as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (SBREFA). The RFA acknowledges that small entities have limited resources and makes it the responsibility of the regulating federal agency to avoid burdening such entities unnecessarily. If, based on an initial assessment, a regulation is likely to have a significant economic impact on a substantial number of small entities, the RFA requires a regulatory flexibility analysis.

EPA has determined that the proposed rule will not have a significant economic impact on a substantial number of small entities. Despite this determination, EPA prepared a small business flexibility analysis that examines the impact of the proposed rule on small entities along with regulatory alternatives that could reduce that impact. This small business flexibility analysis would meet the requirements for an initial regulatory flexibility analysis (IRFA) and is summarized below.

The Chapter is organized as follows: Section 8.2 provides EPA's initial assessment; Section 8.3 describes the components of the small business flexibility analysis; Section 8.4 presents the analysis of economic impacts to small entities in the concentrated aquatic animal production (CAAP) industry; and Section 8.5 summarizes the steps EPA has taken to minimize the impacts to small entities under the proposed rule.

8.2 INITIAL ASSESSMENT

EPA guidance on implementing RFA requirements suggests the following must be addressed in an initial assessment. First, EPA must indicate whether the proposal is a rule subject to notice-and-comment rulemaking requirements. EPA has determined that the proposed concentrated aquatic animal production effluent limitations guidelines (ELG) are subject to notice-and-comment rulemaking requirements.

Second, EPA should develop a profile of the affected small entities. EPA has developed a profile of the AAP industry that covers all affected operations, including small entities. The industry profile information is provided in Chapter 2 of this report, while Chapter 7 presents the projected economic impacts to the industry. Much of the discussion in these two chapters applies to small businesses. Additional information on small businesses in the AAP industry is also provided below in Sections 8.3 and 8.4.

Third, EPA's assessment needs to determine whether the rule would affect small entities and whether the rule would have an adverse economic impact on small entities. EPA has determined that some small entities may incur incremental compliance costs as a result of the rule, if promulgated as proposed. EPA examines the impacts of these compliance costs in Section 8.4.

8.3 SMALL BUSINESS FLEXIBILITY ANALYSIS COMPONENTS

Section 603 of the RFA requires that an IRFA must contain the following:

- An explanation of why the rule may be needed.
- A short explanation of the objectives and legal basis for the proposed rule.
- A description of, and where feasible, an estimate of the number of small business entities to which the proposed rule will apply.
- A description of the proposed reporting, recordkeeping, and other compliance requirements (including estimates of the types of small entities that will be subject to the requirement and the type of professional skills necessary for the preparation of the report or record).
- An identification, to the extent practicable, of all relevant federal rules that may duplicate, overlap, or conflict with the proposed rule.

- A description of "any significant regulatory alternatives" to the proposed rule that accomplish the statement objectives of the applicable statutes and minimize any significant economic impact of the rule on small entities.

Each of these issues are addressed in the following subsections.

8.3.1 Need for Objectives of the Rule

The Agency is considering this action because the operation of CAAP facilities may introduce a variety of pollutants into receiving waters. Under some conditions, these pollutants can be harmful to the environment. According to the 1998 USDA Census of Aquaculture (USDA, 2000), there are approximately 4,200 commercial aquatic animal production (AAP) facilities in the United States that might qualify as a small business. Aquaculture has been among the fastest-growing sectors of agriculture until a recent slowdown that began several years ago caused by declining or level growth among producers of several major species. EPA analysis indicates that many CAAP facilities have treatment technologies in place that greatly reduce pollutant loads. However, in the absence of treatment, pollutant loads from individual CAAP facilities such as those covered by the proposed rule, can contribute up to several thousand pounds of nitrogen and phosphorus per year, and tens to hundreds of thousands of pounds of TSS per year. These pollutants can contribute to eutrophication and other aquatic ecosystem responses to excess nutrient loads and BOD effects. In recent years, Illinois, Louisiana, North Carolina, New Hampshire, New Mexico, Ohio and Virginia have cited the AAP industry as a potential or contributing source of impairment to water bodies (EPA, 2000). Several state authorities have set water quality based permit requirements for CAAP facilities in addition to technology based limits based on best professional judgement (EPA, 2002a).

Another area of potential concern relates to non-native species introductions from CAAP facilities, which may pose risks to native fishery resources and wild native aquatic species from the establishment of escaped individuals (Hallerman and Kapuscinski, 1992; Carlton, 2001; Volpe et al., 2000). CAAP facilities also employ a range of drugs and chemicals used therapeutically that may be released into receiving waters. For some investigational drugs, as well as for certain application of approved drugs, there is a concern that further information is needed to fully evaluate risks to ecosystems and human health associated with their use in some situations (EPA, 2002b). Finally, CAAP facilities also may inadvertantly introduce pathogens into receiving waters, with potential impacts on native biota. The proposed rule attempts of address a number of these concerns. These regulations are proposed under the authority of Section 301, 304, 306, 308, 402, and 501 of the Clean Water Act, 33 U.S.C.1311, 1314, 1316, 1318, 1342, and 1361.

8.3.2 Small Entity Identification

The RFA/SBREFA defines several types of small entities, including:

- Small governments,
- Small organizations, and
- Small businesses.

These are described in Sections 8.3.2.1 through 8.3.2.3, respectively.

8.3.2.1 Small Governments

The RFA/SBREFA defines "small governmental jurisdiction" as the government of a city, county, town, school district, or special district with a population of less than 50,000. For the purposes of the RFA, States and tribal governmental are not considered small governments but rather as independent sovereigns (EPA, 1999).[1] Federal facilities, regardless of their production levels, are not part of small governments.

[1] See Section 11.2 where impacts on these entities are analyzed in accordance with Unfunded Mandates Reform Act requirements.

8.3.2.2 Small Organizations

The RFA/SBREFA defines "small organization" as any not-for-profit enterprise that is independently owned and operated and is not dominant in its field. For the purpose of this rulemaking, EPA considers many of the non-profit organizations that produce salmon for the State of Alaska to be "small." These non-profit facilities have assumed what is usually a State function, which is to raise fish (in this case salmon) in hatcheries to be released into the wild to supplement wild populations, and sustain the Alaska commercial and recreational fishing industries.

8.3.2.3 Small Businesses

The Small Business Administration (SBA) sets size standards to define whether a business entity is small and publishes these standards in 13 CFR 121. The standards are based either on the number of employees or annual receipts. Table 8-1 lists the North America Industry Classification System (NAICS) codes potentially in scope of the proposed rule and their associated SBA size standards as of January 1, 2002 (SBA, 2000 and SBA, 2001).

Table 8-1
Small Business Size Standards

NAICS Code	Description	Size Standard (Annual Revenues)
112511	Finfish Farming and Fish Hatcheries	$0.75 million
112512	Shellfish Farming	$0.75 million
112519	Other Animal Aquaculture	$0.75 million

When making classification determinations, SBA counts receipts or employees of the entity and all of its domestic and foreign affiliates (13 CFR.121.103(a)(4)). SBA considers affiliations to include:

- stock ownership or control of 50 percent or more of the voting stock or a block of stock that affords control because it is large compared to other outstanding blocks of stock (13 CFR 121.103(c)).

- common management (13 CFR 121.103(e)).

- joint ventures (13 CFR 121.103(f)).

EPA interprets this information as follows:

- Sites with foreign ownership are not small (regardless of the number of employees or receipts at the domestic site).

- The definition of small is set at the highest level in the corporate hierarchy and includes all employees or receipts from all members of that hierarchy.

- If any one of a joint venture's affiliates is large, the venture cannot be classified as small.

EPA's estimate of the number of small entities in the AAP industry is presented in Section 8.3.5 below.

8.3.3 Description of the Proposed Reporting, Recordkeeping, and Other Compliance Requirements

In the proposed rule, flow-through and recirculating facilities would be subject to compliance with numeric limitations; however, EPA proposes to provide an alternative compliance provision that would allow facilities to develop and implement a BMP plan to control solids provided that the permitting authority determines the plan will achieve the numeric limitations. Also flow-through facilities that segregate the bulk discharge from off-line settling discharge would develop and implement the solids control BMP plan. Larger flow-through facilities and all recirculating and net pen facilities within the scope of the proposed rule would also develop a BMP plan to address mortalities, non-native species, and drugs and chemicals storage. These facilities would also be required to report to the permitting authority whenever an investigational new animal drug is used or drug or chemical is used for a purpose that is not in accordance with its label requirements.

EPA estimates that each plan will require 40 hours per facility to develop the plan. The plan will be effective for the term of the permit (5 years). An additional two hours per month (comprised of l hour of a manager's time and 1 hour of a laborer's time) or 24 hours per year are assumed to be required for implementation. EPA does not believe that the development and implementation of these BMPs will require any special skills. All of the CAAP facilities within the proposed scope should currently be permitted, so incremental administrative costs of the regulation are negligible. However, Federal and State permitting authorities will incur a burden for tasks such as reviewing and certifying the BMP plan and reports on the use of drugs and chemicals. EPA estimated these costs at approximately $10,011 for the three-year period covered by the information collection request (EPA, 2002, Table 9) or roughly $3,337 per year.

8.3.4 Identification of Relevant Federal Rules That May Duplicate, Overlap, or Conflict with the Proposed Rule

EPA identified Federal rules that have an impact on the CAAP industry and believes that there are no such rules that would duplicate, overlap or conflict with the proposed rule. EPA has identified two sets of Federal rules, however, the implementation of which would be supplemented by the proposed rule requirements – specifically, the reporting requirements proposed for certain drugs and chemicals. The proposed rule requires reporting of investigational new animal drugs and any drug that is not used according to label requirements. Regulations administered by the Food and Drug Administration published at 21 CFR Part 511 impose restrictions on such usage, but typically do not require reporting of the usage after discharge to waters of the United States. Similarly, the proposed rule requires reporting of the usage (and discharge) of chemicals when such usage does not comply with label requirements. Some such chemicals would be pesticides subject to regulatory requirements under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), which is administered by EPA. EPA has not published FIFRA requirements to require the reporting proposed in the rule for CAAP facilities.

8.3.5 Significant Regulatory Alternatives

EPA took steps to minimize the regulatory burden associated with the rulemaking. EPA reviewed effluent characteristics from the aquatic animal production industry and determined that several sectors were not within the scope of the rule (see Development Document for more details as well as Section 6.1.1 of this report). EPA is not proposing regulations for discharges from:

- closed ponds,
- lobster pounds,
- alligator pens,
- crawfish facilities,
- molluskan shellfish production in open waters,
- aquariums.

In addition, EPA proposed an annual production threshold of 100,000 pounds before a facility is in the scope of the regulation. The number of facilities to which the proposed rule would apply after excluding: (1) ponds, lobster pounds, alligator pens, crawfish, molluskan shellfish production in open waters, and aquariums, and (2) facilities with annual production of less than 100,000 pounds, is estimated in sections 8.3.5.1 and 8.3.5.2 below.

8.3.5.1 Evaluation of the Number of Small Entities Based on Publicly Available Data

8.3.5.1.1 Small Facilities

Prior to receipt of the screener survey data, EPA's primary data source for an upper bound estimate of the number of small entities in the AAP industry was the Census (USDA, 2000). The reasons why the USDA data provide an "upper bound" estimate include:

- The aquaculture revenues for a site might be underestimated when costs are evaluated on a species-by-species basis. EPA developed cost models for various production system/species combinations. The USDA data are given by species and revenue category. When USDA presents the data on an industry basis, it identifies 4,028 sites with aquatic animal production. When the data are presented on a species basis, the counts sum to 4,789 sites. This indicates that as many as 761 sites raise more than one species (compare Table 2-8 and Table 2-9 in the industry profile). EPA therefore loses any economies of scale that might occur when treating effluents from multiple species on a combined basis. EPA's cost estimates might be an overestimate and, if the revenues against which the costs are compared are based only one species, the facility revenues might be an underestimate.

- Total site revenues might be underestimated. The Census data report only aquatic animal production revenues, not revenues from all agricultural products produced at that site (whether it is a farm, facility, or single-facility company).

- The USDA revenue data are on an individual site basis while the SBA small business definitions are based on total company revenues. An individual facility can have revenues less than the SBA size standard while the total company revenues may or may not exceed the size standard depending on the revenues from the other facilities owned by the company. For example, a company in NAICS code 112511 (finfish farming) that owns eight facilities, each with $100,000 in annual revenues, would exceed the size standard and hence would not be classified as a small business.

EPA is aware that classifying operations as "small" solely on the basis of aquaculture revenues at individual facilities will likely overestimate the number of small entities, and intends to conduct a company level analysis using the detailed survey data for final promulgation.

While a small facility might be part of a large company, the inverse is not possible. If the revenues from a single species at a single site exceed that SBA standard for a small business, that site must belong to a large company. EPA requested a special tabulation of the USDA *Census of Aquaculture* data (USDA, 2002).[2] The special tabulation provides information for a new revenue catergory that corresponds to the SBA size standard for a small AAP business. EPA used the special tabulation data to examine the distribution of aquatic animal operations by revenue and species and to estimate the number of small entities in the industry. USDA data identify a minimum of 261 aquatic animal production facilities that are not small, implying that as much as 94 percent of the total AAP facilities might be considered small. On the basis of this estimate, EPA initiated the SBAR process.

[2]EPA requested data for alligators, baitfish, carp, catfish, crawfish, frogs, mollusks, ornamentals, perch, salmon, shrimp, sport fish, striped bass, tilapia, trout, turtles, and walleye. USDA provided as much data as possible without compromising confidentiality. The observations for each species matched the total count presented in Table 2 of the Census. The special tabulation reflected 4,489 observations.

8.3.5.1.2 Summary

The Census (USDA, 2000) identified approximately 4,800 facility/species combinations. Specifically, it identified 4,028 facilities with aquaculture activities, while the facility counts by species sum to 4,789 facilities. In approximate terms, EPA proposed to exclude catfish (1,370 operations), baitfish (275 operations), ornamental fish (345 operations), crawfish (563 operations), molluskan shellfish (535 operations) in addition to the 20 farms that raise algae and other sea vegetables – or a total of 3,108 operations. In other words, EPA proposed to exclude approximately 65 percent of the aquatic animal production operations from the scope of the regulation based on technical reasons.

An alternative approach is to estimate the number of facilities with production systems for which EPA is proposing guidelines and standards (i.e., flow-through systems, recirculating systems, and net pens systems). A coarse measure of the size of the regulated community might be to assume that the count for trout, salmon, and other food fish operations given in the Census represent an approximation of the number of these production systems (996 farms).

EPA also proposed an annual production threshold of 100,000 pounds before a facility is in the scope of the proposed regulation. This would exempt approximately 453 of the 561 trout operations and about 319 of the 435 food fish operations listed Table 2 of the Cenus (USDA, 2000). This results in a regulated community of about 224 operations. Even though this is only 224 out of 4,789 – or about five percent of the aquatic animal production industry – this count might still be an over estimate if any of the trout and food fish production facilities use pond systems for production. The number of small facilities, then, is some fraction of the 224 facilities that are within the regulated community yet have revenues of $750,000 or less. Because the Census data do not cross reference production systems by revenue and species, EPA cannot provide a better estimate of the number of small facilities, except to say that it is a small fraction of the original industry.

8.3.5.2 EPA Screener Survey Data

Table 8-2 summarizes facility counts based on the screener survey data and information submitted by the state of Alaska. EPA identified a universe of almost 1,500 aquatic animal production facilities. About 1,000 of these are potentially small commercial facilities (i.e., earn less than $750,000 per year in revenues). Many of the remaining 500 facilities produce less than 475,000 pounds per year and/or earn less than $750,000 per year in revenues, but are not small businesses based on other criteria (e.g., federal or state ownership).

Table 8-2
Estimated Number of Facilities

Description	Number of Facilities					
	All Facilities			Small Facilities		
	Screener	Alaska	Sum	Screener (Commercial)	Alaska	Sum
Universe	1,446	31	1,477	973	26 [1]	999
Meeting definition of a CAAPF	600	25	625	318	16 [2]	334
Annual production in excess of 100,000 pounds	118	18	136	36	12 [3]	48

Source: Tetra Tech e-mail, 29 May 2002.
[1] Excludes two State and three Federal/Tribal facilities.
[2] Six facilities have less than 20,000 pounds in annual production. Five facilities that belong to a large nonprofit organization are counted as a single entity.
[3] Eighteen facilities with 100,000 pounds or more in annual production minus one State facility and five facilities that belong to a large nonprofit organization.

Table 8-2 indicates that the community considered for regulation is about 9 percent of the original universe of AAP operations (i.e., 136 of 1,477 facilities). The number of small facilities within the proposed regulated community, however, is only about 5 percent of the original universe of small entities (i.e., 48 of 999 facilities). EPA identified 48 small facilities (including 36 commercial facilities and 12 Alaskan facilities). An additional 81 commercial facilities earn less than $750,000 per year, and are thus considered small, but are not within the proposed scope (i.e., they produce less than 100,000 pounds per year).

8.4 POTENTIAL IMPACTS FROM PROMULGATED RULE ON SMALL ENTITIES

EPA examined potential impacts on all facilities that earn less than $750,000 per year before concluding that it would not regulate facilities with annual production ranging from 20,000 to 100,000 pounds. Section 8.4.1 presents EPA's impact analysis on facilities that fall within this production range. Section 8.4.2 and 8.4.3 present projected impacts small facilities in the regulated community.

8.4.1 Small Facilities with 20,000 to 100,000 Pounds Annual Production

EPA identified 81 commercial and 78 non-commercial flow through facilities, as well as one non-commercial recirculating facility in the screener data, that: (1) earn less than $750,000 per year, and (2) whose annual production is more than 20,000 but less than 100,000 pounds. Table 8-3 summarizes EPA's analysis of these facilities.

EPA examined a lower cost option for facilities in the 20,000 to 100,000 pounds of annual production range based on the BMP plan. Total annualized compliance costs for these 160 facilities total $208,000 under the BMP Option. Even with these relatively minimal requirements, 85 percent of commercial flow through facilities (69 of 81) and 49 percent of all facilities (78 of 160) exceed the 1 percent threshold. Furthermore, 32 percent of all facilities (51 of 160) are projected to incur costs exceeding 3 percent of revenues. Based on these results, EPA is not proposing any guidelines and limitations for facilities with 20,000 to 100,000 pounds of annual production.

Table 8-3
Facilities with 20,000 - 100,000 Pounds Annual Production
Estimated Compliance Costs and Facilities Showing Impacts at 1% and 3% Revenue Test Thresholds

Subcategory	Number of Facilities	BMP Option		
		Total Annualized Compliance Costs ($2000)	Revenue Test Threshold	
			1%	3%
Flow Through Commercial	81	$102,743	69	45
Flow Through Non-Commercial	78	$104,087	8	6
Recirculating Non-Commercial	1	$1,424	1	0
Total	160	$208,254	78	51

8.4.2 Small Commercial Facilities

EPA identified 36 small facilities with (1) flow-through or recirculating systems, (2) annual production above 100,000 pounds, and (3) annual revenues at or below $750,000.[3] Of these, approximately 17 (which represents 5 percent of the total small CAAPs or 47 percent of the small CAAPs within the scope of the proposed rule) incur compliance costs greater than 1 percent of aquaculture revenue and 10 small commercial entities (which represents less than 3 percent of the total small CAAPs or 28 percent of the small CAAPs within the scope of the proposed rule) incur compliance costs greater than 3 percent. For commercial facilities, EPA assumed that the facility is equivalent to the business, an assumption that will be re-examined when detailed survey data is available.

[3]As noted in Section 8.2.3, small facilities might belong to large companies. Given the predominance of foreign-ownership of salmon aquaculture and the dominance of a single firm in trout aquaculture, there is a good probability of small facilities belonging to large firms, but EPA will need to have the detailed questionnaire data to conduct further evaluations.

8.4.3 Nonprofit Organizations

EPA estimates that 17 Alaskan facilities within scope of the proposed rulemaking meet the definition of a small nonprofit organization. EPA guidance recommends a test for nonprofit organizations that calculates annualized compliance costs as a percentage of total operating expenditures (EPA, 1999). EPA used the sum of operator-reported revenues and enhancement tax revenues as a proxy for total operating expenditures.

For commercial facilities, EPA assumed that the facility is equivalent to the business, an assumption that will be re-examined when detailed survey data is available. However, because sufficient data is available to determine the parent nonprofit association (and its revenues) for the small Alaskan nonprofit facilities, EPA analyzed small entity impacts at the level of the parent association. EPA determined that 12 small Alaskan nonprofit facilities within scope of the proposed rule are owned by 8 small nonprofit associations. Of the 6 small Alaskan nonprofit associations for which EPA had data, 3 associations incur compliance costs greater than 1 percent of revenues and 1 association incurs compliance costs greater than 3 percent.

8.5 REGULATORY FLEXIBILITY ANALYSIS

EPA has chosen to minimize economic impacts to small business establishments in the aquatic animal production industry by tailoring its proposed guidelines to differences in species, production systems, and facility size. Specifically, EPA is :

- not proposing regulations for discharges from: ponds, lobster pounds, alligator pens, crawfish operations, molluskan shellfish production in open waters, or aquariums;
- proposing to exclude facilities that produce less than 100,000 pounds of aquatic animals per year;
- proposing to set less stringent guidelines (Option 1 instead of Option 3) for facilities that produce more than 100,000 pounds, but less than 475,000 pounds of aquatic animals per year in flow through production systems.

Furthermore, EPA finds that 17 small commercial facilities, and three small nonprofit associations are expected to incur costs exceeding 1 percent of revenues. EPA intends to make its final determination of the impact of the aquatic animal production rulemaking on small businesses based on analyses of the detailed survey data. At this time, the Agency sees no basis for finding that the regulation would impose a significant impact on a substantial number of small entities, specifically, based on restrictions in the scope of the proposed rule as well as the estimates of (low) costs of compliance.

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CHAPTER 9

ENVIRONMENTAL IMPACTS OF THE AAP INDUSTRY IN THE UNITED STATES

9.1 INTRODUCTION

Concentrated aquatic animal production (CAAP) facilities produce a variety of waste products that are discharged to receiving waters. CAAP facilities, such as those covered by the proposed rule, add nutrients and solid loadings to receiving waters. In the absence of treatment, pollutant loadings from individual CAAP facilities can contribute up to several thousand pounds of nitrogen and phosphorus per year and up to several million pounds of total suspended solids (TSS) per year. Water quality concerns related to these pollutant loadings are among several environmental concerns associated with the CAAP industry. CAAP facilities may also be associated with risks to native fishery resources and wild native aquatic species from the establishment of escaped individuals. Several chemicals and therapeutic drugs are used by the CAAP industry and can be released into receiving waters. CAAP facilities can also be associated with the introduction of pathogens into receiving waters with potential impacts on native biota. This chapter summarizes background information on these environmental concerns.

9.2 WATER QUALITY IMPACTS FROM NUTRIENTS AND SOLIDS

The nutrient (nitrogen and phosphorus) and organic solids generated by CAAP facilities and contained in their effluents have the potential to contribute to eutrophication (e.g., NOAA, 1999). Eutrophication can be defined as an increase in the rate of supply of organic matter in an ecosystem (NSTC, 2000). The increase in organic matter can be caused either by increased inputs from sources outside of the ecosystem (e.g., CAAP effluents, agricultural runoff, or industrial effluents) or by enhanced organic matter production within the ecosystem caused by increased nutrient inputs to the system. Eutrophication can lead to many water resource and aquatic ecosystem effects. Consequences of eutrophication have long been a concern in the protection and development of water resources and include algal blooms, increased turbidity, low dissolved oxygen and associated stresses to stream biota, increased water treatment requirements, changes in benthic fauna, and stimulation of harmful microbial activity with potential consequences for human health (e.g., Dunne and Leopold, 1978, Wetzel, 1983).

Ammonia, which is a form of the nutrient nitrogen, can also be directly toxic to aquatic life, affecting hatching and growth rates of fish. It can also cause changes in the tissues of the liver, kidneys, and gills during structural development (Murphy, 2000a). When un-ionized levels of ammonia exceed 0.0125 - 0.025 mg/L, growth rates of rainbow trout are reduced and damage to liver, kidney, and gill tissue may occur (IDEQ, n.d.).

Solids (both suspended and settleable) can degrade aquatic ecosystems through multiple mechanisms. Suspended solids can increase turbidity and reduce the depth to which sunlight can penetrate, which decreases photosynthetic activity and oxygen production by plants and phytoplankton and potentially causes plant death and oxygen depletion associated with organic matter decomposition. Decreased growth of aquatic plants also affects a variety of aquatic life, which use the plants as habitat. Increased suspended solids can also increase the temperature of surface waters by absorbing heat from sunlight. Suspended particles can also abrade and damage fish gills, increasing the risk of infection and disease. Increased levels of suspended solids can also cause a shift toward more sediment tolerant species, reduce filtering efficiency for zooplankton in lakes and estuaries, carry nutrients and metals, adversely impact aquatic insects that are at the base of the food chain, (Schueler and Holland, 2000), and reduce fish growth rates (Murphy, 2000b). Suspended particles reduce visibility for sight feeders and disrupt migration by interfering with a fish's ability to navigate using chemical signals (USEPA, 2000a). As sediment settles, it can smother fish eggs and bottom-dwelling organisms, interrupt the reproduction of aquatic species, destroy habitat for benthic organisms (USEPA, 2000a) and fish spawning areas, and contribute to the decline of freshwater mussels and sensitive or threatened darters and dace. Deposited sediments also increase sediment oxygen demand, which can deplete dissolved oxygen in lakes or streams (Schueler and Holland, 2000).

A number of studies have quantified relationships between solid loadings and specific biological endpoints. These include studies relating suspended solids or turbidity levels to stream macroinvertebrate and invertebrate abundance and diversity (Gammon, 1970; Quinn et al., 1992) and reduced growth rates of stream invertebrates (Herbert and Richards, 1963; Buck, 1956). Turbidity and suspended solids have also been associated with reduced food consumption by certain life-stages of such species as striped bass (Brietburg, 1988); coho salmon (Gregory and Northcote, 1993; Redding, 1987); and cutthroat trout (European Inland Fisheries Advisory Council, 1964).

The following subsections describe general characteristics of each major production system that affect the potential of CAAP facilities to discharge nutrients and solids to receiving waters. Descriptions for ponds, crawfish production, lobster pounds, bottom and off-bottom shellfish culture, aquariums, and alligator production systems are not included because they are not subject to the proposed rule.

Flow-Through Systems[1]

Flow-through systems consist of raceways, ponds, or tanks that have constant flows of water through them. Flowing water in the systems is used to maintain water quality in the production system by carrying away accumulating waste products, including feces, uneaten feed, and other metabolic wastes. Discharges from flow-through systems tend to be large in volume and continuous.

Raceway systems typically have quiescent zones located at the tail ends of the raceways to collect solids. The flowing water and swimming fish help move solids down through the raceway. The quiescent zones allow solids to settle in an area of the raceway that is screened off from the swimming fish. The settled solids are then regularly removed from the quiescent zone by vacuuming. Designs, which include baffles or other solids-flushing enhancements, help move solids to the quiescent zones without breaking them into smaller particles. Some systems, typically smaller raceway systems, use full-flow settling in which all of the effluent passes through prior to discharge. Tanks can be self-cleaning or use concentrating devices to collect solids, enabling solids to be efficiently removed from the system. Most facilities treat the collected solids in settling basins or some other type of dewatering process. When solids in tanks or raceways are collected and removed, waste streams from the treatment systems are usually higher in pollutant concentrations, including solids, nutrients, and biochemical oxygen demand than bulk flow discharges.

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[1] Information for the following four subsections was adapted from J. Avault, *Fundamentals of Aquaculture* (AVA Publishing, Baton Rouge, Louisiana, 1996).

Recirculating Systems

Recirculating systems are highly intensive culture systems that actively filter and reuse water many times before it is discharged. Recirculating systems usually have tanks or raceways to hold the growing animals, and they have extensive filtration and support equipment to maintain adequate water quality. Recirculating systems use filtration equipment to remove ammonia from the production water. Solids removal, oxygenation, temperature control, pH management, carbon dioxide control, and disinfection are common water treatment processes used in recirculating systems. The size of the recirculating system depends primarily on available capital to fund the project and can be designed to meet the production goals of the operator.

The production water treatment process is designed to minimize water requirements, which leads to small-volume, concentrated waste streams. A typical recirculating facility has one or more discrete waste streams. Solids removal from the production water produces an effluent that is high in solids, nutrients, and BOD. Most systems add make-up water (about 5 to 10 percent of the system volume each day) to dilute the production water and to account for evaporation and other losses. Some overflow water, which is dilute compared to the solids water, is usually generated.

Recirculating system facilities use a variety of methods to treat, hold, or dispose of the solids collected from the production water. Some facilities send the collected solids, and some overflow water directly to a publicly owned treatment works (POTW) for treatment. Other facilities pretreat in settling ponds or other primary treatment systems to concentrate solids and send a more dilute effluent to the POTW. Still others concentrate solids and then land-apply the solids slurry when practical. The overflow water may be directly discharged, land-applied, or otherwise treated.

Net Pens

Net pens are suspended or floating holding systems used to culture some species of fish in larger water bodies, such as lakes, reservoirs, coastal waters, and the open ocean. The systems may be located along a shore or pier or may be anchored and floating offshore. Net pens rely on tides and currents to provide a continual supply of high-quality water to the cultured animals. In most locations, net pens are designed to withstand the high-energy environments of open waters and are anchored to keep them in place during extreme weather events. Strict siting requirements typically restrict the number of units at a given site to ensure sufficient flushing to distribute wastes and prevent degradation of the bottom near the net pens.

Net pens use a floating structure to support nets, which are suspended under the structure in the water column. The net pens vary in shape but are typically circular, square, or rectangular on the water surface. Their size also varies, depending on the available surface area and depth. A common practice in net pen culture is to use two nets—a containment net on the inside and an outer predator net to keep out predators, such as seals. At the surface, jump nets are used to keep fish from jumping out of the net pen. Bird nets are also suspended above the surface of the net pens to prevent bird predation.

For net pen culture, the mesh size of the netting used to contain the fish is as large as possible to prevent reduced water flows when fouling occurs, while still keeping the cultured fish inside the structure. Most nets are cleaned mechanically with brushes and power washers. Antifoulants have limited use in the United States. A few have been approved for food fish production, but those typically show minimal effectiveness.

Most net pens are regularly inspected by divers. The divers look for holes in the nets, dead fish, and fouling problems. State regulatory programs require benthic monitoring at many net pen sites to ensure that degradation is not occurring under or around the net pens.

9.2.1 CAAP Industry Pollutant Loadings

Pollutant concentrations in CAAP facility process waters are generally low because cultured species require relatively high water quality for optimal production. However, pollutant concentrations in effluents from waste treatment systems (e.g., settling basins) and solids storage structures can be quite high, although discharges typically occur in small volumes. Table 9-1 indicates example raw (in the absence of effluent pollutant reduction treatments) pollutant concentrations from two different kinds of CAAP facilities, as estimated by EPA for CAAP model facilities (Hochheimer and Mosso, 2002b, Mosso, 2002).

Table 9-1

Example Raw Pollutant Concentrations for Flow-Through and Recirculating Model Facilities

	BOD_5 (mg/L)	TSS (mg/L)	NH_3 (mg/L)	Organic N (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	Dissolved P (mg/L)	Organic P (mg/L)
Flow-Through	11.172	9.576	0.010	0.014	0.001	0.023	0.059	0.053
Recirculating	1,838.66	1,576.00	1.58	2.36	0.20	3.77	11.37	8.67

Source: EPA estimates (Hochheimer and Mosso, 2002b).

The values in Table 9-1 do not represent actual facilities but were derived using an engineering model developed by EPA to calculate raw pollutant loadings from model facilities. The model calculates wastes generated in an CAAP system based on feed inputs, which were acquired from literature reviews (Hochheimer and Mosso, 2002b).

In the absence of treatment, CAAP facilities can generate locally significant loadings of pollutants in terms of total annual mass (Table 9-2). These values are derived by multiplying appropriate facility effluent flow rates, as estimated by EPA (Mosso, 2002) for a given facility type by the corresponding raw pollutant concentrations in Table 9-1. Raw pollutant loading estimates are presented in Table 9-2 for several flow-through and recirculating systems model facilities. Raw pollutant loadings from large net pen systems can be equal to or greater than the pollutant loading values shown in Table 9-2.

Table 9-2

Example Model Facility Raw Pollutant Loadings for Flow-Through and Recirculating Systems

Model facility	**Effluent flow (ft^3/s)**	**BOD_5 (lb/yr)**	**Total Suspended Solids (lb/yr)**
Large salmon flow-through	92.7	2,019,852	1,731,301
Medium striped bass flow-through	2.7	62,149	53,271
Medium tilapia flow-through	6.0	155,373	133,177
Large tilapia flow-through	22.3	388,433	332,943
Medium trout flow-through	4.7	77,687	66,589
Large trout flow-through	47.2	1,009,926	865,651
Medium trout stockers flow-through	4.9	77,687	66,589
Large trout stockers flow-through	20.7	466,120	399,531
Large striped bass recirculating	0.1	383,564	328,770
Large tilapia recirculating	0.05	127,855	2,039,478

Note: See text for description of calculation.
Source: Hochheimer and Mosso, 2002b; Mosso, 2002.

Table 9-2 demonstrates that total annual BOD_5 and TSS loadings from medium and large CAAP model facilities can be considerable. To place these annual loadings in context, the BOD_5 and TSS loading from a large salmon flow-through system is equivalent to the BOD_5 and TSS loading in the domestic wasteload of a city with over 20,000 individuals. Appendix D documents the conversion factors for this calculation. Loadings from net pen facilities can also be relatively high. For example, the annual BOD_5 loading produced by a single large salmon net pen facility (e.g., a facility with annual production of over 3 million pounds, estimated to produce over 4 million pounds of BOD_5 per year, is equivalent to the BOD_5 loading in the domestic wasteload of a city of approximately 65,000 people (Hochheimer, 2002).

In addition, when multiple CAAP facilities are located on a single receiving water, which occurs in such states as Idaho and Maine, cumulative pollutant loadings to the receiving water may be correspondingly higher and may be of concern from a stream ecology perspective. EPA's Region 10 identified discharges from CAAP facilities as contributors to phosphorus loadings in the middle Snake River, where over 70 CAAP facilities, several municipal treatment plants, and several food processors were identified. The region adopted strict numeric limits on phosphorus from the CAAP facilities that led to an overall reduction in phosphorus over the past 5 years (Fromm and Hill, 2002). Finally, observations in Idaho receiving waters downstream of aquaculture facilities suggest that in the absence of solids capturing treatments, sediment deposition can occur. Observations of 18 inches or more of organic accumulations downstream of aquaculture facilities in Billingsley Creek, prior to the adoption of solids capturing, and six feet deep below Box Canyon, also prior to solids capturing, have been reported (USEPA, 2002b).

9.2.2 Literature Review on Potential and Observed Water Quality Impacts

EPA performed a literature review for reports of environmental effects associated with aquatic animal production facilities (Tetra Tech, 2001; Mosso, 2002). EPA's review focused on scientific research reports in the United States. EPA also recognizes that research has been performed on the environmental effects of CAAP facilities in other countries (e.g., within the European Union) as well.

Much of the literature reviewed by EPA describes observations of nutrient and solids within the discharge from CAAP facilities. Some of these studies also discuss the release of biochemical or chemical oxygen demand. There are limited studies in which biological variables downstream of CAAP facilities have been measured. Impacts such as the presence of pollution-tolerant benthic invertebrates have been observed; but in other cases, pollutants were not found to negatively impact the receiving stream (e.g., Kendra, 1991; Selong and Helfrich, 1998). Overall, EPA's initial literature search did not identify extensive research literature regarding ecological effects arising from water quality degradation downstream of CAAP facilities in the United States. Appendix E lists publications found in EPA's literature review that describe water quality measurements associated with CAAP facilities, by major production system, as well as citations to additional literature describing aquatic animal production practices or studies outside of the United States.

9.2.3 State Listings of Impaired Waters

Nutrient impacts from aquatic animal production facilities can also be evaluated from reports to EPA on the causes and status of impaired water bodies (TMDL listings or State 303(d) reports). State listings of waters for which CAAP has been identified as a potential source of impairment have been compiled from 1998 and 2000 State TMDL listings (i.e. all 1998 State listings plus any new listings added between 1998 and 2000). Approximately forty-five different sources of impairment have been identified on State TMDL listings. These other sources include general agricultural runoff, hydromodification, and urban runoff. According to these recent reports, seven States (IL, LA, NH, NM, NC, OH, and VA) have identified CAAP facilities as a potential source of impairment for one or more water bodies. Again, however, multiple potential causes of impairment are frequently cited for an impaired water body.

Table 9-3 provides information about water bodies that are listed as impaired, where CAAP has been identified as a potential source of impairment. Data which isolate the exclusive impact of CAAP facilities on stream/river miles, lake/reservoir/pond acres, or square miles of estuaries/bays does not exist. Thus, the values presented in the tables below represent water bodies and areas impacted by a number of sources, where CAAP is one of the potential sources. The table also provides the specific cause (e.g., pollutants) contributing to the impairment and the number of miles or acres affected. Types of causes include nutrients, solids, organic enrichment, benthic degradation, other water quality concerns, and listings where the cause was unknown.

Table 9-3

Impaired Water Bodies Where CAAP is Listed as a Source of Impairment

ID	State	Water Body Name	Stated Cause(s)	Miles	Acres
ILNDDA01_NDDA01	Illinois	L Grassy Creek	Flow Alterations, Nutrients, Siltation, Suspended Solids	4.6	
LA-120201	Louisiana	Lower Grand River and Belle River	Nutrients, Organic Enrichment/Low DO, Pathogens	39.5	2,026.0
LA-120302	Louisiana	Company Canal	Organic Enrichment/Low DO, Pathogens	5.9	183.1
NHL70002010	New Hampshire	Marsh Pond	Phosphorus		59.4
NHL80101150(B)	New Hampshire	York Pond	Phosphorus		180.0
NM-MRG2-20400	New Mexico	Rio Cebolla	Stream Bottom Deposits, Temperature	15.0	23.5
NC_27-86-26	North Carolina	Little Contentnea Creek	Low DO	27.0	
NC_2-SANTEETLAH_LAKE_GRAHA M	North Carolina	Santeetlah Lake	Nutrients		280.0
NC_6-10-1b	North Carolina	Morgan Mill Creek	Unknown	0.3	
NC_6-10b	North Carolina	Peter Weaver Creek	Unknown	0.8	
NC_6-2-(0.5)b	North Carolina	West Fork French Broad	Unknown	0.5	
OH70 1	Ohio	Auglaize River (Blanchard R. To Little Auglaize R)	Habitat Alterations, Siltation, Organic Enrichment/Low DO, Metals	7.5	
OH71 16	Ohio	Flatrock Creek (OH/IN Border To Wildcat Creek)	Flow Alteration, Organic Enrichment/ Low DO, Pathogens	10.1	
OH80 17- 86	Ohio	Bucyrus Reservoir #2	Flow Alteration, Noxious Aquatic Plants, Nutrients, Siltation, Turbidity		36.4
VAV-B10R-02	Virginia	Cockran Spring	Benthic Degradation	16.0	
VAV-B47R-03	Virginia	Lacey Spring	Benthic Degradation	16.0	
VAV-B52R	Virginia	Orndorff Spring Branch	Benthic Degradation	16.0	
VAV-H09R	Virginia	Montebello Spring Branch	Benthic Degradation	0.2	
VAV-I14R	Virginia	Coursey Springs Branch	Benthic Degradation	16.0	
VAV-I32R-01	Virginia	Castaline Spring Branch	Benthic Degradation	16.0	

Summary of Water Bodies Listed as Impaired

The information from Table 9-3 can be summarized by water body type and scope of impact to provide a general summary of the impact of CAAP on impaired water bodies. Table 9-4 summarizes the specific causes of impairment for each water body type. According to the data, streams and rivers have the most reported impairments (sixteen) from causes in which CAAP was a contributing source. Only four lakes, reservoirs, and ponds were listed as impaired, while only no estuaries/bays were reported as impaired.

Table 9-4

Source of Impairment by Water Body Type

Water Body Type	Nutrients	Solids	Organic	Benthic	Other Water	Total Number
Stream/River	X	X	X	X	X	16
Lake/Reservoir/Pond	X				X	4

Table 9-5 provides information about the number of stream/river miles and lake/reservoir/pond acres listed as impaired (where CAAP is a source of impairment) in each State.

Table 9-5

Miles/Acres for Which CAAP is Listed as a Potential Source of Impairment.[a]

State	Miles of Streams/Rivers Impaired	Acres of Lakes/ Reservoirs/Ponds Impaired
Illinois	5	n/a[b]
Louisiana	45	2,209
New Hampshire	n/a	239
New Mexico	15	24
North Carolina	29	280.0
Ohio	18	36
Virginia	80	n/a
Total	**192**	**2,788**

[a]Other sources in addition to CAAP may have been cited as a potential source of impairment by the State
[b]n/a = not available.

Comparison to National Information

Nutrients, solids, organic enrichment, benthic degradation, and other water quality concerns (which as a group include flow alteration, siltation, low dissolved oxygen, turbidity, pathogens, metals, temperature, and habitat alterations) are the leading pollutants in impaired streams and rivers in which CAAP may be a contributing factor to the impairment. Nationally, the leading pollutants causing impairment in streams and rivers are nutrients and other water quality concerns, such as metals and siltation (USEPA, 2000b). Thus, nutrients are frequently identified as a potential cause of impairment both nationally and in waters where CAAP facilities are a potential source of impairment. Additionally, metals and siltation are important causes of impairment both nationally and with CAAP-related listings.

The leading pollutants in impaired lakes, reservoirs, and ponds in which CAAP may be a contributing factor to the impairment are nutrients and other water quality concerns (which include flow alteration, noxious aquatic plants, siltation, and turbidity). Nationally, the leading pollutants causing impairment in lakes, reservoirs, and ponds are nutrients, metals, and siltation (USEPA, 2000b). Thus, nutrients are frequently identified as a potential cause of impairment both nationally and in waters where CAAP facilities are a potential source of impairment. Siltation is also an important cause of impairment both nationally and in water bodies where CAAP may be a source of impairment.

CAAP is listed as one of the sources of impairment for 192 miles of rivers and streams, based on 1998 and 2000 TMDL State listings. Nationally, a total of 291,264 miles of rivers and streams are impaired (USEPA, Appendix A-2, 1998a). For lakes, reservoirs, and ponds, CAAP was listed by the States as a source of impairment for 2,788 acres. By comparison, in the entire United States, a total of 7,897,110 acres of lakes, reservoirs, and ponds are listed as impaired (USEPA, Appendix B-2, 1998b). No information was available about the number of square miles of estuaries and bays listed as impaired, in cases where CAAP was a potential source of impairment. Again, it is important to note that not all of the water bodies in the United States have been assessed.

Comparison to Other Sources of Impairment

To compare the leading pollutants associated with select sources of impairment, information about the types of pollutants generally associated with each source was compiled in Table 9-6. Based on the information in this table, nutrients and solids are the most common pollutants associated with each of the sources of impairment examined.

Table 9-6

Comparison of Leading Pollutants Among Sources of Impairment

Source of Impairment	Pollutants					
	Nutrients	Solids	Organic Matter	Pathogens	Metals	Oil/Grease
Agriculture	X	X				
Animal Feeding Operations	X	X	X	X		
Natural Sources	X	X	X	X		
Urban Runoff	X	X		X	X	X

The leading sources of impairment in assessed streams, rivers, lakes, reservoirs, and ponds are agriculture, hydromodification, and urban runoff/storm sewers. Hydromodification is defined as the alteration of the hydrologic characteristics of coastal and noncoastal waters, which in turn could cause degradation of water resources (USEPA, 1997). It includes such changes as channelization or channel modification. The leading sources of impairment in estuaries are municipal point sources, urban runoff/storm sewers, and atmospheric deposition (USEPA, 2000b).

The scope of impact on various water bodies can be compared among sources of impairment. Information from Table 9-7, where the scope of impact was provided for those States that reported CAAP as a source of impairment, was compared to the scope of impact for other sources of impairment. For the purposes of this comparison, other sources of impairment include agriculture, animal feeding operations, natural sources, and urban runoff. These other sources are known to be large contributors to the same causes of impairment (e.g., nutrients) as CAAP. Table 9-7 compares the miles of impaired streams and rivers among different sources of impairment.

Table 9-7

Comparison of Sources of Impairment in Rivers and Streams (Miles)

State	CAAP Industry	Animal Feeding Operations	Urban Runoff/ Storms Sewers	Natural Sources	Agriculture
Illinois	5	124	1,865	213	10,977
Louisiana	45	269	1,122	1,377	1,662
New Mexico	15	0	97	221	3,179
North Carolina	28	0	700	0	2,496
Ohio	17	28	508	240	1,121
Virginia	80	0	341	532	842
Total	**192**	**421**	**4633**	**2583**	**20277**

Note: Only States that reported CAAP as an impairment source are listed.
Note: New Hampshire was not included in this table because the number of impaired miles in the State was not provided.
Source: *National Water Quality Inventory, Appendix A-5* (USEPA, 1998a).

Table 9-8 provides information to compare the acres of impaired lakes, reservoirs, and ponds among different sources of impairment. No impairment information was provided for animal feeding operations for this category of water body.

Table 9-8

Comparison of Sources of Impairment in Lakes, Reservoirs, and Ponds (Acres)[a]

State	Urban Runoff/ Storms Sewers	CAAP Industry	Natural Sources	Agriculture
Louisiana	60	2,209	76,397	17,040
New Hampshire	68	239	75	0
New Mexico	18	24	11,357	92,834
North Carolina	470	280	0	74
Ohio	0	36	0	0
Total	**616**	**2,788**	**87,829**	**109,948**

[a]Only States that reported CAAP as an impairment source are listed. Illinois and Virginia were not included in this table because the number of impaired acres in these States was not provided.
Source: *National Water Quality Inventory, Appendix B-5* (USEPA, 1998b).

Comments

It is also important to recognize that not all water bodies have been assessed in every State and the percentage assessed may vary widely. In some States, a very small percentage of water bodies have been assessed. In other States, most or all of the water bodies have been assessed. For example, it is reported that Louisiana has only assessed 9 percent of their rivers and streams (USEPA, 1998a) and that Ohio has not assessed any of their lake, reservoir, and pond acres (USEPA, 1998b). In contrast, North Carolina has assessed 89 percent of their river and stream miles (USEPA, 1998a) and New Hampshire has assessed 95 percent of their lake, reservoir, and pond acres (USEPA, 1998b). Differences in percentage of water bodies assessed makes comparisons among States difficult. More important, for States that have a low percentage of assessed water bodies, conclusions from limited data may not accurately represent the condition of a State's water bodies. Finally, when more than one source of impairment and more than one pollutant are listed for a water body, it is difficult to determine which source of impairment is "responsible" for which pollutant. For example, if CAAP and animal feeding operations (AFOs) are both listed as the sources of impairment and nutrients and pathogens are both listed as the pollutants causing impairment, such a listing makes it appear as if the nutrients and pathogens are caused by both sources. It is possible that CAAP may not be a source of pathogens for that particular listed water body. As a result, 303(d) data can complicate linkages between sources of impairment and pollutants.

9.3 NON-NATIVE SPECIES

Another area of concern regarding environmental impacts of CAAP facilities relates to potential introductions of non-native aquatic organisms via intentional or accidental releases from CAAP facilities. Non-native species can be defined as an individual, group, or population of a species that is introduced into an area or ecosystem outside its historic or native geographic range. This term may include both foreign (i.e., exotic) and transplanted species, and it can be used synonymously with "alien" and "introduced" (Fuller et al., 1999). There is some inconsistency in the terminology used by literature and scientists when discussing non-native species. The following terms are also used and their differences should be noted:

- *Aquatic nuisance species* (ANS) – nonindigenous species that threaten the diversity or abundance of native species; the ecological stability of infested waters; or commercial, agricultural, aquacultural, or recreational activities dependent on such waters (Fuller et al., 1999).

- *Exotic species* – an organism introduced from a foreign country; a species native to an area outside of, or foreign to, the national geographic area under discussion (Fuller et al., 1999).

- *Nonindigenous species* – synonymous with non-native species (Fuller et al., 1999).

- *Introduced* – An organisms moved by humans (or by human actions) to an ecosystem, or region where it was not found historically due to human actions (i.e., an individual, group, or population of organisms that occur in a particular locale because of human actions (Fuller et al., 1999).

- *Invasive species* – a species that is 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health (USDA, 2002).

Scientists and resource managers have identified CAAP as a potential source of concern with respect to non-native species issues (e.g. Alaska Department of Fish and Game, 2002; Carlton, 2001; Goldburg et al., 2001; Naylor et al., 2001; and Volpe et al., 2000). In addition, scientists have highlighted concerns related to potential risks associated with the possible future use of genetically modified organisms in aquatic animal production (e.g. Hedrick, 2001; Reichardt, 2000).

9.3.1 Impacts of Non-Native Species

In general, non-native species, which might be considered biological pollutants, can alter and degrade habitat. When species are introduced into new habitats, they often overrun the area and crowd out existing species. If enough food is available, populations of non-native species can increase considerably. Once non-native species are established in an area, they can be difficult to eliminate (UMN, 2000).

Many non-native species are introduced into the environment by accident when they are carried into an area by vehicles, ships, produce, commercial goods, animals, or clothing (UMN, 2000) or when they escape from CAAP facilities. Other non-natives are introduced intentionally. Although some species can be harmless or beneficial to an environment, others can be detrimental to ecosystems and recreation (UMN, 2000). Impacts of non-native aquatic organisms on native aquatic species in North America can be classified into five general categories, which include habitat alteration, trophic alteration, spatial alteration, gene pool deterioration, and introduction of diseases.

Habitat Alteration

Non-native fish, such as carp or tilapia, introduced to control vegetation can cause a variety of habitat impacts. Both exotic and native vegetation can be destroyed as a result of carp predation. This, in turn, results in bank erosion, restrictions on fish nursery areas, and acceleration of eutrophication as nutrients are released from the plants. Grass carp may adversely impact rice fields and waterfowl habitat, while common carp reduce vegetation by direct consumption and by uprooting, as they dig through the substrate in search of food. Digging also increases turbidity in the water (AFS, 1997; Kohler and Courtenay, n.d.).

Trophic Alteration

Non-native species may also cause complex and unpredictable changes in community trophic structure. Communities can be changed by explosive population increases of non-native fish or by predation of native species by introduced species (AFS, 1997). Several studies have documented dietary overlap in native and introduced fishes. As a result, there is potential for competition. However, it has proven difficult to link dietary overlap to competition (Kohler and Courtenay, n.d.).

Spatial Alteration

Spatial changes may result from overlap in the use of space by native and non-native fish, which may lead to competition if space is limited or of variable quality (AFS, 1997).

Gene Pool Deterioration

Heterogeneity may be decreased through inbreeding by species being produced in a hatchery. This risk is most serious with species of intercontinental origin because the initial broodstock has a limited gene pool to begin with. If these species are introduced to new habitat, they may lack the genetic characteristics necessary for them to adapt or perform as predicted. There is also a possibility that native gene pools may be altered through hybridization when non-native species are introduced to a habitat. However, hybridization events in open waters are rare (AFS, 1997; Kohler and Courtenay, n.d.).

Introduction of Diseases

Non-native species may transmit diseases caused by parasites, bacteria, and viruses to an environment. The transmission of diseases from non-native species to native species is considered one of the most serious threats to native communities (AFS, 1997). There are numerous examples of non-native species introducing diseases in native species. Transfer of diseased non-native fish from Europe is believed to be responsible for introducing whirling disease in North America. Infectious hypodermal and hematopoietic necrosis (IHHN) virus has been spread to a number of countries as a result of shipments of live penaeid shrimp. IHHN was first diagnosed at Hawaiian shrimp culture facilities in shrimp from Panama. "Ich," a common fish disease that is caused by a ciliated protozoan, may have been transferred from Asia throughout the temperate zone with fish shipments (Kohler and Courtenay, n.d.).

9.3.2 Case Studies of Non-Native Species

EPA reviewed the literature for examples that illustrate the potential or actual role of aquatic animal production in releases of non-native species. Several examples are presented below describing Atlantic Salmon and several carp species.

Atlantic Salmon

Atlantic salmon (*Salmo salar*) are native to the Atlantic Coast drainages from northern Quebec to the Housatonic River in Connecticut; inland to Lake Ontario. They are also found in eastern Atlantic drainages from the Arctic Circle to Portugal (USGS, 2000b). Atlantic salmon are raised in net pens off the East and West Coasts of the United States and in British Columbia. Escapement has become a critical concern due to potential impacts from disease, parasitism, interbreeding, and competition. In areas where the salmon are exotic, most concerns do not focus on interbreeding with other salmon species. Rather, they center on whether the escaped salmon will establish feral populations, reduce the reproductive success of native species through competition, alter the ecosystem in some unpredictable way, or transfer diseases (EAO, 1997).

Smolts and adult salmon are lost mainly as a result of operator error, predation, storms, accidents, and vandalism. However, it is important to note that escapement reports may not always be accurate. While most escapement reports involve large numbers of fish, small escapements are often unnoticed or unreported. Leakage may occur from small holes in the net, during handling, or during transfer of fish to another cage. Therefore, the number of escapements may be considerably greater if small escapes were accounted for (Alverson and Ruggerone, 1998). It is also important to consider the fact that losses of salmon from net pens may not always result from escapements. Fish may be lost because of decomposition of carcasses or scavenging by birds, mammals, and fish (Nash, 2001). As a result, this could reduce the estimated number of escapes. Reported escapes of Atlantic salmon in the United States are summarized in Table 9-9.

In addition to accidental escapes, some Atlantic salmon have been introduced intentionally. Between 1951 and 1991, the State of Washington released 76,000 Atlantic salmon smolts into the Puget Sound Basin in an attempt to establish this species on the west coast (Nash, 2001).

Table 9-9

Atlantic Salmon Escapements in Maine and Washington

Year	Area	No. of Escapes	Comments	Reference
Maine				
1996	Trumpet Island	18,000	Approximately 18,000 fish escaped when seals ripped open one net pen.	Lewis, 2002, personal communication
2000	Maine	22,315	Atlantic salmon escaped off the coast of Maine, near one of the rivers where wild Atlantic salmon are listed as endangered. The fish escaped from a net pet, when a boat slammed into the pen and tore a hole. The number of escaped fish reported by Clancy (2000) was 13,000. However, the Department of Marine Resources reported the number of escapes as 22,315.	Clancy, 2000; Lewis, 2002, personal communication
2000	Maine, Stone Island	170,000	Atlantic salmon escaped from net pens when a December Northeaster rocked Maine's Machias Bay and uprooted the pen's moorings. The number of fish that escaped has frequently been reported as 100,000. However, the actual number, which was obtained from the Department of Marine Resources, was 170,000.	Daley, 2001; ASF, 2001; Lewis, 2002, personal communication
2001	Maine	3,000-5,000	Atlantic salmon escaped from a net pen in Eastport, Maine.	Daley, 2001; ASF, 2001
Washington				
1996	Cypress Island	107,000	Atlantic salmon smolt and adults escaped from net pens near Cypress Island	Amos and Appleby, 1999; Appleby, 2002, personal communication; Mottram, 1996; Goldburg and Triplett, 1997
1997	Bainbridge Island	369,000	Atlantic salmon escaped near Bainbridge Island when the net pens were damaged pens as they were towed away from a toxic algae bloom.	Amos and Appleby, 1999; Appleby, 2002, personal communication; Mottram 1999
1999	Bainbridge Island	115,000	Atlantic salmon escaped from pens near Bainbridge Island when extreme tidal flows snapped anchor lines.	Amos and Appleby, 1999; Appleby, 2002, personal communication

It is also important to note the number of escapes of Atlantic salmon in British Columbia because these fish may end up in U.S. waters. Between 1987 and 1996, an estimated 154,554 Atlantic salmon were reported to have escaped from marine farms in British Columbia. These losses do not include "leakage," which could be substantial over time and may double estimated escapes as a worst-case scenario (Alverson and Ruggerone, 1998). Additionally, the average number of escapees in British Columbia reported from 1992 to 1996 was approximately 42,000 fish per year (EAO, 1997). Specific examples of escapements of Atlantic salmon in British Columbia include the following (Alverson and Ruggerone, 1998):

- Based on a 1994 report, 7,000 Atlantic salmon escaped from a trucker tank spill at Morstrom Lake.
- In the same year, more than 20,000 salmon escaped at Johnstone Strait because of seals.
- Over 21,000 salmon escaped at Johnstone Strait in 1994 because of a break in the mooring lines.
- In 1995, more than 31,000 salmon escaped because of a 15-foot tear at 30 feet depth.
- 40,000 young Atlantic salmon escaped in 1996 from a net pen in Georgia Lake.

Although it remains uncertain whether escaped Atlantic salmon can definitely transfer diseases, it is useful to examine some biological information on escaped salmon, which was reported by the Environmental Assessment Office (EAO) of British Columbia. Between 1991 and 1995, ninety adult Atlantic salmon recovered in British Columbia and Alaska were examined to determine if they were infected with any diseases. Two fish were infected with *Aeromonas salmonicida*, the causative agent of furunculosis, and none of the fish contained unusual parasite infestations. Additionally, none of the tested fish were infected with common viral infections (Alverson and Ruggerone, 1998).

In contrast, Atlantic salmon stocked in Puget Sound were believed to have been responsible for introducing a new disease, viral hemorraghic septicemia (VHS), to the west coast. This disease has been found in two salmon hatcheries in Puget Sound (Dentler, 1993). VHS is a systemic infection of various salmonid and a few nonsalmonid fish. It is caused by a rhabdovirus and may result in significant cumulative mortality. Fish that survive become carriers of the disease. VHS is enzootic in most countries of continental Eastern and Western Europe. However, the virus has been isolated off the coast of Washington, in Puget Sound (McAllister, 1990).

Experiments have shown that Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), golden trout (*O. aguabonita*), rainbow trout x coho salmon hybrids, giebel (*Carassius auratus gibelio*), sea bass (*Dicentrarchus labrax*) and turbot (*Scophthalmus maximus*) are all susceptible to VHS. Experiments have also shown that common carp (*Cyprinus carpio*), chub (*Leuciscus cephalus*), Eurasian perch (*Perca fluviatilis*), roach (*L. rutilus*), and tench (Tinca tinca) are all refractory to VHS (McAllister, 1990).

Common Carp

Common carp (*Cyprinus carpio*), which are also referred to as German carp, European carp, mirror carp, leather carp, and koi, are native to Eurasia. There is some uncertainty concerning when and where they were first introduced into the United States (USGS, 1999). However, early reports state that common carp were brought to the United States from Europe in 1831. After that time, common carp were produced and distributed throughout the Upper Mississippi River System (USGS, 2001a). Common carp can be used as an example to show how other carp species can become an environmental problem.

The common carp can be considered a nuisance species because it is widely distributed throughout the United States and it detrimentally affects aquatic habitats (USGS, 1999). Richardson et al. (1995) found that common carp adversely affect biological systems, causing increased turbidity and destruction of vegetated breeding habitats for birds and fish. The carp stirs up bottom sediments during feeding, which increases turbidity and siltation (Lee et al., 1980). This type of behavior also destroys rooted aquatic plants, which provide habitat for native fish species and food for waterfowl (Dentler, 1993). Laird and Page (1996) also found that common carp might compete with ecologically similar species such as buffalos and carpsuckers.

Common carp sometimes prey on the eggs of other fish species (Taylor et al., 1984; Miller and Beckman, 1996). This may have caused the decline of the razorback sucker (*Xyrauchen texanus*) in the

Colorado River basin (Taylor et al., 1984). Additionally, Miller and Beckman (1996) found white sturgeon (*Acipenser transmontanus*) eggs in the stomachs of common carp in the Columbia River.

Grass Carp

The grass carp (*Ctenopharyngodon idella*), or white amur, is native to the Amur River in China and Russia. It was first imported to the United States in 1963 to aquatic animal production facilities in Alabama and Arkansas and is used for biological control of vegetation. The first release of grass carp occurred in Arkansas, when fish escaped from the Fish Farming Experimental Station (Courtenay et al., 1984). Grass carp were first documented in the Mississippi River along Illinois in 1971 (USGS, 2001a). In the last few decades, the grass carp has spread rapidly as a result of research projects, escapes from ponds and aquaculture facilities, legal and illegal interstate transport, releases by individuals and groups, stockings by Federal, State, and local government agencies, and natural dispersion from introduction sites (Pflieger, 1975; Lee et al., 1980; Dill and Cordone, 1997).

Pennsylvania, New Jersey, Delaware, and Virginia have all approved the use of grass carp for weed control, with certain restrictions. These States require that the fish be "triploid," meaning that they must have three sets of chromosomes instead of two, which makes the fish sterile (University of Delaware, 1995). Although researchers have reported that the probability of successful reproduction of triploid grass carp is "virtually nonexistent" (Loch and Bonar, 1999), some researchers have questioned the sterility of triploids because techniques used to induce triploidy are not always effective. Therefore, each fish should be genetically checked (USGS, 2001b). Measures should also be taken to reduce the number of escapes by these fish. Barriers could be constructed and maintained to prevent migration from lakes. Additionally, consideration should be given to the location and type of water bodies stocked with grass carp. Lakes and ponds that are prone to flooding should not be stocked with these carp (Loch and Bonar, 1999).

According to the literature, there are a variety of actual and potential impacts of introducing grass carp to an area. Shireman and Smith (1983) concluded that the effects of grass carp on a water body are complex and depend on the stocking rate, macrophyte abundance, and the ecosystem's community structure. Negative effects of grass carp include interspecific competition for food with invertebrates and other fish, interference with fish reproduction, and significant changes in the composition of macrophyte, phytoplankton, and invertebrate communities. Chilton and Muoneke (1992) reported that grass carp might affect other species indirectly, by modifying preferred habitat, or directly, through predation or competition when food is scarce. Bain (1993) reports that grass carp have significantly altered the food web and trophic structure of aquatic ecosystems by causing changes in fish, plant, and invertebrate communities. More specifically, he indicates that these effects are largely a result of decreased density and composition of aquatic plants.

The removal of vegetation by grass carp can result in the elimination of food, shelter, and spawning substrates for native fish (Taylor et al., 1984). Additionally, the partial digestion of plant material by grass carp results in increased phytoplankton populations because grass carp can only digest half of the plant material that they consume. The rest of the material is released into the water and increases algal blooms (Rose, 1972), which decreases oxygen levels and reduces water clarity (Bain, 1993).

Grass carp may carry diseases and parasites that are known to be infectious or potentially infectious to native fish. Grass carp imported from China are believed to be responsible for introducing the Asian tapeworm *Bothriocephalus opsarichthydis* (Hoffman and Schubert, 1984; Ganzhorn et al., 1992).

Other Species of Carp

Black carp (*Mylopharyngodon piceus*), which are also known as Asian black carp, black amur, snail carp, and Chinese roach, are native to eastern Asia, from the Pearl River basin in China north to the Amur River (USGS, 2000a). Black carp are currently maintained in research, resource management, and other fish production facilities in several States and were first brought into the United States in the early 1970s as a “contaminant” in imported stocks of grass carp. In the early 1980s, black carp were imported as a food fish and as a biological control agent to combat the spread of yellow grub *Clinostomum* *margaritum* in aquaculture ponds (Nico and Williams, 1996). Although black carp have been in the United States for about 30 years, they have not been found in the wild (USFWS, 2002).

Although Asian black carp provide a cheap means for controlling trematodes in catfish ponds, they feed on many different mollusks. This may pose an ecological risk in the Mississippi Basin because black carp are currently held in eight southern States and 90 percent of the freshwater mollusks designated as threatened, endangered, or of special concern are found in the Southeast. Additionally, black carp have escaped and colonized open water in all other countries where they have been introduced. Although most of the carp in the eight States are in sterile triploid form, Mississippi permitted the use of fertile diploids in 1999 in response to a major outbreak of trematodes. This caused fishing and conservation groups to petition for black carp to be listed as "injurious" under the Federal Lacey Act (Naylor et al., 2001). The U.S. Fish and Wildlife Service has proposed to list black carp as an injurious species (67 FR 49286, July 31, 2002).

Black carp are very similar to grass carp. The body shape and size and the position and size of both the eyes and fins are similar with both species. Additionally, it is difficult to distinguish between juveniles of the two species. Nico and Williams (1996) expressed concern that if black carp become more common in U.S. aquaculture, there will be an increased risk of accidental introductions as grass carp if the two species are identified incorrectly.

Silver and bighead carp are two Asian carp that have been identified as species of significant, immediate concern to aquatic resource managers. Bighead carp first began to appear in open waters in the Ohio and Mississippi rivers in the early 1980s "likely as a result of escapes from aquaculture facilities" (Jennings 1988, as cited in Fuller et al., 1999). According to the International Joint Commission (Schomack and Gray, 2002), Asian carp pose a tremendous threat to the biological integrity of the Great Lakes and may result in economic and ecological damages to the Great Lakes ecosystem that far exceed those brought about by the previous introduction of the sea lamprey and the zebra mussel. The International Joint Commission recently urged that U.S. and Canadian governments should consider implementing regulatory controls to prevent introduction of Asian carp via other pathways including the food and bait fish industries, the aquarium trade, and aquaculture (Schomack and Gray, 2002).

9.4 PATHOGENS

CAAP facilities are not considered a source of pathogens that adversely affect human health. CAAP facilities culture cold-blooded animals (fish, crustaceans, mollusks, etc.) that are unlikely to harbor or foster such pathogens (MacMillan et al., 2002). Although it is possible for CAAP facilities to become contaminated with human pathogens (e.g., by contamination of facility or source waters by wastes from warm-blooded animals) and, as a result, become a source of human pathogens, this is not considered a substantial risk in the United States (MacMillan et al., 2002).

On the other hand, some CAAP facilities may serve as sources of pathogens that adversely affect aquatic organisms (JSA, 1997). For example, wastes and escapement of infected shrimp from CAAP facilities is considered a major potential pathway for wild shrimp exposure to viral diseases (JSA, 1997). The Pacific Northwest Fish Health Protection Committee (PNFHPC) has established policies to prevent the spread of pathogens that might lead to release from hatcheries of seriously infected salmon (Strom et al., n.d.). With respect to fish hatcheries, however, while they may potentially be reservoirs of infectious agents (due to higher rearing densities and stress), little evidence suggests that disease transmission to wild stocks from hatcheries occurs routinely (Strom et al., n.d.).

9.5 DRUGS AND OTHER CHEMICALS

A number of drugs and chemicals are in use at CAAP facilities. For example, formalin and hydrogen peroxide are used to control fungus on salmon and esocid eggs (Hochheimer and Mosso, 2002a). In addition, antibiotics are also used at CAAP facilities, are typically incorporated into feed, and can ultimately be released into the environment. Once in the environment, antibiotics are most commonly bound to sediment and other particles. Prolonged exposure to residual antibiotics can alter target organisms, making them antibiotic resistant with effects that may spread beyond the original area of use (NOAA, 1999).

Metals may be present in CAAP wastewaters due to a variety of reasons. They may be used as feed additives, occur in sanitation products, or they may result from deterioration of CAAP machinery and equipment. Many metals are toxic to algae, aquatic invertebrates, and/or fish. Although metals may serve useful purposes in CAAP operations, most metals retain their toxicity once they are discharged into receiving waters. EPA has observed that many of the treatment systems used within the CAAP industry provide substantial reductions of most metals since most of the metals can be adequately controlled by controlling solids.

Pesticides may be used for controlling animal parasites and aquatic plants and may be present in wastewaters. Some pesticides are bioaccumulative and retain their toxicity once they are discharged into receiving waters. Similar to metals, although EPA observed that many of the treatment systems used within the CAAP industry provide adequate reductions of pesticides, most systems are not specifically designed and operated to remove pesticides.

The U.S. Food and Drug Administration (FDA)/Center for Veterinarian Medicine (CVM) regulates animal drugs under the Federal Food, Drug, and Cosmetic Act (FFD&CA). Four categories of drugs are used in aquaculture: (1) six commercial drugs currently approved for specific species, specific diseases, and at specific doses or concentrations; (2) investigational new animal drugs which are used under controlled conditions under an Investigational New Animal Drug (INAD) application; (3) other veterinary and human drugs as determined by a veterinarian under the extra-label use provisions of the Animal Medicinal Drug Use Clarification Act of 1994 (AMDUCA); and (4) drugs designated by FDA as low regulatory priority. The use of these drugs is regulated by FDA/CVM, which requires that users read the label directions to ensure that the product is used in a safe and effective manner. The label directions may include directions on proper dilution before discharge and can require other conditions that affect the amount of drug contained in effluents. FDA/CVM approves new animal drugs based on scientific data provided by the drug sponsor. This data includes environmental safety data that is used in an environmental risk assessment for the drug (Eirkson et al., 2000).

Reviews of literature relating to drugs and chemicals used in aquaculture have been published (e.g., GESAMP 1997; Boxall et al., 2001). Although these reviews are not focused on practices in the United States, certain observations may have relevance to the United States. GESAMP (1997) reviewed chemicals used in coastal aquaculture, which include chemicals associated with structural materials, soil and water treatments, antibacterial agents and other therapeutic drugs, pesticides, feed additives, and anaesthetics. According to this review, most aquaculture chemicals, if properly used, can be viewed as wholly beneficial with no adverse environmental impacts or increased risks to aquaculture workers. However, the authors identified several factors that could make the use of otherwise acceptable chemicals unsafe: these include excessive dosage and failure to provide for adequate neutralization or dilution prior to discharge. Among potential environmental issues of concern relating to improper use include chemical residues in wild fauna, toxic effects in non-target species, and antibacterial resistance. The authors conclude with recommended measures to promote safe and effective use of chemicals in coastal aquaculture.

Boxall et al. (2001) present a summary of environmental impacts from drug use in aquatic animal production that includes a comprehensive review of the potential impacts of oxytetracycline, which is the most widely used antibiotic medication at CAAP facilities in the United States. Because most CAAP treatments with medications use medicated feed and treatment baths, the direct application of the drug to the production water presents higher risks for water quality and ecological problems. In net pen systems, the production water is the receiving water and any uneaten or residual drug directly transfers to the water around and bottom sediments under the net pen. For other CAAP facilities, like flow-through and recirculating systems, much of the unmetabolized drug can be bound to feces and other solids in the effluent. Unless all of the solids are captured in these systems, some of the drug is released to the surrounding receiving water bound to the released solids, as well as any of the drug still in aqueous forms.

Using oxytetracycline as an example, the drug is administered through the feed, which presents several challenges. Oxytetracycline is administered in the feed, to sick fish that often have reduced appetites. Most forms of oxytetracycline are not readily assimilated by the fish, so much of the medication in the feed eaten by the fish passes through unmetabolized. Boxall et al. (2001) reported that oxytetracycline is very persistent in manures and manure slurries, soils, and sediments with detection in these media ranging from 9 to over 400 days post treatment. These bound forms of oxytetracycline create the potential for uptake by non-targeted species (i.e., wild populations of fish, crustaceans, and other organisms). Some of the studies reported by Boxall et al. (2001) indicate evidence of oxytetracycline residue in wild species (see Capone et al., 1996 for an example from net pen systems in the western United States).

In the United States, some attention has been given to potential water quality and environmental effects of the release of drugs and chemicals into receiving waters (e.g., Goldburg et al., 2001). EPA's Region 10 office has included requirements in a general permit for CAAPs in Idaho to submit data on disease control drugs, disinfectants, and similar products. As stated in the proposed permit, these data would be used to enable EPA to determine whether there is a reasonable potential for the effluent discharge to cause or contribute to an instream excursion above the state of Idaho's water quality standards. In addition, in the Response to Comments document accompanying the proposed permit, EPA noted that such data were deemed necessary to determine whether aspects of these products' application may have adverse effects on aquatic biota (USEPA, 2002b). Similarly, in a final permit issued to a salmon net pen CAAP in Maine, EPA's Region 1 office required certain limits and monitoring requirements to ensure that the discharge of some chemicals will meet state water quality standards. These provisions include limiting of the discharge of drugs to those approved by FDA for treatment of salmonids; prohibition of prophylactic use of drugs except for specific situations which warrant such use; monthly reporting requirements regarding drug use; monitoring for the presence of copper in sediments if nets are impregnated with copper-based antifoulants; and monitoring for the presence of zinc in sediments if feed contains zinc additives. In addition, EPA reserved the right to require the permittee to monitor the discharge of FDA approved drugs if EPA suspects that the frequency, concentration, or method of application creates a reasonable potential to cause or contribute to a violation of state water quality standards (USEPA, 2002a).

9.6 OTHER POTENTIAL IMPACTS

Maintenance of the physical plant of aquaculture facilities can generate organic materials that may contribute to water quality degradation (NOAA, 1999). For example, the activity of cleaning fouling organisms from net pens can contribute solids, BOD, and nutrients, although these inputs are generally produced only over a short period of time. Cleaning algae from flow-through raceway walls and bottoms similarly generates pollutants in effluent. Net pen facilities in both Maine and Washington are prohibited from cleaning net pens in place and must take them onshore for cleaning.

Some concern about the potential presence of contaminants (e.g., PCBs, dioxins, pesticides, and mercury) in aquatic animals produced at CAAP facilities has been reported and debated in the technical literature. EPA found limited evidence that contaminants, primarily from feed ingredients, could be infrequently present in the aquatic animals and presumably in the effluents. EPA also found that the most comprehensive studies indicate very few problems associated with such contaminants in aquatic animals produced at CAAP facilities.

The Massachusetts Office of Coastal Zone Management asserts that the fish consumption advisories set by the Department of Public Health do not pertain to fish cultured in aquaculture facilities because fish from aquaculture facilities come from clean water sources and do not bioaccumulate contaminants during the short time they are being grown out to market size (Massachusetts Office of Coastal Zone Management, 2001). The World Bank Group argues that aquaculture facilities can minimize public health risks by proper site evaluation and good aquacultural practices because operators of aquaculture facilities have more control over the environment of their cultured fish than anyone has over wild fish, and can therefore reduce health risks (The World Bank Group, 2001).

The Pennsylvania Department of Environmental Protection laboratory conducted testing from Pennsylvania Fish and Boat Commission hatcheries revealed levels of PCBs in trout did not warrant a fish consumption advisory, as the hatchery fish were below the Food and Drug Administration (FDA) tolerance level of two parts per million (ppm). In fact, the PCB levels were found to be less than 0.10 ppm (Pennsylvania Department of Health, 2001; Fish and Boat Commission, 2001). Santerre et al., (2000) studied contaminants in channel catfish, rainbow trout, and red swamp crayfish collected from 8 southern States in the United States. The research revealed that 45% catfish, 72% trout, and 92% crayfish contained no detectable residues of organochlorine, organophosphate, pyrethroid compounds. Of the detectable residues, most were well below FDA action limits for fish. Chlorpyrifos was detected in some samples of catfish, but there is not an established limit for this and these residues were not found in fish collected after the first year of study (Santerre et al., 2000). This study also showed that levels of mercury in the fish were 40 to 100 times lower than the 1-ppm limit set by FDA. In a related study, these researchers found very low levels of 34 pesticides in the same fish species (Scientific America, 2001).

Results from these studies tend to indicate that most aquaculturally grown fish contain very low and safe amounts of potentially harmful pollutants. When they occur, the most likely source of these pollutants is the feed or ingredients used to formulate the feed, although source water or local soil conditions could contribute pollutants as well. A study conducted by Rappe et al., (1998) analyzed a combined catfish feed sample from Arkansas and concluded that one of its ingredients (soybean meal) was highly contaminated with polychlorinated dibenzo-p-dioxens (PCDDs). A more extensive study by the same researchers showed that samples of farm-raised catfish from the southeast US contained significant levels of PCDD, polychlorinated dibenzofurans (PCDF), and PCB. They concluded that the major source for the PCDD, PCDF, and PCB appeared to be from the feed, which, as discovered earlier, contained high levels of PCDD (Fiedler, 1998). The source of contaminants in the catfish feed was identified and subsequently eliminated from the feed ingredients.

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CHAPTER 10

ENVIRONMENTAL BENEFITS OF PROPOSED REGULATION

10.1 INTRODUCTION

EPA anticipates several environmental benefits of the proposed concentrated aquatic animal production (CAAP) regulatory action. These include improvements in water quality and, as a consequence, increases in the recreational and non-use value of affected water bodies. The proposed minimization of releases of non-native species (through best management practices) is also anticipated to better protect aquatic ecosystems and resources. Finally, the proposed action is expected to reduce releases of drugs and other chemicals, and aquatic animal pathogens, into the environment by requiring facilities to develop and implement best management practice (BMP) plans.

EPA has quantified and monetized a subset of the anticipated benefits of the proposed action listed above. The central basis for the quantitative benefits analysis is a water quality modeling assessment that estimates water quality responses to the pollutant loading reductions under technology options described earlier in this document. Specifically, the benefits that EPA has been able to quantify are (a) water quality improvements in stream reaches downstream of flow-through and recirculating systems, and (b) improvements in the recreational use value of these same reaches. Benefits that were not quantified include water quality and ecological responses to pollutant loading reductions at net pen systems and ecological and other water resource benefits from reductions in releases of non-native species, aquatic animal pathogens, and drugs and chemicals used at CAAP facilities. EPA did not quantify or monetize these potential benefits due to lack of readily available assessment modeling tools for such an analysis. Thus, the estimated monetized benefits of the proposed action are based only on a portion of the expected environmental benefits of the proposed regulation.

10.2 BENEFITS ENDPOINTS EVALUATED

EPA considered several possible endpoints or metrics for characterizing the national environmental benefits of the proposed regulation. For receiving waters of representative CAAP facilities, EPA considered comparing baseline and post-regulatory values for specific water quality parameters for which national numeric or narrative criteria had been established (e.g., total nitrogen and total phosphorus). EPA also considered using a composite index of water quality which could, based upon a national contingent valuation survey, be related to households' willingness-to-pay (WTP) for water quality improvements. Finally, EPA considered estimating responses of key biological variables (e.g., presence of pollution tolerant or intolerant species) to water quality changes induced by the regulation. Each of these approaches require analysis of the effect of the proposed regulation on receiving waters of CAAP facilities.

Data limitations precluded detailed site-specific water quality studies for actual representative CAAP facilities. Such analyses would be needed to develop accurate baseline water quality estimates for representative CAAP facilities, which would in turn be preferable bases for benefits estimates. Instead, EPA used a water quality model to simulate a range of potential water quality changes arising from the regulation downstream of CAAP model facilities, using a range of assumed hypothetical background conditions. EPA then used this range of simulated changes to determine a potential range of national economic benefits from water quality improvements, using the composite water quality index and national contingent valuation survey results. EPA also included a qualitative discussion of potential changes in downstream water quality and the impact of these changes on stream impairment as judged by comparison to water quality criteria. These analyses are described in the following sections.

10.2.1 Water Quality Standards and Nutrient Criteria

Water quality criteria reflect the latest scientific knowledge on the effects of water pollutants on public health and welfare, aquatic life, and recreation. These criteria guide states, territories, and authorized tribes in developing water quality standards and ultimately provide a basis for controlling discharges or releases of pollutants into our nation's waterways. Ambient water quality criteria are based solely on data and scientific judgments on the relationship between pollutant concentrations and the effects on aquatic life, human health, and the environment. These criteria do not reflect consideration of economic impacts or the technological feasibility of reducing chemical concentrations in ambient water (USEPA, 2002a). Water quality criteria have been established for ammonia and dissolved oxygen. More information about these criteria is provided in Appendix F. Appendix F also includes information on BOD and solids limits established for water quality protection purposes.

Nutrient criteria represent nutrient levels that protect against the adverse effects of nutrient overenrichment in aquatic environments. The criteria are associated with preventing and assessing eutrophic conditions. Surface waters that meet nutrient criteria would have minimal impacts caused by human activities (USEPA, 2001b). EPA has developed criteria for each of several ecoregions for total phosphorus, total nitrogen, chlorophyll a, and turbidity. More information about these criteria is provided in Appendix F.

10.2.2 Water Quality for Recreational Use

Improvements in water quality change the ways people can use water bodies. Recreational use of water is highly dependent on water quality. The recreational use supported is also an indicator of other benefits derived from the water body, such as use by public water authorities and aesthetic enjoyment. Changes in the recreational use supported by waterways associated with the CAAP regulatory options forms the basis for estimating monetized benefits of the proposal.

Monetized benefits are based on incremental changes in the recreational use supported by water bodies receiving CAAP facility flows. Waters can be classified into a spectrum of permissible recreational uses from boatable, which does not require the water to be suitable for body contact, to swimmable, which requires the water to be nearly potable. A national contingent valuation survey has related changes in water quality along this spectrum to households' willingness to pay (WTP) for water quality improvements (Carson and Mitchell, 1993). EPA used this value, along with estimates of the affected water area and population, to measure the benefits of improved water quality for recreational uses.

Nutrient and solids loadings lead to biological and ecological impacts in the receiving waters. These impacts were described in Chapter 9 of this document. EPA has not separately quantified potential biological and ecological benefits arising from pollutant load reductions. EPA may explore methods for evaluating potential biological and ecological benefits from reduced CAAP pollutant loads for the final regulation.

10.3 OTHER BENEFITS NOT QUANTIFIED

There are several additional categories of potential environmental and economic benefits that EPA has not quantified for the proposed CAAP rule. The following subsections describe these potential areas. EPA believes that these unquantified benefits have the potential to be significant and may pursue quantification of these benefits for the final rule.

10.3.1 Water Quality Benefits from Net Pen Loadings Reductions

EPA estimates that large salmon net pen facilities (i.e., with annual production greater than 500,000 lb) discharge significant pollutant loadings into receiving waters, most frequently marine embayments. For a large salmon facility with an annual production of 3.6 million pounds per year, quantities of BOD_5, total nitrogen, total phosphorus, and total suspended solids discharged annually to the environment are 4,086,153; 350,242; 58,374, and 3,502,417 lbs, respectively. For comparison, the annual domestic wasteload of a city of about 65,800 individuals produces an equivalent annual load of BOD_5. In many cases, facilities may be sited such that adequate flushing prevents water quality degradation in the receiving water. EPA is aware of research that has examined environmental impacts of net pen aquaculture (e.g., Strain et al., 1995; Findlay et al., 1995), as well as recent regulatory activity to address potential environmental concerns with net pen aquaculture (USEPA, 2002c). EPA estimates that under the regulatory options set forth in the proposed CAAP regulation, substantial reductions in net pen pollutant loadings would occur. However, EPA has not evaluated the water quality, biological, recreational use, or other benefits from the loadings reductions anticipated under the proposed CAAP effluent guideline.

10.3.2 Reductions in Escapements

A reduction in the incidences of escapements may have the potential to have economic and ecological benefits because of the large impacts that non-native aquatic species can have, as described in Chapter 9. In addition, sources indicate that equipment-related failures, catastrophic events, and accidents are major causes of escapements from marine aquaculture facilities (Ministry of Agriculture, Food and Fisheries, n.d.). In the proposed CAAP regulation, EPA proposes to require BMPs to minimize potential escapement of non-native species. Although EPA expects reductions in escapements as a result of this requirement, the Agency has not quantified potential environmental or economic benefits from reductions in releases of non-native species from CAAP facilities. EPA may explore methods for evaluating benefits for the final regulation.

10.3.3 Reductions in Drugs and Other Chemicals

EPA's proposed rule requires some regulated facilities develop and implement Best Management Practices (BMP) plans which, among other elements, specifies that facilities' BMP plans must ensure the storage of drugs and chemicals to avoid inadvertent spillage or release into the aquatic animal production facility. Moreover, EPA proposes to require that CAAP permittees comply with reporting requirements under certain situations involving the use of extra-label and unapproved drugs and chemicals at the CAAP facility. EPA expects that implementation of these two provisions of the proposed rule will lead to reductions in releases of drugs or chemicals that may have occurred as a result of inadvertent spillage or release. EPA has not quantified either baseline quantities of drugs and chemicals released to the environment, or potential environmental or economic benefits that might arise from the proposed requirements. EPA may pursue a quantitative benefits analysis for the final regulation.

10.4 BENEFITS MODELING APPROACH

At the time of the proposed rule, EPA focused on modeling CAAP industry impacts to streams and rivers. This enables the quantification of water quality and recreational use benefits for flow-through and recirculating facilities, which are primarily located on streams and rivers, but not for net pen systems which are primarily located in embayments, reservoirs, and other non-riverine systems. Thus, some of the potential benefits associated with the proposed regulation are not captured by this modeling approach. The focus on developing a method for assessing impacts to streams and rivers was shaped by limited availability of environmental and economic modeling tools and data required to quantify benefits other than stream-based water quality and recreational use benefits.

This preliminary focus is reasonable because the majority of CAAP facilities throughout the nation discharge to streams and rivers. Based upon a preliminary analysis of NPDES permit data (data not shown), approximately 87 percent of the facilities contribute to streams and rivers; 8 percent to reservoirs and lakes; and 5 percent to estuaries, bays, and coastal areas. Moreover, among the water bodies identified as “impaired” or included on states’ Clean Water Act Section 303(d) and for which CAAP is cited as one of the potential sources of impairment, rivers and streams are identified more frequently than other water body types (see Chapter 9, section 9.2.3, of this document). Finally, CAAP impacts on rivers and streams can be more completely assessed in a less complex manner (e.g., with a one-dimensional water quality model) than for other water body types – an important consideration when a large number of facility types and scenarios must be evaluated. Nevertheless, EPA believes that environmental benefits from reduced pollutant loadings from net pen facilities may be significant and intends to pursue methods for characterizing these benefits for the final rule.

10.4.1 Water Quality Modeling and “Prototype” Case Study

EPA applied the QUAL2E model to quantitatively assess the water quality-related impacts to receiving stream waters from the proposed CAAP rule. QUAL2E (Enhanced Stream Water Quality Model) is a one-dimensional water quality model that allows both dynamic and steady state flow, providing simulation of diurnal variations in temperature, algal photosynthesis, and respiration (Brown and Barnwell, 1987). The basic equation in QUAL2E solves the advective-dispersive mass transport equation. Water quality constituents simulated include conservative substances, temperature, bacteria, BOD, DO, ammonia, nitrate and organic nitrogen, phosphate and organic phosphorus, and algae (Brown and Barnwell, 1987).

Definition of "Prototype" Stream Hydrology and Hydraulics

To model the impacts of CAAP facilities on receiving waters of flow-through and recirculating systems, EPA developed a "prototype" case study using a range of background flow and water quality conditions. Briefly, a set of model facilities, representing different species, effluent flow rates, and system types (i.e., flow-through and recirculating) was used to reflect the characteristics of the potentially regulated population of facilities. The results of this "prototype" case study for this set of model facilities were then extrapolated based on number of facilities of each type to form a national estimate of water quality-based benefits of the proposed CAAP regulation.

In order to develop the prototype case study, adequate facility location and water quality, hydrology, and hydraulic characteristics for the relevant streams were required. At the time of proposal, such data were available for the Central and Eastern Forested Uplands ecoregion. Although case studies should ideally be developed for all regions in which potentially regulated CAAP facilities are found, sufficient data were not available at time of proposal. The results of the prototype case study should therefore be interpreted with caution. The restricted geographic scope of the analysis is thought to be less of a limitation for flow-through systems because most flow-through systems are located on upland streams such as those used in the analysis described below. EPA intends to explore enhanced approaches to evaluating water quality benefits of CAAP regulation, including expanding the case study approach to other regions in which CAAP facilities are found.

A stream network was developed for a typical system representative of those characteristics most common in the Central and Eastern Forested Uplands ecoregion. Receiving water bodies in the mountains of North Carolina were selected for survey, and the hydraulic and hydrology attributes of those streams in the region that receive CAAP discharges were analyzed. Sources of data utilized for this study included streamflow data, land use data, RF1 stream coverages in GIS, NPDES permit information, and gage data provided by USGS and the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) modeling system (USEPA, 2001a).

To develop the streamflow characteristics of the prototype stream, the following procedure was used. First, USGS streamflow gages located in the North Carolina mountains were reviewed. All CAAP facilities identified in BASINS for the study area are located only on tributaries of the RF1 stream coverage. Therefore, all USGS stream gages located on RF1 stream mainstems, or water bodies receiving substantial flow from tributaries, were removed from the collection of gages under review. Also, all streamgages located below lakes or dams were also removed from the review, since such obstructions to the natural streamflow would affect results from the analysis. The set of remaining streamgages was further reduced by removing those with certain flow criteria which were inconsistent with those for streamgages associated with CAAP facilities in this region. Of the remaining USGS stream gages that met the defined criteria, 12 gages provided sufficient streamflow, depth, and velocity data to determine average depth and velocity verses flow relationships. These relationships and resulting regression equations were utilized in the QUAL2E model to simulate the characteristic hydraulic conditions of the typical CAAP receiving waters in the study area:

$$depth = 0.524 \times Flow^{0.1295}$$
$$velocity = 0.391 \times Flow^{0.2212}$$

where *depth* = stream depth (m)
velocity = streamflow velocity (m/s)
Flow = streamflow (m^3/s)

Baseflow in the model stream is assumed to increase with stream distance. This function is the driving force for much of the dispersion, settling, and dilution processes that control constituent concentrations and their respective longitudinal variations within the stream during low flow. To estimate the gradual increase in baseflow as a function of stream distance, a typical stream in the North Carolina mountains was assessed in GIS using BASINS. The selected stream met the same flow criteria used in the aforementioned hydraulic analysis. Contributing drainage areas were measured at varying locations along the length of the stream, and a correlation was made between distance and size of watershed. Assuming the size of the watershed is proportional to streamflow, a relation between distance downstream and magnitude of flow could be estimated. The resulting equation was used to predict the gradual increase in streamflow corresponding to the segmented distance in the QUAL2E model.

$$Flow(down) = Flow(up) \times 1.16^{d}$$

where *Flow(down)* = downstream flow (m^3/s)

Flow(up) = upstream flow (m^3/s)

d = distance between upstream and downstream locations (km)

Typical values that describe evaporation, temperature correction factors for model calculations, biological processes, climatological influence, and decay and settling or water quality constituents were selected from the literature and using professional judgment (Brown and Barnwell, 1987; Chapra, 1997; Bowie et al., 1985). Parameters were selected based upon the assumed applicability to the study area. Due to the lack of data for a specific site, and since the predictive capability of the QUAL2E model is not to be descriptive of a single stream segment but rather a range of typical scenarios under varying conditions, calibration of the QUAL2E model and the associated parameters (beyond inspection of results for reasonableness according to professional judgment) was not performed for proposal. However, a more thorough calibration and validation of the model can be provided once sufficient water quality data is collected for a specific stream segment and facility discharge.

Definition of Background Flow and Water Quality in the Prototype Receiving Water

To account for differences in background concentrations in the model stream, "low" and "high" background stream water quality scenarios were determined. To estimate the "low" scenario (representing relatively pristine water quality) water quality data was accessed from a typical upland water quality gage maintained by the State of North Carolina (station C1370000). This station is within a primarily wooded tributary in the North Carolina mountains, and has no discharges or other obvious influences within its vicinity that might influence water quality observations within the stream. As a result of data analysis, the water quality concentrations shown in Table 10-1 were assumed. Dissolved phosphorus was assumed as 1 percent of total phosphorus observations and organic phosphorus was assumed to be 75 percent of total phosphorus[1]. Also, nitrate and nitrite concentrations were assumed to constitute 95 percent and 5 percent, respectively, of the combined nitrate + nitrite observations at the gage[2]. Concentrations for the "high" scenario, intended to represent relatively high background

[1] This assumption was based on PCS and DMR monitoring data that show similar ratios.

[2] This was also based on PCS and DMR monitoring data indicating similar ratios.

concentrations of pollutants, were developed based upon an analysis of water quality data from a sample of stream gages in watersheds of North Carolina that encompass a variety of land uses and that are associated with CAAP facilities (see Appendix G).

Table 10-1

Model Stream Background Concentrations

Scenario	BOD_5 (mg/L)	TSS (mg/L)	NH_3 (mg/L)	Organic N (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	Dissolved P (mg/L)	Organic P (mg/L)	DO (mg/L)
Low	0.4	15	0.04	0.15	0.02	0.4	0.001	0.003	6.63
High	3.86	45	0.28	0.57	0.05	0.78	0.159	0.013	6.63

The background concentrations shown in Table 10-1 were modeled with steady state stream flows of both 15 cfs and 30 cfs to represent a range of summer flow conditions in the hypothetical stream. The modeled combinations are described in Table 10-2. These flows were chosen to represent a range of summer low-flow conditions on the "prototype" stream.

Table 10-2
Background Flow/Hydrology Scenarios Used in the Modeling

	Background Water Quality 1 "Low"	Background Water Quality 2 "High"
Background Flow 1	Flow = 15 cfs BOD_5 = 0.4 mg/L TSS = 15 mg/L NH_3 = 0.04 mg/L Organic N = 0.15 mg/L NO_2 = 0.02 mg/L NO_3 = 0.4 mg/L Dissolved P = 0.001 mg/L Organic P = 0.003 mg/L DO = 6.63 mg/L	Flow = 15 cfs BOD_5 = 3.86 mg/L TSS = 45 mg/L NH_3 = 0.28 mg/L Organic N = 0.57 mg/L NO_2 = 0.05 mg/L NO_3 = 0.78 mg/L Dissolved P = 0.159 mg/L Organic P = 0.013 mg/L DO = 6.63 mg/L

	Background Water Quality 1 "Low"	Background Water Quality 2 "High"
Background Flow 2	Flow = 30 cfs BOD_5 = 0.4 mg/L TSS = 15 mg/L NH_3 = 0.04 mg/L Organic N = 0.15 mg/L NO_2 = 0.02 mg/L NO_3 = 0.4 mg/L Dissolved P = 0.001 mg/L Organic P = 0.003 mg/L DO = 6.63 mg/L	Flow = 30 cfs BOD_5 = 3.86 mg/L TSS = 45 mg/L NH_3 = 0.28 mg/L Organic N = 0.57 mg/L NO_2 = 0.05 mg/L NO_3 = 0.78 mg/L Dissolved P = 0.159 mg/L Organic P = 0.013 mg/L DO = 6.63 mg/L

Definition of Pollutant Loading Scenarios

For each regulatory option, EPA estimates the pollution reduction from operating and maintaining specific techniques and practices. EPA traditionally develops pollution loads that are either facility-specific or specific to a "model" facility, described below. Facility-specific compliance loads require detailed information about many, if not all, facilities in the industry. These data typically include production, capacity, water use, wastewater generation, waste management operations, monitoring data, geographic location, financial conditions, and any other industry-specific data that may be required for the analyses. EPA then uses each facility's information to estimate the loads or impact associated with new pollution controls.

When facility-specific data are not available, EPA develops model facilities to provide a reasonable representation of the industry. Model facilities are developed to reflect the different characteristics found in the industry, such as the size or capacity of an operation, type of operation, geographic location, mode of operation, and type of waste management operations. These models are based on data gathered during site visits, information provided by industry members and their associations, and other available information. EPA estimates the number of facilities that are represented by each model. Pollutant loads and their impacts are estimated for each model facility. The model facility approach was chosen for estimating compliance pollutant loads, impacts, and associated benefits for the CAAP industry.

EPA developed three technology-based options (Options 1, 2, and 3) and estimated pollutant loadings under each of these Options using an engineering model. The CAAP engineering model estimates loadings for different facility systems (e.g., flow-through or recirculating), species (e.g., trout, tilapia, or hybrid striped bass), and sizes under these technology Options. Option 1 and Option 2 are grouped for this case study because they estimate the same pollutant loadings (Option 2 adds a health management plan, but does not reduce the loadings estimated with Option 1). Option 3 adds solids polishing to reduce effluent loadings further.

EPA evaluated treatment-in-place at surveyed facilities and determined that the majority have in place all or most of the technology and practices that would be required by the lowest technology Option. However, to estimate the benefits of the regulation for the few facilities that have no treatment in place, EPA also estimated loadings in the absence of treatment ("Raw effluent"). Again, the loadings included under "Raw effluent" estimates are wastes generated in an CAAP system based on feed inputs, which were acquired from literature reviews. Only a minority of CAAP facilities lack some form of treatment. The majority of CAAP facilities employ some form of effluent treatment. The pollutant reductions estimated with Option 1/Option 2, and Option 3 were taken from literature reviews and sampling data. A wastewater treatment model was then used to obtain treatment efficiencies for the reductions, which are expressed in loads. The loadings were converted to concentrations to accommodate the requirements of the QUAL2E model. The conversion equations for flow-through and recirculating systems, along with example calculations for both, are described in Appendix H.

Three pollutant concentrations scenarios (Raw, Option 1/Option 2, and Option 3) were each modeled for different species types and facility production sizes (medium and large). Table 10-3 summarizes the effluent concentrations modeled for each model facility, by option and facility type. The effluent flow for each of the model facility types is summarized in Table 10-4, along with a summary of the total number of facilities for each facility type. Several scenarios of the model CAAP discharge and stream were simulated using a low-flow, steady state procedure in the QUAL2E model framework. The stream was divided into 3 segments, each consisting of 20 computational elements for iterative water quality calculations. The values in Tables 10-1, 10-2, 10-3, and 10-4 were combined to create a variety of scenarios of effluent flows and concentrations and background stream flows and concentrations.

Table 10-3

Modeled Untreated and Treated Effluent Concentrations for Flow-Through and Recirculating Systems

	BOD_5 (mg/L)	TSS (mg/L)	NH_3 (mg/L)	Organic N (mg/L)	NO_2 (mg/L)	NO_3 (mg/L)	Dissolved P (mg/L)	Organic P (mg/L)	DO (mg/L)
Raw effluent (Flow-Through)	11.172	9.576	0.010	0.014	0.001	0.023	0.056	0.053	5.0
Opt 1/Opt 2 (Flow-Through)	2.876	5.453	0.010	0.014	0.001	0.023	0.056	0.050	5.0
Opt 3 (Flow-Through)	1.773	4.985	0.009	0.014	0.001	0.022	0.056	0.047	5.0
Raw effluent (Recirculating)	1,838.66	1,576.00	1.58	2.36	0.20	3.77	11.37	8.67	5.0
Opt 1/Opt 2 (Recirculating)	1,537.10	237.98	0.73	1.09	0.09	1.74	9.22	7.02	5.0
Opt 3 (Recirculating)	768.56	95.19	0.36	0.54	0.05	0.87	9.22	3.51	5.0

Example Water Quality Modeling Output

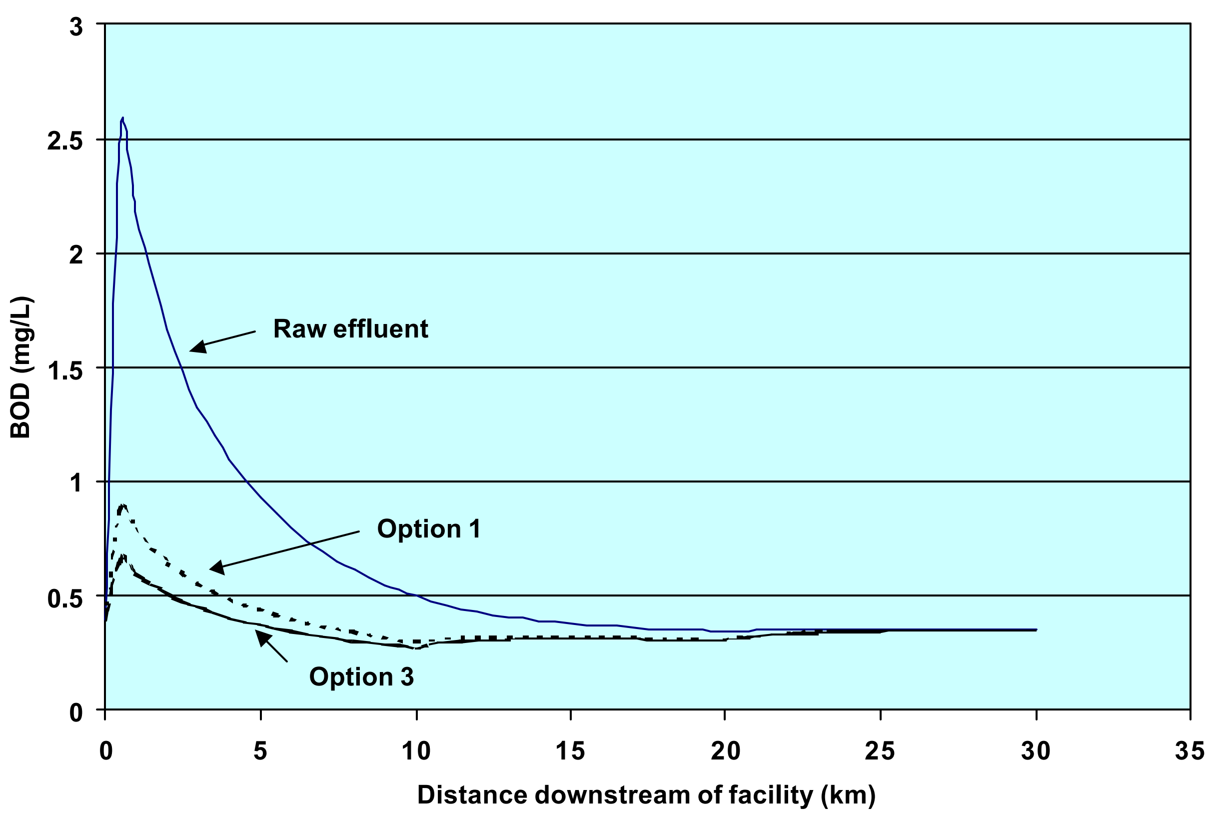
Water quality modeling output were generated for the 30-km "prototype" downstream reach for each model facility (listed in Table 10-4) under the 4 different background water quality and flow scenario described earlier in this section. Pre- and post-regulatory dissolved oxygen, BOD, TSS, and nutrient concentrations were simulated. Figure 10-1 presents an example of simulated BOD downstream of a medium-sized Trout Stockers Flow-Through model facility. For this example, background (receiving water) flow is assumed to be 30 cfs and background water quality is assumed to be relatively pristine ("low" scenario in Table 10-2). Output similar to this for all model facility species/size combinations listed in Table 10-4, for all four different background water quality and flow scenarios (Table 10-2), and for the parameters BOD, TSS, and DO, were generated.. These ouput were considered in a discussion (Section 10.5.1) of potential contributions of facility effluents to stream impairment, expressed as possible exceedences of water quality criteria values. These output were also used as inputs to the monetized benefits calculation described in Section 10.5.2.

Table 10-4

Effluent Flows

Facility Type	Facility Size	Effluent Flow	
		(ft^3/s)	(m^3/s)
Salmon Flow-through	Medium	-	-
	Large	92.7	2.6
Striped Bass Flow-through	Medium	2.7	0.0
	Large	-	-
Tilapia Flow-through	Medium	6.02	0.2
	Large	22.28	0.5
Trout Flow-through	Medium	4.7	0.1
	Large	47.2	1.3
Trout Stockers Flow-through	Medium	4.9	0.1
	Large	20.7	0.6
Striped Bass Recirculating	Large	0.1	0.003
Tilapia Recirculating	Large	0.05	0.001

Figure 10-1
Example QUAL2E output for simulated BOD concentrations downstream of a medium trout stockers flow-through facility on the "prototype" stream



10.4.2 Extrapolation to National-Scale Impacts

For the national monetized benefits calculation, it was necessary to extrapolate monetized benefits that were obtained from the "prototype" water quality modeling results for each model facility, described in Section 10.4.1, to all flow-through and recirculating systems nationwide that fall under the scope of the proposed regulation. Information on the total number of facilities for each facility type, derived from the AAP screener survey described earlier in this document and from USDA's Census of Aquaculture (USDA, 2000), were used to perform this extrapolation. The calculation of monetized benefits arising from water quality improvements at each model facility, and the extrapolation to a national benefits estimate, are described in Section 10.5.2.

10.5 ESTIMATED WATER QUALITY BENEFITS

10.5.1 Water Quality Standards and Nutrient Criteria

EPA briefly reviewed the results of the QUAL2E "prototype" case study analyses for individual model facilities, described in Section 10.4.1 to gain some insight as to whether CAAP facilities could potentially contribute to water quality criteria exceedences and whether the proposed controls could reduce these exceedences. The results suggested that the modeled flow-through and recirculating systems may, under certain background receiving water conditions, contribute to water quality impairments in receiving waters. EPA compared simulated stream water quality in the receiving waters (such as the output shown in Figure 10-1) with national ambient water quality standards that have been established for the protection of aquatic life. Results (Hochheimer and Mosso, 2002) from these initial evaluations show that nutrients, such as total phosphorus (TP), added to streams from CAAP facilities can lead to changes in the observed impairment (as measured by changes in impaired stream length) for different background water quality scenarios. For example, the length of impaired stream ranged from 3.5 to 12.5 km for untreated wastes from model CAAP facilities located on the simulated stream reach. When the regulatory scenarios were imposed on the model facilities, the length of impaired stream was reduced by 0.5 to 2.5 km in smaller facilities and up to 4.5 km in larger facilities.

For other parameters (dissolved oxygen, total nitrogen (TN), and ammonia), the simulated model CAAP facility discharges did not cause impairments relative to the criteria chosen, even when discharging "raw" effluent. This was a common result when a facility with relatively small effluent volumes or pollutant concentrations was assumed to be located on a stream with relatively high background pollutant concentrations and higher flow rate.

Modeling results such as these may be useful for EPA in evaluating water quality changes arising from the proposed CAAP rule in streams and rivers in the context of national (or other) water quality criteria. However, EPA recognized several limitations with the initial case study analysis approach for evaluating water quality standards and nutrient criteria. Presently, there is not an efficient methodology to assign a monetary value to reductions in nutrients for receiving waters. Furthermore, EPA has not considered water quality effects when multiple facilities discharge to the same receiving waters. In addition, the models were not calibrated with site-specific data, which are needed to provide accurate absolute values of modeled baseline and post-regulatory water quality, and therefore the results may be more amenable for analyses that are less sensitive to baseline conditions. Consequently, EPA primarily used the model results for evaluating and monetizing recreational benefits, described in the following section, which require changes in the water quality variables. EPA intends to continue to refine this modeling approach for wider, national application. EPA also intends to create additional model stream case studies to reflect a wider range of stream conditions to better simulate "real world" scenarios.

10.5.2 Recreational Use Benefits

The facility modeling described above also provided estimates of changes in water quality measures in terms of stream lengths. These measures, BOD, DO, and TSS, are also indicators of the type of recreation which may be permitted in the waters. That is, they locate the water body in the spectrum of uses from boatable to swimmable described in Section 10.2.2. If the proposed regulation improves these measures, then more demanding uses may be safely enjoyed and the value of the water body to society increases. With the information from the facility models, estimates of how society values changes in recreational use, and estimates of the population affected, it is possible to place a monetary value on the changes anticipated from the regulation. The method is discussed in some detail below.

Each use category can be defined in terms of a set of water quality indicators. In past benefits assessments, categories were defined discretely so that if all of the indicator measures exceeded all of the criteria for a given use, then the water body could be used for that use. Vaughan (1986) developed a water quality criteria ladder that describes criteria for four types of recreational use (none, boating, fishing, or swimming). For example, a water body with a biological oxygen demand (BOD) between 3 and 4 mg/l is suitable for boating and fishing but not for swimming. All of the indicators must achieve the proscribed level for the water body to support a given level of use. Thus, if the water body had a fecal coliform count greater than 2,000 per 100 ml, even though its BOD was between 3 and 4 mg/l, it would be classified as not boatable because of the high coliform count. With the discrete water quality ladder, the overall use category is the least demanding use supported by any of the water quality indicators.

Once the use of the water body is defined by the Vaughan ladder, the public willingness to pay for changes in use category can be estimated. Carson and Mitchell (1986) conducted a national contingent valuation survey which sought households′ willingness to pay for improvements in the quality of the nation's waters in terms of a use ladder. This survey characterized households′ annual willingness to pay for improvements in freshwater resources from their baseline conditions to fishable and swimmable conditions. The survey sought values for discrete changes from one use category to another which corresponded with the Vaughan water quality ladder.

Several regulatory impact analyses have operationalized the Vaughan/Carson and Mitchell approach to estimate the value of benefits from proposed regulations. When the proposed regulation causes a reach to change category, the household annual willingness to pay from the Carson and Mitchell study is applied to estimate the benefits of the change. Carson and Mitchell (1993) also established that families value water quality changes in their own region more highly than generic national improvements. In past benefit assessments, EPA has attributed two-thirds of the willingness to pay value to households within the state and one-third to households elsewhere. As specific information about where facilities are located was not available at this time, EPA treated all of the benefits estimated in this assessment as being distant from individual households. Thus, only one-third of the Carson and Mitchell willingness to pay amount is applied. As the Carson and Mitchell willingness to pay refers to improvement in ALL of the nation's waters, the benefits are also scaled by the proportion that the length of streams improved in the model facilities analysis is to the total length of all streams in the U.S. These assumptions greatly reduce the level of benefits estimated for this proposed rule.

A Continuous Measure of Benefits

One criticism of the water quality ladder approach is that a rule is only credited with a benefit when it results in a change from one category to another. Thus, even if a regulation causes significant improvements in water quality, if it does not result in a change in use, no benefits are attributed to it. When a marginal change in water quality measures results in a change in use category, large benefits are ascribed to it. This critique is unimportant for major rules affecting many point sources of pollution. It is more significant for rules affecting non-point sources where the diffuse nature of the contaminant makes it unlikely a single rule will shift use categories for many reaches. There has been considerable debate about how to measure benefits continuously in the non-point emissions context.

As an alternative to the stepwise ladder approach, EPA has adopted a change in a single unified index as an indicator of water quality improvement for valuation for this proposed regulation. The Water Quality Index (WQI) combines information from four water quality measures rather than using only the limiting lowest quality criterion to define use category. For this benefit valuation, the model facilities analysis generated estimates of changes in BOD, dissolved oxygen, and TSS. Fecal coliforms were assumed to be unaffected by the proposed rule. These estimates were converted into a WQI based on work by McClelland (1974). McClelland developed a method whereby water quality indicators are converted from whatever units are appropriate for the indicator, e.g., mg/l, NTU, to a single index of water quality valued from zero to 100. One hundred indicates excellent water quality in terms of that particular measure. The conversion equations for each measure are of different, non-linear functional forms and segmented so they cannot be expressed in simple equations. EPA has developed spreadsheet functions which accomplish the conversion (Miles, 2002, personal communication). Once all of the indicators are in the same index units, they can be combined into a single index of overall water quality. This combined WQI is a geometrically weighted average of its four components, such that

$$WQI = DOI^{0.333}\ FEC^{0.314}\ BOD^{0.216}\ TSS^{0.137} + 0.5$$

Where DOI, FEC, BOD, and TSS are water quality indexes for dissolved oxygen, fecal coliforms, biological oxygen demand, and total suspended solids. The weighting exponents were derived by McClelland (1974) using a Delphi approach among water quality experts.

EPA developed a simple method to map the WQI onto the Vaughan water quality ladder in the Meat Products Industry Economic Analysis (USEPA, 2002b). The same method was used to translate changes in combined WQI into changes in water use for this assessment. The mapping is based on the observed combined WQI calculated for all stream reaches in the RF3 database. Each reach is classified as to use category so the average WQI for each use category in the baseline file can be calculated. Assuming WQI values are normally distributed within each use category, placing the upper bound for the category at the mean plus one standard deviation should ensure that 84 percent of observations will fall below the upper bound. Tests with the baseline data indicated that this method of assigning values by WQI tends to assign a lower value than other mapping approaches. Table 10-5 shows the lower threshold WQI for each category. A more detailed description of the mapping and testing is in the Meat Products Industry Economic Analysis (USEPA, 2002b).

Table 10-5

Criteria and Values

Use Category	Lower Threshold (WQI)	Household Annual WTP[a] ($ 1999)	Rate, R ($/WQI, 1999)
No Use	---	---	$ 3.10
Boatable	79.0	$ 245	$ 11.91
Fishable	94.4	$ 429	$ 44.92
Swimmable	99.0	$ 634	---

Source: EPA Meat Products Industry Economic Analysis; WTP values from USEPA, 2001b, CAFOs Economic Analysis.

[a] Total annual willingness to pay for upgrading all U.S. freshwater bodies from baseline quality to the next designated use category, i.e. annual WTP is $634 to move all sub-swimmable waters to use category 3, swimmable.

The Carson and Mitchell willingness to pay values were updated to 1999 values for the recent Concentrated Animal Feeding Operations (CAFOs) regulation benefit assessment to account for changes in income and the value of the dollar. The CAFOs assessment, however, valued only changes in use categories. The continuous WQI method requires that the Carson and Mitchell willingness to pay values be converted to continuous measures of benefits. This rate of change for each use category is calculated so that the total willingness to pay at each breakpoint is equal to the total in the Carson and Mitchell study and shown in Table 10-5. The "no use" category is arbitrarily spread over the whole range from 0 to 79.[1] No value is associated with improvements above the swimmable level, which is a very small range. With each step, the rate of increase in benefits is roughly four times higher than the previous step.

Thus the average household would be willing to pay $3.10 for a one point change in WQI from 50 to 51 in all of the nation's rivers, i.e. an improvement in water quality within the "no use" category. The same household would be willing to pay $11.91 for a one point change in WQI from 83 to 84 in all of the nation's rivers, i.e. an improvement in water quality within the boatable category. Changes that cross category boundaries are valued at the rate for each portion of the categories included. Table 10-6 illustrates the WQI values and changes for the medium size trout stocker flow-through facility, discharging into a stream with high water quality, B.G. 1, and low flow, 15 cfs. The change in WQI for km 29.0 shows the non-linearity of the valuation method. The three point change from a baseline value of 76 to the Option 1/Option 2 value of 79 is valued at $9.30, three times $3.10 the per point value for changes in the non-usable category. The four point change from 76 to 80 for Option 3 is valued at $21.21, three times $3.10 plus $11.91, since the fourth point is in the more valued boatable category. Clearly, the larger values occur in reaches with better water quality.

Each set of WQI values represents the conditions in a 0.5 km reach of the model stream. Thus, the total of the WTP values is the average value per household for that level of change in all of the nation's waters in terms of half kilometers. The bottom of Table 10-6 illustrates the calculation from WQI to benefit value. To place the value on a kilometer basis the total is divided by two. This total value for the model stream was scaled up by the number of facilities identified as similar to the model facility. There were 57 facilities judged to be similar to the medium flow-through trout stocker model facility. This value must then be weighted by the proportion of the nation's waters represented by the

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[1]Mitchell and Carson described non-boatable waters in graphic terms so their value for the change may be an overestimate. However, few water bodies approach a zero WQI, so much less than the full value for the improvement from not usable to boatable can ever be attributed to the regulation.

Table 10-6

Example of Application of Water Quality Index Use

Trout Stockers, Flow-through Facility, Medium Size, Receiving waters flow 15 cfs, High water quality, i.e., B.G. 1						
	Water Quality Index (WQI)			**Willingness to Pay for Change**		
Km	Baseline	Option ½	Option 3	Option ½	Option 3	
30	80	80	80	-	-	
29.5	75	78	79	9.30	12.40	
29.0	76	79	80	9.30	21.21	
28.5	77	80	81	18.11	30.02	
28.0	78	81	81	26.92	26.92	
27.5	79	81	82	23.82	35.73	
27.0	80	82	82	23.82	23.82	
26.5	80	82	82	23.82	23.82	
26.0	81	83	83	23.82	23.82	
25.5	81	83	83	23.82	23.82	
25.0	81	83	83	23.82	23.82	
24.5	82	83	83	11.91	11.91	
24.0	82	83	84	11.91	23.82	
23.5	82	84	84	23.82	23.82	
23.0	83	84	84	11.91	11.91	
22.5	83	84	84	11.91	11.91	
22.0	83	84	84	11.91	11.91	
21.5	83	84	84	11.91	11.91	
21.0	83	84	84	11.91	11.91	
20.5	84	84	84	-	-	
20.0	84	84	85	-	11.91	
19.5	84	84	84	-	-	
19.0	83	84	84	11.91	11.91	
18.5	83	84	84	11.91	11.91	
18.0	83	84	84	11.91	11.91	
17.5	83	84	84	11.91	11.91	
17.0	83	84	84	11.91	11.91	
16.5	84	84	84	-	-	
	No change Km 16.0-9.0					
8.5	84	84	84	-	-	
8.0	83	84	84	11.91	11.91	
7.5	83	83	83	-	-	
	No change Km 8.0-4.0					
3.5	83	83	83	-	-	
3.0	83	84	84	11.91	11.91	
2.5	84	84	84	-	-	
	No change Km 2.0-0.0					
Total				$397.11	$459.76	
Total/2				$198.55	$229.88	
Number of facilities of model type			x 57	11318	13103	
Total km of streams in U.S.			/1,067,019	0.0106	0.0123	
Out-of-Locality factor			x 0.33	0.0035	0.0041	
Total Households in U.S.			x 103,874,000	$363,584	$420,944	

Source: EPA Analysis

length of the prototype stream improved in the model analysis. EPA assumed that each reach is valued equally and divided the total value by the total number of stream kilometers in the nation.

Carson and Mitchell found that households placed a greater value on changes in water quality close to home where they were likely to have access to and use the water resource. As specific information on the location of each facility is not available at this time, EPA could not identify the number of households that would consider each facility as local. As a conservative assumption, EPA assumed that all of the reaches would be considered non-local and so receive only one third of the total WTP. In the trout stocker example, this process resulted in an estimated benefit value per household of 0.35 cents and 0.41 cents for Option 1/Option 2 and 3, respectively. EPA scaled this value up by the number of households in the country in 1999, 103.9 million (U.S. Census Bureau, 2000), to yield national benefits for this class of facility. The values derived for all classes of facilities in this way were then summed to yield a national estimate of benefits.

The Mitchell-Carson WTP values represent annual household values in 1999 dollars. EPA has no intuition as to the timing of these benefits and no dynamic modeling was undertaken to suggest variation in benefits through time. Thus, the estimate of total benefits represents a typical year once the proposed regulation is in place. When the same discount rate is used to calculate both the present value and annualized value of a stream of equal flows through time, the annual flow is the same as the annualized value. So, the total benefits stated may be considered an annualized value for any time period and any discount rate (unless different discount rates are to be used for the present value and annualization calculations).

As discussed in Section 10.4, each facility model was run with two flow regimes, 15 and 30 cfs, and two ambient quality levels in the receiving waters. This resulted in four different benefit estimates for each model facility under each option. The largest benefits occurred when CAAP facility outflow was a substantial portion of the total stream flow and when the regulation resulted in substantial improvement in the quality of the outflow. The maximum among the four estimates was considered the high end of the range of benefits and the minimum was considered the low end of the range. Each model facility type was considered separately and all of the minima and maxima summed to yield the national range of benefits in 1999 dollars.[1]

Benefit Valuation Results

As discussed above, data was only available at this time to estimate benefits of flow-through and recirculating systems. Table 10-7 shows the overall benefits if Option 1/Option 2 and 3 are applied to all of the facilities in the current database. Eleven facilities do not achieve Option 1/Option 2 standards.[2] Implementing the Option 1/Option 2 BMPs for these facilities would improve water quality in their receiving streams and generate a benefit of $16,000 to $77,000. Implementing Option 3 for all facilities includes upgrading those facilities not up to Option 1/Option 2 standards and installing solids polishing at 13 large facilities. It would generate benefits of $34,000 to $207,000. Table 10-7 shows the benefits that could be achieved if the standards of Option 3 were applied to all medium and large facilities.

The proposed option, however, applies Option 1/Option 2 standards to medium sized facilities while requiring Option 3 BMPs for large facilities. Table 10-8 shows how the benefits of the two options are combined to generate a total benefit estimate for the Proposed Option. The Option 1/Option 2 and Option 3 columns in Table 10-8 show only those benefit values which will be realized under the proposed option. Thus, all of the medium sized facilities show no benefits from Option 3 since this option will not apply to them and all of the large facilities show no benefits for Option 1/Option 2 since they will meet Option 3 standards.

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[1] Different elements of the development of the regulation have required re-statement of the results in various constant dollar base years. The 1999 constant dollar results are shown above to maintain the direct connection with the CAFO and Meat Products documentation. Results may be re-stated in any base year using the consumer price index for all urban consumers (CPI-U).

[2] The database contains 100 facilities. Thirteen (13) are large, and 87 medium sized. One large and 10 medium sized facilities do not use Option 1/Option 2 BMPs. So, 77 medium sized facilities in the database already comply with Option1/Option2 in the baseline and will not generate any additional benefits as a result of the proposed rule. The 13 large and 10 non-compliant medium facilities are the basis for this assessment.

Table 10-7
National Benefits from CAAP Facility Regulatory Options when Applied to All Facilities
(Annualized difference from baseline; 2000 constant dollars)

Subcategory	Annual Production Level (lbs)	Option 1		Option 3	
		Minimum	Maximum	Minimum	Maximum
Flow-Through	100,000 to 475,000	$12,249	$66,188	$24,242	$160,430
	>475,000	$4,117	$10,984	$6,897	$25,400
Recirculating	100,000 to 475,000	$0	$0	$0	$0
	>475,000	$0	$0	$3,242	$21,564
Total		$16,367	$77,172	$34,381	$207,394

Note: Entries may not sum due to rounding.
Source: EPA Analysis

Table 10-8
National Benefits from the Proposed Option
(Annualized difference from baseline; 2000 constant dollars)

Subcategory	Annual Production Level (lbs)	Option 1		Option 3		Proposed	
		Min.	Max.	Min.	Max.	Min.	Max.
Flow-Through	100,000 to 475,000	$12,249	$66,188	$0	$0	$12,249	$66,188
	>475,000	$0	$0	$6,897	$25,400	$6,897	$25,400
Recirculating	100,000 to 475,000	$0	$0	$0	$0	$0	$0
	>475,000	$0	$0	$3,242	$21,564	$3,242	$21,564
Total		$12,249	$66,188	$10,139	$46,964	$22,389	$113,152

Note: Entries may not sum due to rounding.
Source: EPA Analysis

The annualized national monetized benefits for the change from baseline to the post-regulatory condition for the proposed option are estimated to range from $22,000 to $113,000 (2000 dollars). Almost half of the benefits are attributable to the medium sized trout stocker flow-through facility model that encompasses 7 of the 23 facilities included in this assessment.

The Carson and Mitchell survey question requested an overall value so the total willingness to pay based on their survey results may be considered to include aesthetic and non-use values, as well as recreational and other use values.

10.6 UNQUANTIFIED BENEFITS

EPA has quantified and monetized a subset of the anticipated benefits of today's proposed action as described in this chapter. In summary, the central basis for the quantitative benefits analysis is a water quality modeling assessment that estimates water quality responses to the pollutant loading reductions under technology options described earlier in this document. Specifically, the benefits that EPA has only been able to quantify and monetize are improvements in the recreational use value of these same reaches.

Several potential benefits associated with the proposed regulation were not quantified. These include water quality and ecological responses to pollutant loading reductions at net pen systems; and ecological and other water resource benefits from reductions in releases of non-native species, aquatic animal pathogens, and drugs and chemicals used at CAAP facilities. EPA did not quantify or monetize these important benefits due to lack of assessment modeling tools readily available for such an analysis. For these reasons, as well as for the assumptions that were made in the benefits monetization calculations due to lack of data on facility locations (see section 10.5.2), the estimated monetized benefits of the proposed regulatory action are believed to represent a lower bound of potential benefits of the proposed regulation.

10.7 REFERENCES

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CHAPTER 11

COST-BENEFIT COMPARISON AND UNFUNDED MANDATES REFORM ACT ANALYSIS

11.1 COST-BENEFIT COMPARISON

Table 11-1 summarizes the social costs and benefits of the proposed rule. The estimated pre-tax annualized compliance cost is $1.51 million in 2000 dollars for the proposed rule (see Table 6-5). All of the CAAP facilities in the proposed scope currently permitted, so incremental administrative costs of the regulation are expected to be negligible. However, Federal and State permitting authorities will incur a burden for tasks such as reviewing and certifying the BMP plan and reports on the use of drugs and chemicals. EPA estimated these costs at approximately $10,011 for the three-year period covered by the information collection request (EPA, 2002, Table 9) or roughly $3,337 per year. That is, the recordkeeping and reporting burden to the permitting authorities is less than two-tenths of one percent of the pre-tax compliance cost for the proposed rule. The costs are shown using both a 7 percent discount rate and a 3 percent discount rate in Table 11-1.

The monetized benefits are based on the Carson and Mitchell (1993) contingent valuation estimates of an annual willingness to pay. Hence, the total willingness to pay derived from those values is an annual amount. The model facility approach did not provide any intuition about the timing of compliance or the dynamics of when benefits would accrue, so the benefit analysis is based on the environmental effects achieved when the proposed regulation is fully implemented. There is no variation through time. The annualized value of a level annual flow is equal to the annual flow itself, when the rate for discounting and annualization are the same. Thus, the annualized benefits are the same as the annual benefits no matter what discount rate is applied. The estimated quantified and monetized benefits of the rule range from $0.022 million to $0.113 million. These values are likely to be underestimates because EPA can fully characterize only a limited set of benefits to the point of monetization. Section 10.6 in this report describes several types of benefits—those that can be both quantified and monetized; those that can be quantified but not monetized; and those that cannot be quantified or monetized.

Table 11-1

Estimated Pre-Tax Annualized Compliance Costs and Monetized Benefits

Production System	Number of Regulated CAAPs	Pre-tax Annualized Cost (Millions, 2000 dollars) Discount Rate 7%	3%	Annualized Monetized Benefits* (Millions, 2000 dollars) Min	Max
Flow-through	181	$1.31	$1.20	$0.019	$0.091
Recirculating	21	$0.11	$0.11	$0.003	$0.022
Net Pen	20	$0.09	$0.08	---	---
Industry Total	222	$1.51	$1.39	$0.022	$0.113
State and Federal Permitting Authorities		$0.003	$0.003		
Estimated cost of the proposed rule		$1.513	$1.393	$0.022	$0.113

**Monetized benefits are not scaled to the national level.*

The monetized benefits are based on the 128 flow-through and recirculating systems from the screener data (i.e., are not scaled to the national level) because EPA was not able to estimate a representative national scaling factor. Hence, Table 11-1 compares annualized compliance costs associated with 222 facilities to annualized benefits from 128 facilities.

11.2 UNFUNDED MANDATES REFORM ACT ANALYSIS

11.2.1 Background

Title II of the Unfunded Mandates Reform Act of 1995 (Public Law 104-4; UMRA) establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and tribal governments as well as on the private sector. Under Section 202(a)(1) of UMRA, EPA must generally prepare a written statement, including a cost-benefit analysis, for proposed and final regulations that "includes any Federal mandate that may result in the expenditure by State, local, and tribal governments, in the aggregate or by the private sector" in excess of $100 million per year.[1] As a general matter, a federal mandate includes Federal Regulations that impose enforceable duties on State, local, and tribal governments, or on the private sector (Katzen, 1995). Significant regulatory actions require Office of Management and Budget review and the preparation of a Regulatory Impact Assessment that compares the costs and benefits of the action.

State and tribal government facilities are within the scope of the regulated community for the proposed aquatic animal production industry effluent limitations guidelines, see Chapter 2. EPA has determined that this rule would not contain a Federal mandate that may result in expenditures of $100 million or more for State, local, and tribal governments, in the aggregate, or the private sector in any one year. The total annual cost of this rule is estimated to be $1.5 million. Thus, the proposed rule is not subject to the requirements of Sections 202 and 205 of the UMRA. The facilities which are affected by the proposed rule are direct dischargers engaged in concentrated aquatic animal production. These facilities would be subject to the proposed requirements through the issuance or renewal of an NPDES permit either from the Federal EPA or authorized State governments. These facilities should already have NPDES permits as the Clean Water Act requires a permit be held by any point source discharger before that facility may discharge wastewater pollutants into surface waters. Therefore, the proposed rule could require these permits to be revised to comply with revised Federal standards, but should not require a new permit program be implemented.

EPA has determined that this rule contains no regulatory requirements that might significantly or uniquely affect small governments. EPA is not proposing to establish pretreatment standards for this point source category which are applied to indirect dischargers and overseen by Control Authorities. Local governments are frequently the pretreatment Control Authority but since this regulation proposes no pretreatment standards, there would be no impact imposed on local governments. EPA proposed requirements are not expected to impact any tribal governments, either as producers or because facilities

[1] The $100 million in annual costs is the same threshold that identifies a "significant regulatory action" in Executive Order 12866.

are located on tribal lands. Thus, the proposed rule is not subject to the requirements of section 203 of UMRA.

EPA, however, is responsive to all required provisions of UMRA. In particular, the Economic Analysis (EA) addresses:

- Section 202(a)(1)—authorizing legislation (Section 1 and the preamble to the rule);
- Section 202(a)(2)—a qualitative and quantitative assessment of the anticipated costs and benefits of the regulation, including administration costs to state and local governments (Sections 6 and 9 as well as this Chapter);
- Section 202(a)(3)(A)—accurate estimates of future compliance costs (as reasonably feasible; Section 6);
- Section 202(a)(3)(B)—disproportionate effects on particular regions, local communities, or segments of the private sector. EPA identified no disproportionate impacts as a result of the proposed rule (Chapter 7);
- Section 202(a)(4)—effects on the national economy. Due to the small cost associated with the proposed rule (less than $2 million), EPA anticipates no discernable effects on the national economy.
- Section 205(a)—least burdensome option or explanation required (this Chapter).

The preamble to the Rule summarizes the extent of EPA's consultation with stakeholders including industry, environmental groups, states, and local governments (UMRA, sections 202(a)(5) and 204).

11.2.2 Potential Impacts on Non-Commercial Facilities

EPA identified 142 non-commercial flow-through facilities including Federal, State, Tribal, and Academic/Research facilities, see Table 7-1. As mentioned in Section 5.13, EPA imputed revenues for non-commercial facilities based on the market value of production. Under the proposed rule: seven facilities show an impact at a 3 percent revenue test threshold; one facility shows an impact at a 5 percent revenue test threshold; and no facilities show impacts under a 10 percent revenue test threshold.

11.2.3 Summary

Pursuant to section 205(a)(1)-(2), EPA has selected the "least costly, most cost-effective or least burdensome alternative" consistent with the requirements of the Clean Water Act (CWA) for the reasons discussed in the preamble to the rule. EPA is required under the CWA (section 304, Best Available Technology Economically Achievable (BAT)) to set effluent limitations guidelines and standards based on BAT considering factors listed in the CWA such as age of equipment and facilities involved, and processes employed. EPA is also required under the CWA (section 306, New Source Performance Standards (NSPS)) to set effluent limitations guidelines and standards based on Best Available Demonstrated Technology. The preamble to the proposed rule and Chapter 8 review EPA's steps to mitigate any adverse impacts of the rule. EPA determined that the rule constitutes the least burdensome alternative consistent with the CWA.

11.3 REFERENCE

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APPENDIX A

INDUSTRY PROFILE SUPPORTING TABLES

Table A-1

U.S. Fish and Wildlife Facilities

Abernathy Salmon Culture Technology Center
Alchesay - Williams Creek NFH Complex*
Allegheny NFH*
Bears Bluff NFH
Bozeman FTC*
Carson NFH
Chattahoochee Forest NFH*
Coleman NFH
Craig Brook NFH
Creston NFH*
Dale Hollow NFH*
Dexter NFH & TC
Dworshak NFH*
Eagle Creek NFH
Edenton NFH
Ennis NFH*
Entiat NFH
Erwin NFH*
Garrison Dam NFH*
Gavins Point NFH*
Genoa NFH*
Green Lake NFH*
Greers Ferry NFH*
Hagerman NFH
Harrison Lake NFH
Hiawatha Forest NFH
Hotchkiss NFH*
Inks Dam NFH*
Iron River NFH*
Jackson NFH*
Jones Hole NFH*
Jordan River NFH*
Kooskia NFH
Lahontan NFH*
Lamar FTC
Leadville NFH*
Leavenworth NFH
Little White Salmon - Willard NFH
Livingston Stone NFH
Makah NFH
Mammoth Spring NFH*
Mescalero NFH*
Nashua NFH*
Natchitoches NFH
Neosho NFH
Norfork NFH*
North Attleboro NFH*
Orangeburg NFH
Ouray NFH
Pendills Creek NFH*
Pittsford NFH*
Quilcene NFH
Quinault NFH
Richard Cronin NSS
San Marcos NFH & TC
Saratoga NFH
Spring Creek NFH
Tishomingo NFH
Uvalde NFH
Valley City NFH
Warm Springs NFH - Region 1
Warm Springs NFH -Region 4*
Welaka NFH
White River NFH*
White Sulphur Springs NFH
Willard NFH
Willow Beach NFH*
Winthrop NFH
Wolf Creek NFH*

Source: FWS, 2000a through 2000c
NFH: National Fish Hatchery
NTC: National Fish Technology Center
*: also listed as receiving fish or fish eggs from other FWS hatcheries.

Table A-2

Warmwater State Hatcheries

State	Description	Annual Distributions
IA	Total of 6 hatcheries Spirit Lake (SL): walleye, muskellunge Rathbun (R): channel catfish, walleye, saugeye, largemouth bass Fairport (F): largemouth bass, bluegill, northern pike, walleyes, saugeyes, channel catfish, white amur	Walleye: 60-70 million fry (SL), 35 million fry (R); 60,000 fingerlings (R) Muskellunge: (SL) Catfish: 500,000 (R) Saugeye: 5 million fry (R) Bass: 15,000 fingerlings (R)
ID	Total of 22 hatcheries* Kootenai, Sandpoint, Clark Fork, Cabinet George, Mullan, Clearwater, Rapid River, Oxbow, Mc Call, Pahisimeroi, Sawtooth, Henrys Lake, Mackay, Ashton, Eagle, Nampa, Haysur, Hagerman, Niagara Springs, American Falls, Grace, Magic Valley	Together produce 23 million fish*
IN	Total of 8 hatcheries* Avoca, Cikana, Driftwood, East Fork, Fawn River, Mixsawbah, Bodine	
KN	Total of 4 hatcheries Milford (M): walleye, sauger, saugeye wiper, striped bass fry, channel and blue catfish fingerlings, paddle intermediates. Pratt (P): walleye, wiper, sauger, saugeye, largemouth bass, channel catfish, bluegill. Meade (Me): largemouth bass, redear sunfish, smallmouth bass, grass carp. Farlington (F): striped bass, channel catfish, blue catfish, wipers, walleye, saugeye, bluegill, redear sunfish, grass carp.	Walleye: 55-65 million fry (M) Blue Catfish: 50,000 (M) Channel Catfish: 500,000 (M)
KS	Total of 2 hatcheries* Minor Clark, Frankfurt	
LA	Booker Fowler	Fish Stocking in LA Florida Largemouth Bass: 4,869,758 Channel Catfish: 127,759 Blue Catfish: 42,933 Flathead Catfish: 15,561 Bluegill/Redear Sunfish: 217,532 Paddlefish: 533,379

Table A-2 (cont.)

State	Description	Annual Distributions
MA	Total of 5 hatcheries* Roger Reed: northern pike	
MI	Total of 6 hatcheries* Harrietta, Wolf Lake	
MN	Walleye: 17 spawning stations, 15 hatcheries (9 of which also hatch sucker eggs, 5 of which also hatch muskellunge eggs), 300 rearing ponds. Muskellunge: 7 spawning stations, 50 rearing ponds. Sucker (to feed muskellunge): 7 spawning stations.	325 million fish*
MO	Lost Valley Fish Hatchery (40% complete) will produce largemouth bass, walleye, muskellunge, hybrid striped bass, catfish, paddlefish, bluegill, hybrid sunfish.	Capacity of 15 million fish per year
MT	1 hatchery* Giant Springs	1.3 million fish
NC	Total of 3 hatcheries* Armstrong, Marion, Table Rock	
ND	1 hatchery* Valley City	
NE	Total of 5 hatcheries Valentine: largemouth bass, bluegill, black crappie, channel catfish, tiger musky Calamus: walleye, hybrid bass, trout. Also planned: yellow perch, largemouth bass, bluegill, hybrid muskie North Platte: walleye, northern pike, channel catfish	Valentine: northern pike - 3 million eggs walleye - 60 million eggs yellow perch - 5 million eggs largemouth bass - 300,000 bluegill - 1 million black crappie - 50,000 channel catfish - 18,000 tiger musky - 7,000
NH	Total of 6 hatcheries* Berlin, Twin Mountain, Warren, New Hampton, Powder Mill, Milford	

Table A-2 (cont.)

State	Description	Annual Distributions
NJ	2 hatcheries Charles O. Hayword (Hackettstown): channel catfish, walleye, muskellunge, northen pike, tiger muskie, largemouth and smallmouth bass, hybrid striped bass	500,000 to 1 million*
NM	Total of 6 hatcheries* Seven Springs, Glenwood, RockLake	
NY	Total of 12 hatcheries* Chautauqua: muskellunge, walleye Oneida: walleye, lake sturgeon South Otselic: walleye, tiger muskellunge	Together produce 1 million pounds of fish*
OH	7 hatcheries* Senecaville (S): walleye, saugeye, striped bass, hybrid striped bass, channel catfish St. Mary's: saugeye, channel catfish, yellow perch. Broodstock of largemouth bass. Hebron, Kincaid, London, Put-in-Bay	S: 3 - 5 million fish
OK	Total of 4 hatcheries* Durant, Holdenville, Byron, J.A.Manning	Together produce 25 million fish*
OR	1 facility*	
SC	Total of 7 hatcheries* Dennis Wildlife Center: striped bass Springs Stevens, Glenmore Shirey, Barnwell Cohen Campbell, Cheraw, Walhalla	
SD	Total of 3 hatcheries* Blue Dog Lake (B): northen pike, walleye, yellow perch, largemouth & smallmouth bass, bluegill and crappie	B: >70 million
TX	15 hatcheries* Dindee, Possum Kingdom, Jasper, Texas Freshwater, Brownsville, GCCA Center, Palacios, Perry Bass, Port O'Connor, Rockport, Sabine, Seabrook, Sea Center, A.E.Wood, Heart of the Hills	

Table A-2 (cont.)

State	Description	Annual Distributions
UT	Total of 10 hatcheries* J. Perry Egan, Mammoth Creek, Fountain Green, Mantua, Glenwood, Midway, Kamas, Springville, Loa, Whiterocks	
VA	Total of 9 hatcheries* Vic Thomas: striped bass King & Queen: walleye, channel catfish, American shad, redar, bluegill Buller: muskellunge, smallmouth bass, walleye Front Royal: muskellunge, northen pike, walleye	Together produce 3 to 5 million
VT	Total of 5 hatcheries* Bald Hill, Bennington, Roxbury, Salisbury, Ed Weed	
WI	Total of 14 facilities* Art Oehmecke: muskellunge, walleye, and suckers Gov. Tommy G. Thompson: muskellunge, walleye, northern pike, suckers Lake Mills: northern pike, and walleye Wild Rose: muskellunge, suckers, northern pike, walleye and lake sturgeon.	

* Uncertain whether warm water or cold water facility and/or distribution amount.
Source: State Websites, 2000.

Table A-3

Universities with Fisheries/Fishing/Fish and Game Management Departments

Name	Town	State
University of Alaska, Fairbanks	Fairbanks	AK
Sheldon Jackson College	Sitka	AK
Auburn University	Auburn	AL
University of Arkansas at Pine Bluff	Pine Bluff	AR
University of Arizona	Tuscon	AZ
Humboldt State University	Arcata	CA
University of California Davis	Davis	CA
College of the Redwoods	Eureka	CA
Fullerton College	Fullerton	CA
Modesto Junior College	Modesto	CA
Colorado State University	Fort Collins	CO
Delaware State University	Dover	DE
University of Florida	Gainesville	FL
Florida Institute of Technology	Melbourne	FL
University of Georgia	Athens	GA
Oceanic Institute		HI
Iowa State University	Ames	IA
North Idaho College	Cour d'Aloie	ID
University of Idaho	Moscow	ID
College of Southern Idaho	Twin Falls	ID
Lake Land College	Mattoon	IL
Ball State University	Muncie	IN
Kansas State University	Manhatten	KS
Pittsburg State University	Pittsburg	KS
Kentucky State University	Frankfort	KY
Murray State University	Murray	KY
Louisiana State University and Agricultural and Mechanical College	Baton Rouge	LA
Massachusetts Maritime Academy	Buzzards Bay	MA
University of Massacusetts	Amherst	MA
Frostburg State University	Frostburg	MD
University of Maine	Augusta	ME
Unity College	Unity	ME
University of Michigan	Ann Arbor	MI
Michigan State University	East Lansing	MI

Table A-3 (cont.)

Name	Town	State
Mid Michigan Community College	Harrison	MI
Northern Michigan University	Marquette	MI
Lake Superior State University	Sault St. Marie	MI
Vermilion Community College	Ely	MN
University of Minnesota Twin Cities	Minneapolis-St. Paul	MN
East Central College	Union	MO
Mississippi Gulf Coast Community College-Jefferson Davis Campus	Gulfport	MS
Mississippi State University	Mississippi State	MS
Mississippi Gulf Coast Community College-Perkinston	Perkinston	MS
Miles Community College	Miles City	MT
Haywood Community College	Clyde	NC
North Carolina State University	Raleigh	NC
Brunswick Community College	Supply	NC
North Dakota State University	Fargo	ND
University of North Dakota	Grand Forks	ND
Minot State University-Bottineau Campus	Minot	ND
University of Nebraska- Lincoln	Lincoln	NE
Rutgers, The State University of New Jersey, Cook College	Piscataway	NJ
New Mexico State University	Las Cruces	NM
State University of New York College of Agriculture and Technology at Cobleskill	Cobleskill	NY
Cornell University	Ithaca	NY
State University of New York College of Agriculture and Technology at Morrisville	Morrisville	NY
State University of New York College of Environmental Science and Forestry	Syracuse	NY
Ohio State University- Columbus Campus	Columbus	OH
Hocking Technical College	Nelsonville	OH
Central Oregon Community College	Bend	OR
Oregon State University	Corrallis	OR
Mount Hood Community College	Gresham	OR
Mansfield University of Pennsylvania	Mansfield	PA
Penn State University	University Park	PA
University of Rhode Island	Kingston	RI

Table A-3 (cont.)

Name	Town	State
Clemson University	Clemson	SC
South Dakota State University	Brookings	SD
Tennessee Technological University	Cookeville	TN
Lincoln Memorial University	Harrogate	TN
University of Tennessee	Knoxville	TN
Texas A & M University	College Station	TX
Texas A & M University- Galveston	Galveston	TX
Texas Tech University	Lubbock	TX
Stephen F. Austin University	Nacogdoches	TX
Virginia Polytechnic and State University	Blacksburg	VA
University of Vermont	Burlington	VT
Peninsula College	Port Angeles	WA
University of Washington	Seattle	WA
Northland College	Ashland	WI
Bluefield State College	Bluefield	WV
West Virginia University	Morgantown	WV
University of Wyoming	Laramie	WY

Sources: Barron’s, 2001; The College Board, 2000; and University Websites, 2001.

Table A-4
List of Aquariums in the United States

Name	City	State
Aqua Zoo	Alexandria Bay	NY
Berkshire Museum Aquarium	Pittsfield	MA
Cape Cod Aquarium	Brewster	MA
Cold Spring Harbor Fish Hatchery & Aquarium	Cold Spring Harbor	NY
Gulf of Maine Aquarium	Portland	ME
The Maritime Aquarium at Norwalk	Norwalk	CT
Mystic Marinelife Aquarium	Mystic	CT
New England Aquarium	Boston	MA
New Jersey State Aquarium	Camden	NJ
New York Aquarium	Brooklyn	NY
Ocean Alliance / Whale Conservation Institute	Lincoln	MA
Newport Aquarium	Newport	KY
Tennessee Aquarium	Chattanooga	TN
Clearwater Marine Aquarium	Clearwater	FL
The Florida Aquarium	Tampa / St. Petersburg	FL
Miami Seaquarium	Miami	FL
Alaska SeaLife Center	Seward	AK
Maui Ocean Center	Wailuku, Maui	HI
Oregon Coast Aquarium	Newport	OR
Port Defiance Zoo & Aquarium	Tacoma	WA
The Seattle Aquarium	Seattle	WA
Waikiki Aquarium	Honolulu, Oahu	HI
The Whale Museum	Friday Harbor	WA
Colorado's Ocean Journey	Denver	CO
Belle Island Zoo and Aquarium	Detroit	MI
Great Lakes Aquarium	Deluth	MN
Shedd Aquarium	Chicago	IL
St. Lawrence Aquarium and Ecological Center	Massena	NY
Aquarium of the Americas	New Orleans	LA
Dallas World Aquarium	Dallas	TX
Dauphin Island Sea Lab	Dauphin Island	AL
Marine Life Oceanarium	Gulfport	MS
Texas State Aquarium	Corpus Christi	TX
National Aquarium in Baltimore	Baltimore	MD
The North Carolina Aquarium on Roanoke Island	Manteo	NC
The North Carolina Aquarium at Pine Knoll Shores	Atlantic Beach	NC

Table A-4 (cont.)

Name	City	State
The North Carolina Aquarium at Fort Fisher	Fort Fisher	NC
South Carolina Aquarium	Charleston	SC
Virginia Marine Science Museum	Virginia Beach	VA
Birch Aquarium at Scripps	La Jolla	CA
Cabrillo Marine Aquarium	San Pedro	CA
Long Beach Aquarium of the Pacific	Long Beach	CA
Monterey Bay Aquarium	Monterey Park	CA
Roundhouse Marine Lab and Aquarium	Manhattan Beach	CA
Steinhart Aquarium	San Francisco	CA
Underwater World	San Francisco	CA
Columbus Zoo and Aquarium	Powell	OH
Pittsburgh Zoo and Aquarium	Pittsburgh	PA
Ripley's Aquarium	Orlando	FL
San Antonio Zoological Gardens and Aquarium	San Antonio	TX

Source: http://www.whaleofagoodtime.com

Table A-5
1999 Federal Fish Egg Distribution

			Agency Controlling Receiving Water or Facility						
Species Name	**Total Number of Eggs**	**Percent of Distribution**	**NA**	**Bureau of Indian Affairs**	**Corps of Engineers**	**Indian Tribal (Non-BIA)**	**International**	**Local Government**	**National Biological Service**
NA	252,540	0%	252,540						
Apache Trout	557,310	0%							
Atlantic Salmon	10,574,831	7%					859,345	300	
Brook Trout	266,000	0%							
Brown Trout	3,639,131	2%		416,713					
Bull Trout	115,133	0%							
Channel Catfish	2,043,195	1%							
Chum Salmon	217,465	0%					217,465		
Coho Salmon	1,350,500	1%				900,000	450,000		
Colorado Squawfish	90,000	0%							
Cutthroat Trout	410,834	0%		234,700					
Fall Chinook Salmon	4,102,941	3%				1,948,000		1,200	
Lake Trout	15,432,196	11%							154,445
Landlocked Atlantic Salmon	357,136	0%							
Northern Pike	3,414,000	2%							
Rainbow Trout	37,940,493	26%	4,244,935	727,555		548,784		145,089	69,888
Razorback Sucker	129,580	0%							
Sauger	1,375,000	1%							
Saugeye	4,716,000	3%							
Shortnose Sturgeon	8,000	0%							

Table A-5 (cont.)

			Agency Controlling Receiving Water or Facility							
Species Name	**Total Number of Eggs**	**Percent of Distribution**	**NA**	**Bureau of Indian Affairs**	**Corps of Engineers**	**Indian Tribal (Non-BIA)**	**International**	**Local Government**	**National Biological Service**
Splake	285,800	0%							
Spring Chinook Salmon	680,316	0%							
Steelhead	2,703,105	2%							
Walleye	52,960,000	36%			1,440,000				
Yellow Perch	2,750,000	2%							
Total	146,371,506		4,497,475	1,378,968	1,440,000	3,396,784	1,526,810	146,589	224,333

Table A-5 (cont.)

Species Name	Total Number of Eggs	Percent of Distribution	National Fish Hatchery	Private	State Fish Hatchery	State Government	Tennessee Valley Authority	U.S. Fish & Wildlife Service	U.S. Geological Survey	University
			Agency Controlling Receiving Water or Facility							
NA	252,540	2%								
Apache Trout	557,310	5%						557,310		
Atlantic Salmon	10,574,831	100%				2,512,959		7,202,227		
Brook Trout	266,000	3%				61,000		205,000		
Brown Trout	3,639,131	34%				1,462,525		1,734,273	25,620	
Bull Trout	115,133	1%				10,046		59,212		45,875
Channel Catfish	2,043,195	19%				1,596,595		446,600		
Chum Salmon	217,465	2%								
Coho Salmon	1,350,500	13%				500				
Colorado Squawfish	90,000	1%						60,000	30,000	
Cutthroat Trout	410,834	4%				176,134				
Fall Chinook Salmon	4,102,941	39%				2,136,000			17,741	
Lake Trout	15,432,196	146%				374,211		14,903,540		
Landlocked Atlantic Salmon	357,136	3%						357,136		
Northern Pike	3,414,000	32%						3,414,000		
Rainbow Trout	37,940,493	359%		12,868		13,771,573	1,200	17,795,714	530,998	91,889
Razorback Sucker	129,580	1%						102,600	26,980	
Sauger	1,375,000	13%				1,062,500				312,500
Saugeye	4,716,000	45%			520,000	4,196,000				
Shortnose Sturgeon	8,000	0%						8,000		
Splake	285,800	3%				285,800				
Spring Chinook Salmon	680,316	6%				392,570		243,057	44,689	
Steelhead	2,703,105	26%		15,500		2,687,605				

Table A-5 (cont.)

			Agency Controlling Receiving Water or Facility							
Species Name	Total Number of Eggs	Percent of Distribution	National Fish Hatchery	Private	State Fish Hatchery	State Government	Tennessee Valley Authority	U.S. Fish & Wildlife Service	U.S. Geological Survey	University
Walleye	52,960,000	501%	1,200,000		5,240,000	45,080,000				
Yellow Perch	2,750,000	26%						2,750,000		
Total	146,371,506	100%	1,200,000	28,368	5,760,000	75,806,018	1,200	49,838,669	676,028	450,264

Source: FWS, 2000.

Table A-6
1999 Federal Fish Distribution

			Agency Controlling Receiving Water or Facility												
Species Name	Total Fish Weight	Percent of Distribution	NA	Air Force	Army	Bureau of Indian Affairs	Bureau of Land Management	Bureau of Reclamation	Corps of Engineers	DOJ	EPA	Forest Service	Inter jurisdictional waters	Indian Tribal	International
American Shad	1	0%													1
Apache Trout	31,483	1%												30,928	
Arctic Grayling	14	0%													
Atlantic Salmon	173,210	3%											21,280		132,223
Atlantic Sturgeon	33	0%													
Beautiful Shiner	2	0%													
Black Bullhead	9	0%													
Black Crappie	1,405	0%		2					935						
Bluegill	3,684	0%		2	32	59						8			
Bonytail	6,318	0%						2,802							
Brook Trout	12,588	0%		1,265	200	205			5,591					2,278	
Brown Trout	78,698	1%		1,498	801				34,352			668		13,451	
Cape Fear Shiner	3	0%													
Channel Catfish	77,722	1%			12,059			1,542	2,217			1		29,670	
Chihuahua Chub	14	0%													
Chum Salmon	8,353	0%													8,353
Coho Salmon	425,534	8%												27,778	247,615
Colorado Squawfish	79	0%													
Cutthroat Trout	140,169	3%		5,402	1,391	5,661		45,087	36,011			2,974		17,882	
Desert Pupfish	2	0%													
Fall Chinook Salmon	339,921	6%						14	2,544					3,756	292,578

Table A-6 (cont.)

			Agency Controlling Receiving Water or Facility												
Species Name	**Total Fish Weight**	**Percent of Distribution**	**NA**	**Air Force**	**Army**	**Bureau of Indian Affairs**	**Bureau of Land Management**	**Bureau of Reclamation**	**Corps of Engineers**	**DOJ**	**EPA**	**Forest Service**	**Inter jurisdictional waters**	**Indian Tribal**	**International**
Fathead Minnow	2	0%													
Gila Topminnow	2	0%													
Gila Trout	148	0%										100			
Kokanee	761	0%												332	
Lahontan Cutthroat Trout	74,427	1%												59,929	
Lake Sturgeon	762	0%				669									
Lake Trout	372,450	7%					10,354	8,777						726	85,132
Landlocked Atlantic Salmon	24,818	0%											18,715		5,074
Largemouth Bass	5,264	0%				76		252	1,659			8		146	
Late Fall Chinook Salmon	52,936	1%	27					112							40,539
Leon Springs Pupfish	1	0%													
Northern Pike	1,955	0%				3		359	171						
Paddlefish	39,528	1%							16,812				19,349		
Pallid Sturgeon	480	0%											9		
Rainbow Trout	2,174,839	40%		3,440	20,983	2,067	33	250,630	952,099	406		20,133		273,726	
Razorback Sucker	7,479	0%					330	4,218							
Redbreast Sunfish	1,009	0%													
Shortnose Sturgeon	404	0%							325		1				

Table A-6 (cont.)

			Agency Controlling Receiving Water or Facility												
Species Name	**Total Fish Weight**	**Percent of Distribution**	**NA**	**Air Force**	**Army**	**Bureau of Indian Affairs**	**Bureau of Land Management**	**Bureau of Reclamation**	**Corps of Engineers**	**DOJ**	**EPA**	**Forest Service**	**Inter jurisdictional waters**	**Indian Tribal**	**Inter-national**
Shovelnose Sturgeon	83	0%													
Smallmouth Bass	1,605	0%		201				119	816						
Spring Chinook Salmon	522,143	10%							155					21,540	422,039
Steelhead	825,036	15%													690,099
Striped Bass	42,552	1%	1,492					120	27,152				4,503		4,381
Tiger Muskellunge	581	0%							364						
Walleye	5,452	0%		50		1,067	4	1,400	841						
White Bass	400	0%													
White Crappie	530	0%							530						
Winter Chinook Salmon	1,789	0%													
Woundfin	3	0%													
Yaqui Catfish	270	0%													
Yellow Perch	1,457	0%				14		1,232							
Total	5,458,408	100%	1,519	11,860	35,466	9,821	10,721	316,664	1,082,574	406	1	23,892	63,856	482,142	1,928,034

Table A-6 (cont.)

			Agency Controlling Receiving Water or Facility												
Species Name	**Total Fish Weight**	**Percent of Distribution**	**Navy**	**National Biological Service**	**National Marine Fisheries**	**National Park Service**	**National Resources Conservation Services**	**Private**	**State Gov**	**Local Govt**	**TVA**	**U.S. Fish & Wildlife Service**	**U.S. Geological Survey**	**University**	**Veterans Admin**
American Shad	1	0%													
Apache Trout	31,483	1760%							555						
Arctic Grayling	14	1%						14							
Atlantic Salmon	173,210	9682%		373				71	15,451			3,525	286	1	
Atlantic Sturgeon	33	2%										2	11	20	
Beautiful Shiner	2	0%						2							
Black Bullhead	9	1%											9		
Black Crappie	1,405	79%						110	328	3				27	
Bluegill	3,684	206%					38		61	68		3,416			
Bonytail	6,318	353%						1	2			3,513			
Brook Trout	12,588	704%	227						731	370		1,721			
Brown Trout	78,698	4399%							5,053	648	22,227				
Cape Fear Shiner	3	0%							3						
Channel Catfish	77,722	4344%							26,826	1,401		3,751		255	
Chihuahua Chub	14	1%						14							
Chum Salmon	8,353	467%													
Coho Salmon	425,534	23786%							16,497			133,644			
Colorado Squawfish	79	4%		2				22	22			33			
Cutthroat Trout	140,169	7835%				64		56	22,062			3,579			
Desert Pupfish	2	0%						2							
Fall Chinook Salmon	339,921	19001%			2				2,481			38,466	80		
Fathead Minnow	2	0%												2	

Table A-6 (cont.)

			Agency Controlling Receiving Water or Facility												
Species Name	**Total Fish Weight**	**Percent of Distribution**	**Navy**	**National Biological Service**	**National Marine Fisheries**	**National Park Service**	**National Resources Conservation Services**	**Private**	**State Gov**	**Local Govt**	**TVA**	**U.S. Fish & Wildlife Service**	**U.S. Geological Survey**	**University**	**Veterans Admin**
Gila Topminnow	2	0%						2							
Gila Trout	148	8%										48			
Kokanee	761	43%							429						
Lahontan Cutthroat Trout	74,427	4160%							14,478	0				20	
Lake Sturgeon	762	43%							81		12				
Lake Trout	372,450	20819%		621					9,177			257,663			
Landlocked Atlantic Salmon	24,818	1387%										532	57	440	
Largemouth Bass	5,264	294%					54	12	2,773	98		160	10	16	
Late Fall Chinook Salmon	52,936	2959%							12,258						
Leon Springs Pupfish	1	0%							1						
Northern Pike	1,955	109%					5	141	472	207		595	2		
Paddlefish	39,528	2210%							917			2,405	12	33	
Pallid Sturgeon	480	27%						11	63	6		23		368	
Rainbow Trout	2,174,839	121567%					2,517	6,872	430,578	19,397	148,191	41,683		396	1,688
Razorback Sucker	7,479	418%				1,656			1,235			30		10	
Redbreast Sunfish	1,009	56%										1,009			
Shortnose Sturgeon	404	23%							32			46	0		
Shovelnose Sturgeon	83	5%						1	82						

Table A-6 (cont.)

			Agency Controlling Receiving Water or Facility												
Species Name	**Total Fish Weight**	**Percent of Distribution**	**Navy**	**National Biological Service**	**National Marine Fisheries**	**National Park Service**	**National Resources Conservation Services**	**Private**	**State Gov**	**Local Govt**	**TVA**	**U.S. Fish & Wildlife Service**	**U.S. Geological Survey**	**Uni-versity**	**Veterans Admin**
Smallmouth Bass	1,605	90%					4		254	143		68			
Spring Chinook Salmon	522,143	29186%			61				500			77,827	21		
Steelhead	825,036	46117%							134,218	640				79	
Striped Bass	42,552	2379%		16					3,660			1,208		20	
Tiger Muskellunge	581	32%							217						
Walleye	5,452	305%					30	91	991	208		760	10		
White Bass	400	22%										400			
White Crappie	530	30%													
Winter Chinook Salmon	1,789	100%										1,789			
Woundfin	3	0%						2				1			
Yaqui Catfish	270	15%										270			
Yellow Perch	1,457	81%						40	50			67	54		
Total	5,458,408	100%	227	1,012	63	1,720	2,648	7,464	702,538	23,189	170,430	578,234	552	1,687	1,688

Source: FWS, 2000.

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APPENDIX B

ENTERPRISE BUDGETS LITERATURE SEARCH

Citation	Species	Production System	Measure of Return
*Brannan, Darrell, Kenneth Roberts, and Walter Keithly. *Louisiana Alligator Farming: 1991 Economic Impact*. Louisiana Sea Grant College Program and the Louisiana Department of Wildlife and Fisheries. October.	Alligator	Alligator	Profit $5.33 - $60.06 per animal depending on size.
*Dodson, D.L. and R.L. Degner. 1984. *Budgets and Financial Analyses for Various Alligator Enterprises*. Florida Agricultural Market Research Center, University of Florida, Gainesville. July.	Alligator	Alligator	Internal Rate of Return depending on low, medium, and high sales values: High-cost farm: -171% to 13% Low-cost farm: -135 to 27% High-cost feedlot: -175% to 17%
Heykoop, Jerry and Darren Frechette. 1999. A Dynamic Model of the U.S. Alligator Industry: Lessons for Sustainable Use and Farm Management. Selected paper at the *American Agricultural Economics Association Annual Meeting*, Nashville, TN. August.	Alligator	Alligator	An abstract model; not an enterprise budget
* Adams, Chuck, Stephen G. Holiman, and P.J. Van Blokland. 1993. *Economic and Financial Considerations Regarding the Commercial Culture of Hard Clams in the Cedar Key Area of Florida.* Food and Resource Economics Department, Institute of Food and Agricultural Sciences, University of Florida. May.	Hard Clams	Bottom culture	Net returns to owner/operator for capital, management, labor, and risk: $25,313
Riepe, Jean Rousscup. 1997. *Enterprise Budgets for Yellow Perch Production in Cages and Ponds in the North Central Region, 1994/95*. Purdue University. School of Agriculture. Department of Agricultural Economics. Technical Bulletin Series #111. May.	Yellow Perch	Cage and Ponds	Break-even costs $1.92 to $2.80 per lb

Citation	Species	Production System	Measure of Return
Riepe, Jean Rosscup, Paul B. Brown, and LaDon Swann. 1993. *Analyzing the Profitability of Hybrid Striped Bass Cage Culture.* Aquaculture Extension, AS-487, Illinois-Indiana Sea Grant Program. March.	Hybrid Striped Bass	Cages in Ponds	Break-even price is $1.27 per pound
Yohn, Craig W. No date. *Budget for Raising Trout in Pond Cages.* West Virginia University Extension Service. <www.wvu.edu/~agexten/aquaculture/budget.html Downloaded 12 October 2000.	Trout	Cages in Ponds	Net income of $227 in year 1, $878 in year 2, and $865 year 3 onwards
*JSA. 2001. Joint Subcommittee on Aquaculture. Aquaculture Effluent Task Force (AETF). Economics Subgroup. Trout Enterprise Budget. Delivered by the AETF Economics Subgroup to the AETF Co-chair on 20 June 2001 for transmittal to EPA.	Trout	Flow-through	Per-Pound Profit Margin: NC: $0.06 ID: $0.08 VA: $0.01-$0.21 Profit as % of Sales: NC: 5% ID: 11% VA: 0.5% to 10%
Bacon, J.R., C.M. Gempesaw II, W.W. Lussier, and J.W. Dunn. 1996. Economic Viabilitiy and Animal Health Regulation Effects on a Large Scale Trout Hatchery. *Aquaculture* 143(3-4):245-255.	Trout Egg	Flow-through	Internal Rate of Return: 5% to 15%
Bacon, J.R., C.M. Gempesaw II, I. Supitaningsih, J.A. Hankins. 1994. The Economics of Broiler, Grain, and Trout Production as a Risk Diversification Strategy. *Aquaculture* 127:91-102.	Trout	Flow-through	Internal Rate of Return: Without trout: 7% to 7.5% With trout: 7.7% to 8.7%

Citation	Species	Production System	Measure of Return
Engle, R. Carole and Diego Valderrama. 2002. The Economics of Environmental Impacts on Aquaculture in the United States. In Tomasso, J.R., *Aquaculture and the Environment in the United States*, U.S. Aquaculture Society, A Chapter of the World Aquaculture Society.		Flow-through Ponds	Unit cost ($/kg) increases for pollution control Settling basin $0.01 to $0.10 Storage pond up to $0.02 Constructed wetlands $0.11 Quiescent zones and settling basins for flow-through systems $0.08 to $0.18
Hinshaw, Jeffrey M., Lindsay E. Rogers and James E. Easley. 1990. *Budgets for Trout Production*. Southern Regional Aquaculture Center. SRAC Publication No. 221. January.	Trout	Flow-through	Returns to land, overhead, and management: Small: 15% Large: 21%
Shelton, James L. 1994. *Trout Production*. Aquaculture Technical Series. Georgia Cooperative Extension Service. 94-53-5-94. May.	Trout	Flow-through	Descriptive only (i.e., what costs to consider)
Belle, Sebastian. 1998. The Move Offshore: Costs, Returns and Operational Considerations from the Entrepreneurial Perspective. In Stickney, Robert R. (compiler). *Joining forces with industry: open ocean aquaculture 1998.* Corpus Christi, Texas. TAMU-SG-99-103. Page 61.	Salmon	Net Pen Systems	Abstract only - paper not presented
Forster, John. 1996. Cost and Market Realities in Open Water Aquaculture. In Polk, Marie (ed.). *Open Ocean Aquaculture: Proceedings of an international conference, May 8-10, 1996, Portland, ME.* New Hampshire/Maine Sea Grant College Program. Report # UNHMP-CP-SG-96-9. Pp. 137-149.	Salmon	Net Pen Systems	Profit-per-Pound: $0.16 Profit as a percent of sales: 8%

Citation	Species	Production System	Measure of Return
Engle, Carole R. and Nathan Stone. 1996. *Baitfish Production: Enterprise Budget*. Southern Regional Aquaculture Center. SRAC Publication No. 122. October.	Baitfish	Ponds	$275 (Net returns/acre)
Pounds, Gayle L., Larry W. Dorman and Carole R. Engle. 1991. *An Economic Analysis of Baitfish Production in Arkansas*. Arkansas Agricultural Experiment Station. Division of Agriculture. University of Arkansas. December.	Baitfish (golden shiner, goldfish & fathead minnow)	Ponds	5 acre ponds in 160 water acre farm: $(87.26) 5 acre ponds in 320 water acre farm: $(93.92) 20 acre ponds in 160 water acre farm: $153.48 20 acre ponds in 160 water acre farm: $148.57 20 acre ponds in 640 water acre farm: $168.71 (Net returns/ acre)
Stone, Nathan, Eric Park, Larry Dorman, and Hugh Thomforde. 1997. *Baitfish Culture in Arkansas: Golden Shiners, Goldfish, and Fathead Minnows.* Arkansas Cooperative Extension. Publication MP 386.	Baitfish	Ponds	Annual returns can be $137/acre if the yield is 400 pounds per acre and the price is $2.75 per pound
Engle, Carole R. 1998. *Annual Costs and Returns of Bighead Carp Stocked in Fertilized Earthen Ponds*. University of Arkansas. Cooperative Extension Service. FSA 9079. September	Bighead Carp	Ponds	Net returns are $(127) per acre
Engle, Carole R. 1998. *Annual Costs and Returns of Raising Bighead Carp in Commercial Catfish Ponds.* University of Arkansas. Cooperative Extension Service. FSA 9078. September.	Bighead Carp	Ponds	Raising both Bighead carp and catfish yields returns of $536 per acre (returns for catfish alone are $342)

Citation	Species	Production System	Measure of Return
Dunning, R. No Date a. North Carolina Department of Agriculture and Consumer Services. Division of Aquaculture and Natural Resources. Aquaculture in North Carolina. *Catfish: Inputs, Outputs, and Economics*. Plymouth, NC.	Catfish	Ponds	\$562 (Returns above total costs per water acre) \$0.12 (profit per pound)
Engle, Carole R. and P.-Justin Kouka. 1996. *Effects of Inflation on the Cost of Producing Catfish*. Report submitted to The Catfish Bargaining Association. Pine Bluff, AR.	Catfish	Ponds	Data from 1977 through 1995 show real profit of \$0.00 to \$0.33 per pound (1982 dollars) Fitted trend line for real margins has negative slope.
Engle, Carole R. and Gregory N. Whitis. No Date. *Costs and Returns of Catfish Production in Watershed Ponds*. Arkansas Cooperative Extension Program.	Catfish	Ponds	1 levee - \$102 2 levees - \$65 3 levees - \$6 (net returns/acre)
Engle, Carole R. and H. Steven Killian. 1996. *Costs of Producing Catfish on Commercial Farms in Levee Ponds on Arkansas*. Cooperative Extension Program, University at Pine Bluff.	Catfish	Ponds	Breakeven price \$0.70 to \$0.73 per pound
Kouka, Pierre-Justin and Carole R. Engle. 1994. *Cost of Alternative Effluent Treatments for Catfish Production.* Southern Regional Aquaculture Center. SRAC Publication No. 467. June.	Catfish	Ponds	Break-even price will be an additional \$0.03/lb to \$0.05/lb depending on method of effluent treatment
Kouka, Pierre-Justin and Carole R. Engle. 1996. Economic Implications of Treating Effluents from Catfish Production. *Aquacultural Engineering*. 15(4):273-290.	Catfish	Ponds	break-even prices increase up to \$0.05/lb from incremental pollution control costs
Rode, Robert A. and Carole R. Engle. 1997. *Catfish Production Cost Estimates for Farms with Level Land*. University of Arkansas. Aquaculture/Fisheries Center.	Catfish	Ponds	Breakeven prices range from \$0.61 to \$0.65 per lb.

Citation	Species	Production System	Measure of Return
Stone, Nathan, Carole R. Engle, and Robert Rode. 1997. *Costs of Small-Scale Catfish Production*. Arkansas Cooperative Extension Program.	Catfish	Ponds	Breakeven prices: Total costs $0.85/lb Operating costs $0.61/lb
Wynne, Forrest. 1997. *Budgets for Small Scale Catfish Production to Supply a Fee Fishing Operation.* National Aquaculture Extension Conference. <ag.ansc.purdue.edu/aquanic/publicat/state/ky/catfish.htm> Downloaded on 16 August.	Catfish for fee-fishing operations	Ponds	Profit ranges from $0.12 to $0.67 per lb. Net returns to acre: $306 - $2,213
Avery, Jimmy L., Robert P. Romaire, and W. Ray McClain. 1998. *Crawfish Production: Production Economics, Pond Construction and Water Supply.* Southern Regional Aquaculture Center. SRAC Publication No. 240 revised.	Crawfish	Ponds	For new operations, break-even prices vary from $0.27 to $0.83 per pound
Boucher, Robert W. and J.M. Gillespie. 2001. *Projected Costs and Returns for Crawfish and Catfish Production in Louisiana, 2001.* Louisiana State University. Dept. of Agricultural Economics and Agribusiness. A.E.A Info. Series No. 187.	Crawfish and Catfish	Ponds	Breakeven prices Crawfish $0.27 to $0.77 per pound. Catfish $0.43 to $0.73 per pound Returns per acre $820 - $853
de la Bretonne, Larry W. Jr. and Robert P. Romaire. 1990. *Crawfish Production: Harvesting, Marketing and Economics.* Southern Regional Aquaculture Center. SRAC Publication No. 242. January.	Crawfish	Ponds	Break-even prices vary from $0.37 to $1.9 depending on acreage devoted to production and production in pounds
Dunning, R. No Date b. North Carolina Department of Agriculture and Consumer Services. Division of Aquaculture and Natural Resources. Aquaculture in North Carolina. *Crawfish: Inputs, Outputs, & Economics*. Plymouth, NC.	Crawfish	Ponds	$662 in Yr 2 (Returns above total costs per water acre) [$1.02 per lb $6,619 per farm]

Citation	Species	Production System	Measure of Return
Masser, Michael, Gregory Whitis, and Jerry Crews. 1997. *Production of Crawfish in Alabama.* Alabama Cooperative Extension System. ANR-891. May.	Crawfish	Ponds	Break-even cost per pound is $0.75 including variable and fixed costs but not labor costs
Lutz, Greg C. and Jimmy L. Avery. 1999. *Bullfrog Culture.* Southern Regional Aquaculture Center. Publication No. 436. March.	Frog	Ponds	Descriptive only (discussion of culture and breeding)
Dunning, R. No Date c. North Carolina Department of Agriculture and Consumer Services. Division of Aquaculture and Natural Resources. Aquaculture in North Carolina. *Hybrid Striped Bass: Inputs, Outputs, and Economics.* Plymouth, NC.	Hybrid Striped Bass	Ponds	Year 2 = (1,251) Year 3 = 3,272 (Returns above total costs per water acre) [=(0.67) Yr 2 =0.87 Yr 3 per pound]
Wynne, Forrest. *Outlook for Hybrid Striped Bass Production in Kentucky.* Kentucky State university Cooperative Extension Program.	Hybrid Striped Bass	Ponds	Break-even price ranges between $2 and $3 per pound
Riepe, J. Rosscup. 1997. Costs for Pond Production of Yellow Perch in the North Central Region, 1994-1995. North Central Region Aquaculture Center. Fact Sheet Series #111	Perch	Ponds	Breakeven Prices ranges from $2.14 to $3.48 per pound. Prices range from $2.00 to $3.00 per pound
* Hughes, David W. 1999. *The Impact of the Louisiana Pet Turtle Industry on the State Economy.* Department of Agricultural Economics and Agribusiness, Louisiana State University.	Pet Turtles	Ponds	Not an enterprise budget. Examines impact on gross state product through input-output model.
* JSA. 2001. Joint Subcommittee on Aquaculture. Aquaculture Effluent Task Force (AETF). Economics Subgroup. *South Carolina Shrimp Farm Budget Adaptation.* Delivered by the AETF Economics Subgroup to the AETF Co-chair on 20 June 2001 for transmittal to EPA.	Shrimp	Ponds	Internal Rate of Return: 14.16% - 7 years 13.70% - 12 years

Citation	Species	Production System	Measure of Return
D'Abramo, Louis R. and Martin W. Brunson. 1996. *Production of Freshwater Prawns in Ponds.* Southern Regional Aquaculture Center. Publication No. 484. July.	Shrimp	Ponds	Expected rate of return can be as high as $2,000 to $2,500 per acre
Griffin, Wade L. and Granvil D. Treece. 1999. *A Guide to the Financial Analysis of Shrimp Farming, 1999*. Texas A&M University (TAMU), TAMU-SG-99-502	Shrimp	Pond	Internal Rate of Return 45% to 47%
Chaves, P.A., R. M. Sutherland, and L. M. Laird. 1999. An Economic and Technical Evaluation of Integrating Hydroponics in a Recirculation Fish Production System. *Aquaculture Economics & Management* 3(1):83-91.	Catfish	Recirculating Systems	Internal Rate of Return is 27.3%
Martens, Bradley P. and Ernie W. Wade. 1996. Aquaculture in Rural Development: The Economic Impact of Recirculating Aquaculture Systems on Rural Communities. Paper presented at the *First International Conference on Recirculating Aquaculture Systems*. Symposium 2: Business Plans and Management. 12 pages. (Papers are not paginated consecutively.)	Catfish, striped bass, trout	Recirculating Systems	Net income: Catfish - $128,494 Striped Bass - $190,758 Trout - $66,250
Adams, Charles M. and Robert S. Pomeroy. 1992. Economics of Size and Integration in Commercial Hard Clam Culture in the Southeastern United States. *Journal of Shellfish Research*. 11(1):169-176.	Hard Clams	Recirculating system for hatchery, land-based upflow for nursery, and bottom culture for grow-out	Minimum output for profitability.
Van Wyk, Peter. 2000. Economics of Shrimp Culture in a Freshwater Recirculating Aquaculture System. Paper presented at the *Third International Conference on Recirculating Aquaculture Systems*. Special Session 1—Economics/Computers. 6 pages.	Shrimp	Recirculating Systems	Internal Rate of Return: 12%

Citation	Species	Production System	Measure of Return
Bailey, D.S., J.E. Rakocy, W.M. Cole, and K.A. Shultz. 1997. Economic Analysis of a Commercial-Scale Aquaponic System for the Production of Tilapia and Lettuce. In *Natural Resource, Agriculture, and Engineering Service (NRAES), Tilapia Aquaculture: Proceedings from the Fourth International Symposium on Tilapia in Aquaculture.* NRAES-106. Ithaca, NY. Volume 2: 603-612.	Tilapia	Recirculating Systems	Negative unless paired with lettuce production with 24 tanks
Lutz, C. Greg. 1998. *Greenhouse Tilapia Production in Louisiana.* Arkansas Cooperative Extension. Publication 2705.	Tilapia	Recirculating Systems	Production costs \$1.19/lb. Three-year payback period
Lutz, C. Greg and Kenneth J. Roberts. 1998. Investment and Management Aspects of Owner/operator Scale Greenhouse Tilapia Systems. Paper presented at the *Third International Conference on Recirculating Aquaculture Systems*. Pp. 98-105.	Tilapia	Recirculating Systems	Production costs \$1.19/lb. Three-year payback period
O'Rourke, Patrick D. 1996. The Economics of Recirculating Aquaculture Systems. Paper presented at the *First International Conference on Recirculating Aquaculture Systems*. Symposium 2: Business Plans and Management. 19 pages. (Papers not paginated consecutively.)	Tilapia	Recirculating Systems	Net profit: \$3,260 Break-even volume: \$93,528
Timmons, Michael B. and Paul W. Aho. 1998. Comparison of Aquaculture and Broiler Production systems. Paper presented at the *Second International Conference on Recirculating Aquaculture Systems*. Pp. 190-199.	Tilapia	Recirculating	Cost per kilogram produced Tilapia \$1.62 Catfish \$1.56 Broiler \$0.65
Dunning, Rebecca D., Thomas M. Losordo, and Alex O. Hobbs. 1998. *The Economics of Recirculating Tank Systems: A Spreadsheet for Individual Analysis*. Southern Regional Aquaculture Center. SRAC Publication No. 456. November.	—	Recirculating Systems	Price for tilapia set to \$1.25/lb to make costs

Citation	Species	Production System	Measure of Return
Wade, Edward M., Steven T. Summerfelt and Joseph A. Hankins. 1996. Economies of Scale in Recycle Systems. Paper presented at the *First International Conference on Recirculating Aquaculture Systems*. AES Technical Session 2: Open Papers. 13 pages.	—	Recirculating Systems	Break-even prices Calculated ($/lb): $1.04 to $2.64

* Enterprise budget submitted to EPA from JSA AETF.

APPENDIX C

PRODUCTION THRESHOLDS

MEMORANDUM

SUBJECT: Establishing the Production Threshold for the Concentrated Aquatic Animal Production Proposed Effluent Limitations Guidelines

FROM: Janet Goodwin

TO: The Record

The proposed Effluent Limitations Guidelines (ELG) regulation for the Concentrated Aquatic Animal Production (CAAP) Point Source Category apply to CAAP facilities, but not all CAAP facilities. The proposed ELG regulation established a production threshold of 100,000 pounds produced annually. Any CAAP facility producing this amount or more annually would be subject to the ELG regulation. There is a population of CAAP facilities that will not be subject to this proposed ELG because they will fall below this production threshold. This memo describes the basis for establishing the proposed production threshold.

The establishment of the proposed threshold was largely driven by the results of EPA's economic impact analysis. As described in greater detail in the Economic and Environmental Impact Analysis Document, the measure used to estimate economic impacts was the ratio of incremental compliance costs to revenues from aquaculture sales. EPA estimated compliance costs for model facilities which were originally developed from data in the USDA 1998 Census of Aquaculture. From the Census of Aquaculture, EPA developed model facilities based on the six annual revenue ranges presented in the Census Report[1]. We called the corresponding revenue size categories National 1 through National 6, respectively. The appendices present the ranges for the major species both in terms of annual revenues (taken directly from the Census of Aquaculture) and annual production in pounds (derived from price information combined with the revenue data).

As a result of the preliminary round of technology options and estimates of costs, EPA decided to only consider facilities that would be defined as CAAP facilities under the current regulations found at 40 CFR 122.24 and Appendix C of Part 122. Under this definition, any facility producing cold water species (salmon and trout) listed in the tables in the Appendix that produce less than 20,000 pounds annually would not be considered a CAAP facility. Thus for trout (see Table 2 in the Appendix), National Foodsize Model 1 and Stockers Models 1 & 2 are not considered to be CAAP facilities and were not considered for regulation. For salmon, shown in Table 6 in the Appendix, Foodsize Model1 is below the 20,000 pound threshold and is not considered a CAAP facility. Facilities that produce warm water species (catfish, tilapia, hybrid striped bass and shrimp) in amounts less than 100,000 pounds annually are not considered to be a CAAP facility. (Based on separate analysis, EPA determined that pond systems are outside the scope of the proposed ELG; therefore, catfish and shrimp produced in pond systems were not further analyzed.) For tilapia, National Foodsize Models 1 through 3 are not CAAP facilities and were not considered for regulation (see Table 3 in the Appendix). Likewise, hybrid striped bass National Foodsize Models 1 through 3 are also below the production threshold for CAAP facilities.

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[1]The six revenue categories are: $1,000 to $24,999; $25,000 to $49,999; $50,000 to $99,999; $100,000 to $499,999; $500,000 to $999,999; and $1 million or more.

EPA considered three technology options for the three different production systems in scope of the proposed rule, flow-through systems, recirculating systems and net pen systems. The options are described in detail in the Preamble to the proposed regulation and in the Technical Development Document. The following tables (Tables 1 through 4) present the results of the revenue tests for each of the three technology options considered for this proposal. The revenue tests are based EPA's initial (March 21, 2002) compliance cost estimates and 1998 prices. For non-commercial facilities – such as Federal and state hatcheries, academic and research, and tribal facilities – we imputed a revenue based on annual harvest and commercial prices.

Table 1
Flow-through Systems, Trout, Food Size Fish

Owner	Size	Percent of Facilities Showing Revenue Test Impacts (Option 1)			
		1%	**3%**	**5%**	**10%**
Trout Commercial	2	87%	87%	87%	69%
	3	66%	66%	34%	11%
	4	70%	37%	25%	0%
	5	55%	11%	0%	0%
	6	20%	0%	0%	0%
Trout Federal	6	100%	0%	0%	0%
Trout State	2	85%	85%	85%	55%
	4	25%	0%	0%	0%
	5	92%	51%	2%	0%
Trout Academic	2	100%	100%	100%	0%
	3	0%	0%	0%	0%
Trout Other	2	88%	88%	88%	75%
	5	100%	0%	0%	0%

Table 2
Flow-through Systems, Food Size Fish Other Than Trout

Owner	Size	Percent of Facilities Showing Revenue Test Impacts (Option 1)			
		1%	**3%**	**5%**	**10%**
Salmon Commercial	6	0%	0%	0%	0%
Salmon Federal	2	100%	100%	100%	100%
Salmon Other	6	0%	0%	0%	0%
Striped Bass	4	0%	0%	0%	0%
Tilapia	4	88%	50%	13%	0%
	5	100%	0%	0%	0%
	6	0%	0%	0%	0%

Table 3
Flow-through Systems, Stockers

Owner	Size	Percent of Facilities Showing Revenue Test Impacts (Option 1)			
		1%	3%	5%	10%
Trout Commercial	2	50%	0%	0%	0%
	3	51%	22%	7%	0%
	4	62%	7%	0%	0%
Trout Federal	3	100%	75%	50%	0%
	4	64%	10%	0%	0%
Trout State	2	94%	75%	69%	19%
	3	85%	32%	16%	0%
	4	31%	2%	0%	0%
Trout Other	3	100%	0%	0%	0%
	4	0%	0%	0%	0%
Trout Tribal	3	0%	0%	0%	0%

Table 4
Recirculating Systems and Net Pens

Owner	Size	Percent of Facilities Showing Revenue Test Impacts (Option 1)			
		1%	3%	5%	10%
Recirculating	4	0%	0%	0%	0%
Striped Bass	6	0%	0%	0%	0%
Recirculating	4	75%	0%	0%	0%
Tilapia	5	0%	0%	0%	0%
	6	0%	0%	0%	0%
Net Pens	5	0%	0%	0%	0%
Salmon	6	17%	0%	0%	0%

Based on the results of the revenue tests shown above it was determined that flow-through systems below National Model 4 would incur significant financial impacts under even the least stringent option (Option 1) considered. EPA did not identify any facilities below the National 4 production level for recirculating systems and net pens. Model Facility 4 represented a range of annual production values that varied according to the individual species being considered.

Table 5
Production Ranges for Model Facility 4 by Species

Species	Lower Bound 1998 per Farm Production (pounds)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production
Trout Foodsize	**94,339.62**	192,147.17	**471,697.17**
Trout Stockers	43,668.12	88,941.48	218,340.17
Tilapia Foodsize	58,823.53	120,876.47	294,117.96
Hybrid Striped Bass Foodsize	40,983.61	84,217.21	204,917.62
Salmon Foodsize	50,000.00	102,745.00	249,999.50

As shown by Table 5, the lower bound of the annual production for each of the Model 4 facilities ranges from 41,000 pounds for hybrid striped bass to 94,000 pounds for foodsize trout. Since flow-through systems producing foodsize trout showed the greatest impacts based on the revenue test, and given that these facilities represent the largest class of CAAP facilities in terms of the number regulated, EPA chose this basis to establish the production threshold for the ELG requirements. EPA is proposing to round the production threshold up to100,000 pounds produced rather than the actual value calculated when revenues were converted to pounds based on the reported price per pound.

EPA believes this 100,000 pound production threshold represents a reasonable threshold above which all facilities in scope can comply with the proposed regulatory requirements. Facilities that produce less than 100,000 pounds annually of cold water species are not covered by the proposed ELG regulations based on the economic impacts that would result from the costs to comply, while facilities that produce less than 100,000 pounds annually of warm water species do not meet the definition of a CAAP facility and are thus not covered either.

EPA also proposes to establish tiered requirements for the flow-through subcategory, based on the estimated economic impacts associated with more stringent requirements (Option 2) for the National 4 size flow-through facilities. The results of the revenue tests shows that flow-through facilities in Model Size 4 would experience significant economic impacts if they were required to comply with Option 2 requirements while Model Size 5 and 6 would not experience impacts (see Tables 6 through 8 below). Therefore, EPA proposes to establish a threshold within the flow-through subcategory and establish less stringent requirements for flow-through facilities in Model Size 4. As shown above in Table 5, the Model 4 foodsize trout facility size ranges from 94,336 pounds to 471,700 pounds in annual production. EPA rounded these values to range from 100,000 to 475,000 pounds, and used this production range to represent medium sized flow-through facilities. Facilities that produce aquatic animals in flow-through systems and have an annual production greater than 475,000 pounds annually would have to comply with more stringent requirements based on Option 3 as described in the preamble, Economic and Environmental Impact Analysis and Technical Development Document.

Table 6
Flow-through Systems, Trout, Food Size Fish

Owner	Size	Percent Showing Revenue Test Impacts (Option 2)			
		1%	3%	5%	10%
Trout Commercial	4	100%	70%	70%	3%
	5	55%	11%	0%	0%
	6	20%	0%	0%	0%
Trout Federal	6	100%	50%	0%	0%
Trout State	4	100%	25%	25%	0%
	5	92%	51%	2%	0%
Trout Other	5	100%	0%	0%	0%

Table 7
Flow-through Systems, Food Size Fish Other Than Trout

Owner	Size	Percent Showing Revenue Test Impacts (Option 2)			
		1%	3%	5%	10%
Salmon Commercial	6	100%	0%	0%	0%
Salmon Other	6	100%	0%	0%	0%
Striped Bass	4	100%	0%	0%	0%
Tilapia	4	100%	88%	50%	0%
	5	100%	0%	0%	0%
	6	0%	0%	0%	0%

Table 8
Flow-through Systems, Stockers

Owner	Size	Percent Showing Revenue Test Impacts (Option 2)			
		1%	**3%**	**5%**	**10%**
Trout Commercial	4	100%	49%	7%	0%
Trout Federal	4	100%	54%	10%	0%
Trout State	4	100%	27%	2%	0%
Trout Other	4	100%	0%	0%	0%

Table Appendix 1
Catfish

National Foodsize	Lower Bound 1998 per Farm Production ($)	Lower Bound 1998 per Farm Production (pounds)	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production (pounds)
1	1,000.00	1,351.35	6,893.00	9,314.86	24,999.00	33,782.43
2	25,000.00	33,783.78	34,968.00	47,254.05	49,999.00	67,566.22
3	50,000.00	67,567.57	71,676.00	96,859.46	99,999.00	135,133.78
4	100,000.00	135,135.14	222,538.00	300,727.03	499,999.00	675,674.32
5	500,000.00	675,675.68	695,276.00	939,562.16	999,999.00	1,351,350.00
6	1,000,000.00	1,351,351.35	2,606,890.00	3,522,824.32		

National Broodsize	Lower Bound 1998 per Farm Production ($)	Lower Bound 1998 per Farm Production (pounds)	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production (pounds)
1	1,000.00	1,000.00	6,893.00	6,893.00	24,999.00	27,471.43
2	25,000.00	27,472.53	34,968.00	38,426.37	49,999.00	54,943.96
3	50,000.00	54,945.05	71,676.00	78,764.84	99,999.00	109,889.01
4	100,000.00	109,890.11	222,538.00	244,547.25	499,999.00	549,449.45
5	500,000.00	549,450.55	695,276.00	764,039.56	999,999.00	1,098,900.00
6	1,000,000.00	1,098,901.10	2,606,890.00	2,864,714.29		

National Stockers	Lower Bound 1998 per Farm Production ($)	Lower Bound 1998 per Farm Production (pounds)	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production (pounds)
1	1,000.00	1,000.00	6,893.00	6,893.00	24,999.00	24,270.87
2	25,000.00	24,271.84	34,968.00	33,949.51	49,999.00	48,542.72
3	50,000.00	48,543.69	71,676.00	69,588.35	99,999.00	97,086.41
4	100,000.00	97,087.38	222,538.00	216,056.31	499,999.00	485,435.92
5	500,000.00	485,436.89	695,276.00	675,025.24	999,999.00	970,872.82
6	1,000,000.00	970,873.79	2,606,890.00	2,530,961.17		

National Fry/ Fingerlings	Lower Bound 1998 per Farm Production ($)	Lower Bound 1998 per Farm Production (pounds)	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production (pounds)
1	1,000.00	1,000.00	6,893.00	6,893.00	24,999.00	15,059.64
2	25,000.00	15,060.24	34,968.00	21,065.06	49,999.00	30,119.88
3	50,000.00	30,120.48	71,676.00	43,178.31	99,999.00	60,240.36
4	100,000.00	60,240.96	222,538.00	134,059.04	499,999.00	301,204.22
5	500,000.00	301,204.82	695,276.00	418,840.96	999,999.00	602,409.04
6	1,000,000.00	602,409.64	2,606,890.00	1,570,415.66		

1998 per Farm Production ($) numbers are from 1998 Census of Aquaculture, Table 2., p 4. These numbers were then divided by Average per pound (dollars) in Table 8., pp 18-22. Foodsize were divided by (.74); Broodsize by (.91); Stockers by (1.03); Fingerlings by (1.66).

Table Appendix-2
Trout

National Foodsize	Lower Bound 1998 per Farm Production ($)	Lower Bound 1998 per Farm Production (pounds)	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production (pounds)
1	1,000.00	943.40	8,027.00	7,572.64	24,999.00	23,583.96
2	25,000.00	23,584.91	35,707.00	33,685.85	49,999.00	47,168.87
3	50,000.00	47,169.81	73,918.00	69,733.96	99,999.00	**94,338.68**
4	100,000.00	**94,339.62**	203,676.00	192,147.17	499,999.00	**471,697.17**
5	500,000.00	**471,698.11**	751,456.00	708,920.75	999,999.00	943,395.28
6	1,000,000.00	943,396.23	3,732,614.00	3,521,333.96		
Stockers	**Lower Bound 1998 per Farm Production ($)**	**Lower Bound 1998 per Farm Production (pounds)**	**Average 1998 per Farm Production ($)**	**Average 1998 per Farm Production (Pounds)**	**Upper Bound 1998 per Farm Production ($)**	**Upper Bound 1998 per Farm Production (pounds)**
1	1,000.00	1,000.00	8,027.00	8,027.00	24,999.00	10,916.59
2	25,000.00	10,917.03	35,707.00	15,592.58	49,999.00	21,833.62
3	50,000.00	21,834.06	73,918.00	32,278.60	99,999.00	43,667.69
4	100,000.00	43,668.12	203,676.00	88,941.48	499,999.00	218,340.17
5	500,000.00	218,340.61	751,456.00	328,146.72	999,999.00	436,680.79
6	1,000,000.00	436,681.22	3,732,614.00	1,629,962.45		

1998 per Farm Production ($) numbers are from 1998 Census of Aquaculture, Table 2., p 4. These numbers were then divided by Average per pound (dollars) in Table 9., pp 23-25. Foodsize were divided by (1.06); Stockers by (2.29).

Table Appendix-3
Tilapia

National Foodsize	Lower Bound 1998 per Farm Production ($)	Lower Bound 1998 per Farm Production	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production
1	1,000.00	588.24	6,106.00	3,591.76	24,999.00	14,705.29
2	25,000.00	14,705.88	34,013.00	20,007.65	49,999.00	29,411.18
3	50,000.00	29,411.76	67,576.00	39,750.59	99,999.00	58,822.94
4	100,000.00	58,823.53	205,490.00	120,876.47	499,999.00	294,117.06
5	500,000.00	294,117.65	719,808.00	423,416.47	999,999.00	588,234.71
6	1,000,000.00	588,235.29	3,509,109.00	2,064,181.76		

1998 per Farm Production ($) numbers are from 1998 Census of Aquaculture, Table 2., p 4 (Food fish other than catfish and trout). These numbers were then divided by Average per pound (dollars) in Table 12., p 41. Foodsize were divided by (1.70).

Table Appendix-4
Shrimp

Foodsize	Lower Bound 1998 per Farm Production ($)	Lower Bound 1998 per Farm Production	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production
1	1,000.00	362.32	8,166.00	2,958.70	24,999.00	9,057.61
2	25,000.00	9,057.97	33,980.00	12,311.59	49,999.00	18,115.58
3	50,000.00	18,115.94	65,593.00	23,765.58	99,999.00	36,231.52
4	100,000.00	36,231.88	186,995.00	67,751.81	499,999.00	181,159.06
5	500,000.00	181,159.42	766,667.00	277,777.90	999,999.00	362,318.48
6	1,000,000.00	362,318.84	2,463,833.00	892,693.12		

1998 per Farm Production ($) numbers are from 1998 Census of Aquaculture, Table 2., p 4 (Crustaceans). These numbers were then divided by Average per pound (dollars) in Table 17., p 57. Foodsize were divided by (2.76).

Table Appendix-5
Hybrid Striped Bass

National Foodsize	Lower Bound 1998 per Farm Production ($)	Lower Bound 1998 per Farm Production	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production
1	1,000.00	409.84	6,106.00	2,502.46	24,999.00	10,245.49
2	25,000.00	10,245.90	34,013.00	13,939.75	49,999.00	20,491.39
3	50,000.00	20,491.80	67,576.00	27,695.08	99,999.00	40,983.20
4	100,000.00	40,983.61	205,490.00	84,217.21	499,999.00	204,917.62
5	500,000.00	204,918.03	719,808.00	295,003.28	999,999.00	409,835.66
6	1,000,000.00	409,836.07	3,509,109.00	1,438,159.43		

1998 per Farm Production ($) numbers are from 1998 Census of Aquaculture, Table 2., p 4 (Food fish other than catfish and trout). These numbers were then divided by Average per pound (dollars) in Table 12., p 41. Foodsize were divided by (2.44).

Table Appendix-6
Salmon

Foodsize	Lower Bound 1998 per Farm	Lower Bound 1998 per Farm Production	Average 1998 per Farm Production ($)	Average 1998 per Farm Production (Pounds)	Upper Bound 1998 per Farm Production ($)	Upper Bound 1998 per Farm Production
1	1,000.00	500.00	6,106.00	3,053.00	24,999.00	12,499.50
2	25,000.00	12,500.00	34,013.00	17,006.50	49,999.00	24,999.50
3	50,000.00	25,000.00	67,576.00	33,788.00	99,999.00	49,999.50
4	100,000.00	50,000.00	205,490.00	102,745.00	499,999.00	249,999.50
5	500,000.00	250,000.00	719,808.00	359,904.00	999,999.00	499,999.50
6	1,000,000.00	500,000.00	3,509,109.00	1,754,554.50		

1998 per Farm Production ($) numbers are from 1998 Census of Aquaculture, Table 2., p 4 (Food fish other than catfish and trout). These numbers were then divided by Average per pound (dollars) (2.00 as per John H.).

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Appendix D

Calculation of Municipal Domestic Wasteload Equivalents

Typical pollutant concentrations and loads associated with municipal domestic wastewater reported by WEF and ASCE (1998) are shown in Table D-1. These estimated daily per capita pollutant load production values are used in the sizing and design of wastewater treatment facilities. Similar values are reported in Metcalf and Eddy, Inc. (1991).

Table D-1

Typical Major Pollutant Composition of Domestic Wastewater

Parameter	Concentration in Domestic Wastewater	Estimated Daily Per Capita Production of Pollutants	Estimated Annual Per Capita Production of Pollutants
BOD_5	400 mg/L	0.17 lb/cap d	62.05 lb/cap year
Total Nitrogen	30 mg/L	0.04 lb/cap d	14.60 lb/cap year
Total Phosphorus	7 mg/L	0.006 lb/cap d	2.19 lb/cap year
Total Suspended Solids	240 mg/L	0.2 lb/cap d	73.00 lb/cap year

The per capita values can be used to estimate annual municipal domestic wasteload equivalents. The equation for this calculation is:

$$\text{Human Equivalents (persons)} = \frac{\text{AAP Facility Load (lb/yr)}}{\text{Human Load (lb/capita yr)}}$$

REFERENCES

Metcalf and Eddy, Inc. 1991. *Wastewater Engineering*: *Treatment, Disposal, and Reuse*, 3d ed., revised by Tchobanoglous, G., and F. Burton., McGraw Hill, Inc., NY.

WEF and ASCE (Water Environment Federation and American Society of Civil Engineers). 1998. *Design of Municipal Wastewater Treatment Plants*, 4th ed., WEF Manual of Practice, Water Environment Federation, Alexandria, VA.

Appendix E

Literature Review for AAP Impacts on Water Quality

Examples of Effluents by Production System Type

Table E1. Examples of Effluents from Cage Systems

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Cornel, G.E. and F.G. Whoriskey. 1993. The effects of rainbow trout (Oncorhynchus mykiss) cage culture on the water quality, zooplankton, benthos, and sediments of Lac du Passage, Quebec. Aquaculture 109: 101-117.	Foreign	Cages	Trout	8 cages, each 9m x 9m x 9m, combined producing 14 metric tons fish per year with feed input of 52,125 kg dry feed/year	After 4 years of operation, water quality was sampled at the farm: 0.09 to 0.011 mg/l PO_4-P, 0.05 to 0.06 mg/l NO_3-N, 0.03 to 0.04 mg/l NH_4-N. Daphnia were less abundant around the farm during the summer. Wild perch, and escaped farm trout hang around outside the net pens to eat waste feed. Bloodworm (*Chironomus*) was the most widespread benthic organism. Bloodworms are a pollution-tolerant species; therefore, their abundance is a negative indicator of water quality. There was low DO around the farm, but nutrient and chlorophyll a levels were small and localized. Sediment available P levels were higher at the farm than at control sites, but the peaks coincided with periods of overfeeding.	 nutrients (other)

Table E2. Examples of Effluents from Flow-Through Systems

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Ruane, R.J., T.Y.J. Chu, and V.E. Vandergriff. 1977. Characterization and treatment of waste discharged from high-density catfish cultures. Water Res. 11: 789-800.	Primary	Flow-Through	Catfish	190 liters/sec	0.07 kg/day/100 kg fish ammonia nitrogen 0.8 kg/day/100 kg fish suspended solids, 0.3 ml/l settleable solids 10,000,000 organisms/100ml water Fecal coliforms	nutrients solids (other)
Westers, H. 2000. Michigan's Platte River State Fish Hatchery Case History, RAS 2000 Conference, Blacksburg, VA	Gray	Flow-Through	Salmon	1200 + 5000 +8500 GPM (three potential sources)	Yearly P loading from Platte River Hatchery: 1990 to1996: 157 kg/yr P. 1990 to 1992: 316 kg/yr P. 1993 to 1996: 96 kg/yr P.	nutrients
Weston, D.P., B. Dixon, and C. Forney. 1998. Fate and Microbial Effects of Aquacultural Drug Residues in the Environment. University of California, Berkeley.		Flow-Through	Sturgeon	unknown	Tetracycline concentrations in sediments downstream of a sturgeon farm were up to 5 ug/g. Oxytetracycline concentrations in sediments beneath net-cage sites are commonly in the 1 to 10 ug/g range. 300 ug/g under a salmon net pen in Norway was the highest oxytetracycline concentration ever recorded in aquaculture sediment.	(other)

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Boardman, G.D., V. Mallard, J. Nyland, G.J. Flick, and G.S. Libey. 1998. Final Report: The Characterization, Treatment and Improvement of Aquacultural Effluents. Virginia Polytechnic Institute and State University. October 23, 1998.		Flow-Through	Trout	Farm A - 2.70 to 4.05 m^3/min Farm B - 11.2 to 24.8 m^3/min Farm C - 25.6 to 28.9 m^3/min	-Farm A outlet: 0.5 to 0.6 mg/l NH_3-N Farm B outlet: 0.45 mg/l NH_3-N Farm C outlet: 0.02 to 0.17 mg/l NH_3-N -Farm A outlet: 0.8 to 6 mg/l TSS, 0 to 0.04 ml/l suspended solids Farm B outlet: 1.5 to 7.5 mg/l TSS, 0.01 to 0.08 ml/l suspended solids Farm C outlet: 4.1 to 62 mg/l TSS, 0.04 to 0.08 ml/l suspended solids - Farm A outlet: 0.96 to 1.9 mg/l BOD_5, 1.5 to 2.4 mg/l DOC Farm B outlet: 0.6 to 2.4 mg/l BOD_5, 1.2 to 3.1 mg/l DOC Farm C outlet:, 0.5 to 1.8 mg/l BOD_5, 1.5 to 3.8 mg/l DOC	nutrients solids organic enrichment
Brannon, E.L. no date. Fish Farm Effluent Quality. Idaho.		Flow-Through	Trout	unknown, from groundwater source	Post-settling effluent: 0.074 mg/l total P, 0.054 mg/l orthophosphate, .040 mg/l ammonia, 4.980 mg/l NO_2-N + NO_3-N. <0.02 ml/l settleable solids, 3.0 mg/l suspended solids	nutrients solids
Jensen, J.B. No date. Environmental Regulation of Fresh Water Fish Farms in Denmark. Danish National Agency of Environmental Protection. 11 pp.	Foreign	Flow-Through	Trout	not specified	In 1985, pelleted feed was made mandatory. Mandatory improvements in feed quality were phased in 1989-1992. Total Danish fish farm effluent in 1987 was approximately 5,000 t BOD_5/year, 2,200 t nitrogen/year, and 400 t phosphorus/year.	(other)
JRB Associates. 1984. Development of Effluent Limitations for Idaho Fish Hatcheries. July 23, 1984.		Flow-Through	Trout	Flow 22 to 30 cfs	JRB study: 0.72 to 1.64 pounds TSS/ 100 pounds fish. Pisces effluent:, 92 to 150 mg/l TSS, 4,880 to 11,370 kg/day TSS, trace ml/l settleable solids.	solids
Kendra, W. 1991. Quality of salmonid hatchery effluents during a summer low-flow season. Trans. Am. Fish Soc. 120:43-51	Primary	Flow-Through	Trout	0.06 to 0.41 m^3/sec	Yakima Trout Hatchery: - normal operations: 0.43 mg/l TKN, 0.22 mg/l total P - during cleaning: 1.7 mg/l TKN, 4.0 mg/l total P - normal operations: 1 mg/l total suspended solids, 0 mg/l total volatile suspended solids, <0.1 ml/l settleable solids - during cleaning: 88 mg/l total suspended solids, 69 mg/l total volatile suspended solids, and 2.5 ml/l settleable solids. - normal operations: 6 mg/l COD, 3 mg/l BOD_5. - during cleaning: 130 mg/l COD, 32 mg/l BOD_5.	nutrients solids organic enrichment

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Niemi, M., and I. Taipalinen. 1982. Faecal indicator bacteria at fish farms. Hydrobiologia 76(1982):171-175.	Foreign	Flow-Through	Trout	2.6 m^3/sec	Fecal streptococci in effluent 0.18 to 0.37 ml -1, g-1, total coliforms 5.2 to 8.0 ml -1, g -1, fecal coliforms 0.48 to 1.2 ml-1, g-1.	(other)
Piedrahita, R.H. 1994. Managing Environmental Impacts in Aquaculture. Bull. Natl. Res. Inst. Aquaculture, Suppl. 1:13-20. 1994.		Flow-Through	Trout	22.6 m^3/sec	-Fish waste solids were analyzed at 4.13 mg/l N, 2.15 mg/l P, and 88% moisture.	nutrients
Rennert, B. 1994. Water pollution by a land-based trout farm. J. Appl. Ichthyol. 10(1994):373-378.	Foreign	Flow-Through	Trout	110 l/sec with additional 240 1/sec recycled	-Effluent values: 0.02 mg/l NO_2-N, 0.96 mg/l NO_3-N, 0.64 mg/l NH_4-N, 0.21 mg/l PO_4-P. Nitrogen loading rate was 465 g N per tone of fish per day. Phosphorus loading rate was 155 g P per tone of fish per day in water, and also an additional 2.07 g P per ton of fish per day that is in suspended solids that are flushed from the raceways once per day -Effluent values: 0.03 mg/l suspended matter. Nitrogen loading rate was 465 g N per metric ton of fish per day. Additional loadings of 30 liters or suspended matter per metric ton of fish per day. - Effluent values: 4.2 mg/l COD. Additional loadings of 3100 g COD per metric ton of fish per day were also observed.	nutrients solids organic enrichment
Selong, J.H. and L.A. Helfrich. 1998. Impacts of trout culture effluent on water quality and biotic communities in Virginia headwater streams. The Progressive Fish-Culturist 35(7): 247-262.	Primary	Flow-Through	Trout	0.27 to 1.24 m^3/sec	0.3 to 1.0 mg/l total ammonia-N for trout farm A; highest ammonia concentrations occurred during low flow conditions in fall.	nutrients benthic degradation

Table E3. Examples of Effluents from Other Types of Production Systems: Gator Pens

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Pardue, J.H., R.D. DeLaune, W.H. Patrick, Jr., and J.A. Nyman. 1994. Treatment of alligator farm wastewater using land application. Aquacult. Eng. 13(1994) 129-145.	Primary	Gator Pens	Alligators	hypothetical 6000 m^3/year	Data from alligator farm effluent: 10.9 mg/l total P, 77.5 mg/l NH_3, 4.6 mg/l NO_3-N, 153.4 mg/l TKN	nutrients
					379 mg/l total solids, 219 mg/l volatile solids	solids
					452 mg/l BOD	organic enrichment

Table E4. Examples of Effluents from Net Pens

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Hargrave, B.T., Phillips, G.A., Doucette, L.I., White, M.J., Milligan, T.G., Wildish, D.J., and R.E. Cranston. 1997. Assessing benthic impacts of organic enrichment from marine aquaculture. Water, Air and Soil Pollution 99: 641-650.	Foreign	Net Pens	Salmon	11 farms and 11 reference sites. Farm production varied from 40,000 to 320,000 tons of fish per year.	Sediment cores were collected under farms and at reference sites and analyzed at a lab. The authors do not report specific data values for specific farms or control sites. The most sensitive variables for finding differences between farms and reference sites were total sulfide, benthic O_2 uptake, benthic CO_2 release, and redox potential. The polychaete Capitella sp. can tolerate total sulfide concentrations up to 2 mM. Total sulfide concentrations above 2 mM are toxic to larvae and prevent settlement. No Capitella sp. were observed at any of the farm sites. All of the farms had total sulfide over 180 uM, with a maximum of 6 to 7mM. All but one of the reference sites had total sulfide under 200 uM. Redox potential at all but three of the farms was under +100 mV. Redox potential at all but two of the reference sites was over +100 mV. Mean values for total sediment O2 uptake was 175 percent higher at the farms than reference sites. Mean values for total sediment CO2 release was 355 percent higher at farms than reference sites. Measurements of modal grain size pore water salinity, SO_4, and sediment water content were not significantly different between farms and reference sites.	benthic degradation

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Holmer, M. 1991. Impacts of Aquaculture on Surrounding Sediments: Generation of Organic-Rich Sediments. In Aquaculture and the Environment: Reviews of the International Conference Aquaculture Europe 91, European Aquaculture Society, Dublin, Ireland, June 10-12, 1991, pp. 155-175.	Foreign	Net Pens	Salmon	not specified	One farm, seasonal variation 34 to 41 mmol per m2 per day SOU. Six farms, annual mean 86 to 446 mmol per m2 per day SOU. One farm, seasonal variation 60 to 230 mmol per m2 per day SOU. CO2 production in sediment metabolism was related to food input with an r2 = 0.975. Oxygen uptake in sediments increased sharply with sediment thickness up to 10 cm, and then gradually leveled out. Antibiotic resistant bacteria were found in sediments from antibiotic feeds. Zinc from feed, and copper from antifouling agents have been measured in fish farm sediments. Sedimentation rates under mussel rafts were three times the sedimentation rates at control sites. - Zinc from feed, and copper from antifouling agents have been measured in fish farm sediments. Sedimentation rates under mussel rafts were three times the sedimentation rates at control sites.	benthic degradation (other)
Johnsen, R.I., O. Grahl-Nielsen, and B.T. Lunestad. 1993. Environmental distribution of organic waste from a marine fish farm. Aquaculture 118(3-4): 229-244.		Net Pens	Salmon	N/A	Researchers collected sediment under a working farm and at control sites. Feed, feces and sediment were analyzed to screen fatty acids that might be used as chemical markers for organic sediment enrichment caused by fish farms. Pristane is one of the compounds investigated. Anoxic sediments beneath fish farms gave off H_2S smell. Beneath the farm, divers observed a fine white blanket of what was likely elemental sulfur and sulphur-oxidizing bacteria (Beggiatoa) on the sediment surface. The authors used multivariate statistics to show differences between pristine concentrations in farm sediments and control sediments. Fatty acids and/or pristane show promise as fish farm sediment markers.	benthic degradation

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Kaspar, H.F., G.H. Hall, and A.J. Holland. 1988. Effects of sea cage salmon farming on sediment nitrification and dissimilatory nitrate reduction. Aquaculture 70(4): 333-344.	Foreign	Net Pens	Salmon	N/A	Sediment cores and gas bubbles from sediment were collected beneath a working salmon farm in New Zealand. At site 1 (the site beneath the center of a cage at a water depth of 13 m): 14.3 to 34.3 mmol/m^2 NH_4+, 1.4 to 5.3 mol/m^2 Organic N, 0.4 to 3.6 mol/m^2 Total P, 1.4 to 3.1 N:P ratio.	nutrients
					- Gas evolving from sediment at site 1 consisted of 64 percent methane, 5 percent carbon dioxide, 2 percent water vapor, 7 percent air, and 22 percent unknown. The unknown portion probably contained H_2S, because the divers could smell it. In situ nitrification rates were <0.1 to 0.3 mmol N/m^2 per day. Denitrification at the sites was determined not to be a significant nitrogen removal mechanism. Nitrification / Denitrification was not occurring because the sediments lacked oxygen to supply the nitrification step. Beneath the net pens, divers observed black colored sediments covered by a *Beggiatoa*-like bacterial mat that smelled like H_2S and was bubbling off methane.	benthic degradation
Milewski, I., J. Harvey, and B. Buerkle. 1997. After the Goldrush: Salmon Aquaculture in New Brunswick. In Murky Waters: Environmental Effects of Aquaculture in the U.S, ed. R. Goldberg and T. Triplett, pp. 131-152. The Environmental Defense Fund, New York.	Gray	Net Pens	Salmon	N/A	In one study, 8.3 ha out of 34.6 ha salmon farms investigated were classified as heavily degraded. Heavy degradation includes bubbling gas, the absence of fish and sediment-dwelling organisms, accumulations of fish feed and feces not dispersed by a tidal cycle, and bacterial mats. Areas less impacted would have no organisms other than worms tolerant of low DO.	benthic degradation

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Mazzola, A., S. Mirto, and R. Danovaro. 1999. Initial fish-farm impact on meiofaunal assemblages in coastal sediments of the Western Mediterranean. Mar. Poll. Bull. 38(12): 1126-1133.	Foreign	Net Pens	Sea Bream	N/A(cultured fish biomass varied from about 18,000 - 30,000 kg fish during the year)	Sampling of sediment chemistry and meiofauna started when the cages were stocked and continued for six months. After six weeks the sediments were suboxic. Chemical parameters included 2.3 to 8.2 ug/g Chlorophyll-a at the control, and 1.3 to 15.4 ug/g Chlorophyll-a at the cage. 1617 to 3304 ug/g Proteins at the control, and 1677 to 6740 ug/g Proteins at the cage. 503 to 2814 ug/g sedimentary carbohydrates at the control, and 628 to 5690 ug/g sedimentary carbohydrates at the cage. 331 to 2096 ug/g Lipids at the control, and 848 to 3096 ug/g Lipids at the cage. No significant differences were found between control and cage for biopolymeric carbon. Redox potential discontinuity (RPD) depth is the depth at which sediment turns brown to black. 1.4 to 2.9 cm RPD at the control, and 0 to 1.1 cm RPD at the cage. Meiofaunal organisms were extracted from sediment cores. Copepods and ostracods significantly decreased in farm sediments. Kinorhynchs were extremely sensitive to farm reducing sediments and disappeared almost completely from the farms. Polychaete densities were the same at cages and controls. Nematodes are usually tolerant of reducing conditions in sediment, but did show some effects at the farm sites. The nematode to copepod ratio has been used in the literature to detect pollution. In this study, the ratio did not reliably point to pollution effects at either cage or control.	benthic degradation
Gale, P. 1999. Appendix 9. Water Quality Impacts from Aquaculture Cage Operations in the LaCloche/North Channel of Lake Huron. In Addressing Concerns for Water Quality Impacts from Large-Scale Great Lakes Aquaculture: A Roundtable. Habitat Advisory Board of the Great Lakes	Foreign	Net Pens	Trout	N/A	Water quality monitoring at Grassy Bay site: 6 to 10 ug/l total phosphorus. Near the pens, researchers observed 16 to 26 ug/l total P in September, and 40 ug/l total P in October. Anoxic conditions in the hypolimnion can result in the release of P from the sediments. Historic P concentration in that part of the lake is 5 ug/l total P.	nutrients

Table E5. Examples of Effluents from Ponds

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Boyd et al. 2000. Environmental Assessment of Channel Catfish Farming in Alabama, Auburn University, Department of Fisheries and Allied Aquaculture, Auburn, AL.		Ponds	Catfish		-Average effluent concentrations during precipitation overflow events: 0.12 mg/l soluble reactive P, 0.68 mg/l total P, 0.86 mg/l NO3-N, 1.20 mg/l total ammonia N, 3.42 mg/l total N. -Average effluent concentrations during partial drawdown events: 0.01 mg/l soluble reactive P, 0.25 mg/l total P, 0.69 mg/l NO3-N, 1.13 mg/l total ammonia N, 5.68 mg/l total N. -Average effluent concentrations during final pond drawdown: 0.06 mg/l soluble reactive P, 1.59 mg/l total P, 0.14 mg/l NO3-N, 1.37 mg/l total ammonia N, 9.58 mg/l total N	nutrients
					-Average effluent concentrations during precipitation overflow events: 81 mg/l TSS. -Average effluent concentrations during partial draw down events: 69 mg/l TSS. -Average effluent concentrations during final pond draw down: 1027 mg/l TSS	solids
					-Average effluent concentrations during precipitation overflow events: 11.0 mg/l. -Average effluent concentrations during partial draw down events: 9.42 mg/l BOD_5. - Average effluent concentrations during final pond draw down: 31.8 mg/l BOD_5	organic enrichment
Boyd, C.E. 1978. Effluents from catfish ponds during fish harvest. Journal of Environmental Quality 7(1):59-62.	Primary	Ponds	Catfish	0.53 to 5.02 ha with depths of 1.5 to 1.8 m	Mean effluent parameters during seining phase of harvest (Over half of the total settleable matter and orthophosphate was lost during the seining phase.): 59 ug/l soluble orthophosphate, 0.49 mg/l total P, 2.34 mg/l total NH_3, 0.14 mg/l NO_3-N.	nutrients
					28.5-ml/l settleable matter	solids
					28.9 mg/l BOD, 342 mg/l COD	organic enrichment

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Huggett, D.B., D. Schlenk and B.R. Griffin. 2001. Toxicity of copper in an oxic stream sediment receiving aquaculture effluent. Chemosphere 44: 361-367.	Primary	Ponds	Catfish	Nine-10,000 fish/ha ponds were treated with a total of 45 kg of dispersed copper over 3 years, drained after harvest into a nearby stream	*Hyallea azteca* and *Typha latifolia* were exposed to sediments collected upstream, at outflow, and downstream from catfish ponds medicated with copper. No significant loss was observed in the upstream or outflow samples. *H. azteca* did suffer significant mortality in the downstream sample. However, because copper levels in all 3 locations were similar to each other and to those from ponds where copper was not used, it was determined the use of copper in this study did not negatively impact the receiving stream. Bulk sediment copper concentrations in the samples were: Upstream: 29 mg Cu/kg dry weight Outfall: 31 mg Cu/kg dry weight Downstream: 25 mg Cu/kg dry weight	
Schwartz, M.F., and C.E. Boyd. 1994a. Channel catfish pond effluents. Prog. Fish Cult. 56: 273-281.	Primary	Ponds	Catfish	Unknown	-Production water values: 0 to 1.85 mg/l total P, 0 to 0.074 mg/l soluble reactive P, 0.58 to 14.04 mg/l TKN, 0.008 to 8.071 mg/l TAN, 0 to 6.661 mg/l NO_3-N. -Production water values: 0 to 1.8 ml/l settleable solids, 5.2 to 336.7 mg/l suspended solids, 0.02 to 221.0 mg/l volatile solids. - Production water values: 1.9 to 35.54 mg/l BOD_5	nutrients solids organic enrichment
Shireman, J.V., and C.E. Cichra. 1994. Evaluation of aquaculture effluents. Aquaculture 123(1994): 55-68.	Primary	Ponds	Catfish	0.4 hectare by 1.5 m deep = 6,000 m^3 (1 acre pond)	At Schuler Fish Farm, production water ranges: 0.050 to 0.350 mg/l NH_4-N, 0.030 to 0.280 mg/l NO_3-N, 0.000 to 0.007 mg/l NO_2-N, 0.8 to 4.9 mg/l Total N, 0.148 to 0.238 mg/l Total P 4.3 to 63.4 mg/l TSS, 2.7 to 39.4 mg/l VSS, 1.6 to 29.3 mg/l FSS 4 to 16 mg/l CBOD 1,400 to 160,000 number/100ml Fecal coliforms	nutrients solids organic enrichment (other)

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Tucker, C. S., S.K. Kingsbury, J.W. Pote, and C.L. Wax. 1996. Effects of water management practices on discharge of nutrients and organic matter from channel catfish (Ictalurus punctatus) ponds.	Primary	Ponds	Catfish	Ponds averaged 7 ha in area and 1.25 m in depth; water was supplied by wells pumping from an aquifer; periodic additions of well water were made to replace evaporation; overflow occurred only during periods of excessive rainfall.	Predicted discharge (kg ha^{-1} of pond surface) of selected parameters in overflow from levee-type ponds, in an average year, under two management scenarios **(1) With no water storage potential:** total nitrogen: Spring 14.7; Summer 12.4; Autumn 15.2; Winter 17.2 ; total phosphorus: Spring 1.0; Summer 0.9; Autumn 0.7; Winter 1.1; chemical oxygen demand (as O_2) Spring 223; Summer 172; Autumn 165; Winter 245; biochemical oxygen demand (as O_2) Spring 45; Summer 41; Autumn 25; Winter 42. **(2) With 7.5-cm water storage potential:** total nitrogen: Spring 4.2; Summer 1.0; Autumn 2.0; Winter 10.1; total phosphorus: Spring 0.3; Summer 0.1; Autumn 0.2; Winter 0.7; chemical oxygen demand (as O_2) Spring 64; Summer 14; Autumn 22; Winter 143; biochemical oxygen demand (as O_2) Spring 13; Summer 3; Autumn 3; Winter 25.	
Tucker, C.S. no date. Quality of potential effluents from channel catfish culture ponds		Ponds	Catfish	Unknown, but stocked at 17,000 fish / ha	Production water values for August: 3.9 to 9.9 mg/l total N, 0.06 to 1.79 mg/l total ammonia, 0 to 0.15 mg/l NO_3-N, 0 to 0.08 mg/l NO_2-N, 0.45 to 1.13 mg/l total P, 0.01 to 0.06 mg/l soluble phosphorus. 64 to 200 mg/l COD	nutrients organic enrichment

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Tucker, C.S., and S.W. Lloyd. 1985. Water Quality in Streams and Channel Catfish (Ictalurus punctatus) Ponds in West-Central Mississippi. Technical Bulletin 129. Mississippi Agricultural & Forestry Experiment Station, Mississippi.	Secondary	Ponds	Catfish	pond volumes 20,000 to 80,000 m^3, stocked at 10,000 to 20,000 fish per hectare	-Mean production water values for spring: 0.072 mg/l soluble reactive phosphorus, 0.560 mg/l total P, 0.934 mg/l total ammonia, 0.053 mg/l NO_2-N + NO_3-N, 4.41 mg/l total N. -Mean production water values for summer: 0.159 mg/l soluble reactive phosphorus, 0.855 mg/l total P, 0.416 mg/l total ammonia, 0.235 mg/l NO_2-N + NO_3-N, 5.55 mg/l total N.	nutrients
					-Mean production water values for spring: 481 mg/l total solids, 149 mg/l total volatile solids. -Mean production water values for summer: 500 mg/l total solids, 162 mg/l total volatile solids.	solids
					-Mean production water values for spring: 61 mg/l COD. -Mean production water values for summer: 97 mg/l COD	organic enrichment
Smydra, T.M. 1994. Characterization and effects of aquacultural effluents from two Iowa hatcheries. Master's thesis, Iowa State University, Ames, Iowa.	Primary	Ponds	Catfish, Walleye, Largemouth Bass	Unknown and variable	0.10 to 0.49 kg/day soluble reactive P, 0.13 to 0.41 kg/day NO_2-N, 0.29 to 11.68 kg/day ammonia-N, 0.00 to 0.0378 kg/day un-ionized ammonia, 0.95 to 10.11 kg/day Total N	nutrients
					22.8 to 549.9 kg/day TSS	solids
					3.38 to 20.11 kg/day $CBOD_5$	organic enrichment
Tucker, C.S. 1998a. Characterization and Management of Effluents from Aquaculture Ponds in the Southeastern United States. July 1998. SRAC Final Project No. 600. Southern Regional Aquaculture Center.	Gray	Ponds	Crawfish	2.2 to 23.6 ha commercial ponds	Mean values for effluents during draining period (Effluent quality is poorest during the summer drainage period. Ponds with native vegetation generally have lower concentrations of nutrients and solids than ponds with rice or sorghum-sudan grass): 0.139 mg/l soluble reactive P, 0.614 mg/l total P, 0.353 mg/l total ammonia N, 0.009 mg/l NO_2-N, 0.040 mg/l NO_3-N.	nutrients
					607 mg/l total solids, 109 mg/l total volatile solids.	solids
					61.3 mg/l COD, 11.6 mg/l BOD	organic enrichment
Dierberg, F.E., and W. Kiattisimkul. 1996. Issues, impacts, and implications of shrimp aquaculture in Thailand. Environ. Manage. 20(5): 649-666.	Foreign	Ponds	Shrimp	N/A	Effluent loading per 4 month cycle from shrimp grow out ponds stocked at 50-60 shrimp per m2: 0.71 kg/ha NO_2-N, 2.7 kg/ha NO_3-N, 18.4 kg/ha TAN, 178 kg/ha total N, 2.0 kg/ha SRP, 15.7 kg/ha total P	nutrients
					6,650 kg/ha TSS.	solids
					474 kg/ha BOD_5.	organic enrichment

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Hopkins, J.S., C.L. Browdy, R.D. Hamilton II, and J.A. Heffernan III. 1995. The effect of low-rate sand filtration and modified feed management on effluent quality, pond water quality and production of intensive shrimp ponds. Estuaries 18(1A): 116-123.	Primary	Ponds	Shrimp	1300 m^3 ponds, one pond had 5% daily water exchange	Effluent from daily water exchange passed through a sand filter before discharge: 0.08 to 2.86 mg/l TAN, <0.01 to 0.65 mg/l NO_2-N, <0.01 to 0.06 mg/l NO_3-N, 0.07 to 0.90 mg/l reactive orthophosphate, 0.5 to 2.9 mg/l Total P, 2.8 to 15.9 mg/l Kjeldahl N, <0.1 to 19.5 mg/l dissolved Kjeldahl N 18 to 347 mg/l suspended solids, 14 to 143 mg/l volatile solids 5.7 to 43.0 mg/l	nutrients solids organic enrichment
Hopkins, J.S., J.D. Holloway, P.A. Sandifer, and C.L. Browdy. No date. Results of Recent Controlled Comparisons of Intensive Shrimp Ponds Operated With and Without Water Exchange. Waddell Mariculture Center, Bluffton, South Carolina.	Gray	Ponds	Shrimp	0.25 ha lined ponds, 1.3 to 1.5 m deep (about 3,500 m^3) that did not use water exchange	Feeding at 136 kg/ha feed per day with a 20% protein feed, production water values were: 0.2 mg/l TAN, 2.8 mg/l NO_3-N, 0.3 mg/l NO_2-N, 4.0 mg/l TKN, 1.2 mg/l Total P, 0.4 mg/l Reactive orthophosphate 93.3 mg/l TSS, 46.2 mg/l organic suspended solids 15.7 mg/l BOD, 16.5 mg/l total organic carbon.	nutrients solids organic enrichment
Lopez-Ivich, M.A. 1996. Characterization of effluents from three commercial aquaculture facilities in South Texas. Master's thesis, Texas A&M University, Corpus Christi, Texas.	Primary	Ponds	Shrimp	Taiwan Shrimp Village, sampling point TV3 (located at the end of the discharge canal running along eastern border of facility) - 63,961 m^3/day Harlington Shrimp Farm sampling point H2 (located before the last gate of the farm's discharge canal) - 193,562 m^3/day Southern Star Farm sampling point SS2 (located in front of the last gate of the farm's discharge canal) - 12,748 m^3/day	-TV3 effluent sampling point: 1.14 mg/l NH_4-N, 0.23 mg/l NO_2-N, 0.45 mg/l NO_3-N, 0.45 mg/l Total P, 0.23 mg/l Total reactive P -H2 effluent sampling point: 0.04 mg/l NH_4-N, 0.01 mg/l NO_2-N, 0.65 mg/l NO_3-N, 0.15 mg/l Total P, 0.01 mg/l Total reactive P -SS2 effluent sampling point: 0.44 mg/l NH_4-N, 0.12 mg/l NO_2-N, 0.34 mg/l NO_3-N, 0.34 mg/l Total P, 0.11 mg/l Total reactive P -TV3 effluent sampling point: 99.46 mg/l TSS, 0.29 ml/l settleable solids -H2 effluent sampling point: 95.08 mg/l TSS, 0.14 ml/l settleable solids -SS2 effluent sampling point: 71.46 mg/l TSS, 0.12 ml/l settleable solids -TV3 effluent sampling point: 3.56 mg/l $CBOD_5$ H2 effluent sampling point: 9.16 mg/l $CBOD_5$ SS2 effluent sampling point: 3.93 mg/l $CBOD_5$	nutrients solids organic enrichment

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Martin, J., Y. Veran, O. Guelorget, and D. Pham. 1998. Shrimp rearing: Stocking density, growth, impact on sediment, waste output and their relationships studied through the nitrogen. Aquaculture. 164(1998):135-149.	Foreign	Ponds	Shrimp	ponds 1370 to 1520 m^2 by 1.3 m deep, with 10% daily water exchange	Data from shrimp pond stocked at 15 shrimp per m^2: 1460 m^2 pond area, 79.0 percent survival area, 19.9 g final body weight, 346 kg final biomass, 546.5 kg total feed, 1.58 FCR: 0.10 to 0.74 mg/l nitrogen, 10.5 +/- 6.0 ug/l NH_4-N, 2.7 +/-6.6 ug/l NO_2-N + NO_3-N, 127.7 +/- 40.7 ug/l organic N, 72 to 240 ug/l total soluble N.	nutrients
Samocha, T.M., and A.L. Lawrence. 1995. Shrimp farms' effluent waters: environmental impact and potential treatment methods. Water Effluent and Quality, With Special Emphasis on Finfish and Shrimp Aquaculture. U.S.-Japan Cooperative Program in Natural Resources, Corpus Christi, Texas.	Gray	Ponds	Shrimp	378,540 m^3/day permitted average discharge flow	Effluent from main discharge to county canal: 0.39 to 0.66 mg/l total P, 0.15 to 0.37 mg/l reactive P, 0 to 7 mg/l NH_3-N. 58 to 203 mg/l TSS. Effluent from one pond while draining for harvest: 41 to 652 mg/l TSS, and 37 to 49 mg/l VSS. 1.7 to 5.0 mg/l $CBOD_5$.	nutrients solids organic enrichment
Teichert-Coddington, D.R., D.B. Rouse, A. Potts, and C.E. Boyd. 1999. Treatment of Harvest Discharge from Intensive Shrimp Ponds by Settling. Aquacult. Eng. 19(1999): 147-161.	Primary	Ponds	Shrimp	888 m^3, during last month of culture, 25 to 30 percent of water exchanged per week	During draining, mean values for effluent when pond is drained from full capacity to empty: 0.53 to 1.67 mg/L Total P, 1.57 to 4.15 mg/l Total N, 0.59 to 2.40 mg/l TAN 0.4 21.5 ml/l settleable solids, 181 to 2788 mg/l total solids, 88 to 563 mg/l volatile solids. 30.6 to 44.3 mg/l BOD	nutrients solids organic enrichment

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Ziemann, D.A. 1991. Effluent Mixing Zones - Theory and Practice	Gray	Ponds	Shrimp	Pacific Sea Farms - 2.7 to 4.5 mgd Oceanic Institute - 0.032 to 0.058 mgd	-Pacific Sea Farms effluent: 90 to 330 ug/l NO_3-N + NO_2-N, 150 to 1280 ug/l NH_4-N, 1110 to 3930 ug/l Total N, 270 to 1030 ug/l Total P. Loadings Pacific Sea Farms effluent: 2.7 to 4.5 mgd flow, 0.9 to 5 kg/day NO_3-N + NO_2-N, 1.5 to 20.4 kg/day NH_4-N, 17.6 to 61 kg/day Total N, 2.8 to 13.6 kg/day Total P. -Oceanic Institute effluent: 0 to 548 ug/l NO_3-N + NO_2-N, 3 to 1534 ug/l NH_4-N, 80 to 3055 ug/l Total N, 15 to 712 ug/l Total P. Loadings Oceanic Institute effluent: 0.032 to 0.058 mgd flow, 0.000 to 0.100 kg/day NO_3-N + NO_2-N, 0.001 to 0.277 kg/day NH_4-N, 0.020 to 0.600 kg/day Total N, 0.003 to 0.140 kg/day Total P.	nutrients
					- Pacific Sea Farms effluent: 16 to 36 mg/l TSS. Loadings Pacific Sea Farms effluent: 197 to 565 kg/day TSS. -Oceanic Institute effluent: 13 to 102 mg/l TSS. Loadings Oceanic Institute effluent: 2.8 to 17 kg/day TSS.	solids
					- Pacific Sea Farms effluent: 4 to 10 mg/l BOD. Loadings Pacific Sea Farms effluent 63 to 157 kg/day BOD. -Oceanic Institute effluent: 7 to 15 mg/l BOD. Loadings Oceanic Institute effluent: 1.1 to 2.8 kg/day BOD.	organic enrichment
Tucker, C.S. 1998a. Characterization and Management of Effluents from Aquaculture Ponds in the Southeastern United States. July 1998. SRAC Final Project No. 600. Southern Regional Aquaculture Center.	Gray	Ponds, Freshwater And Saltwater	Hybrid Striped Bass	Commercial ponds of unknown size	Production water mean values 7.1 mg/l Kjeldahl Nitrogen, 0.95 mg/l total ammonia, 0.07 mg/l NO_2-N, 0.36 mg/l NO_3-N, 0.31 mg/l total P, 0.02 mg/l soluble reactive P.	nutrients
					49 mg/l suspended solids, 29 mg/l volatile suspended solids.	solids
					11.5 mg/l BOD.	organic enrichment
Seok, K., S. Leonard, C.E. Boyd, and M.F. Schwartz. 1995. Water quality in annually drained and undrained channel catfish ponds over a three-year period. The Progressive Fish-Culturist 57:52-58.	Primary	Ponds, Levee	Catfish	400 to 600 m^2 with average depth 1m is about 400 to 600 m^3 (about 1/10 acre pond)	Ranges for effluents from draining ponds during October harvest: 1.65 to 14.45 mg/l Kjeldahl nitrogen, 0.34 to 3.70 mg/l TAN, 0.004 to 0.065 mg/l NO_3-N. 0.007 to 0.17 mg/l NO_2-N, 0.231 to 3.302 mg/l Total P	nutrients
					47 to 1948 mg/l TSS, 1.1 to 10.0 ml/l settleable solids.	solids
					30.0 to 54.4 mg/l BOD.	organic enrichment

Reference	Source Category	System	Species	Flow Or Volume	Parameter Data	Pollutant
Boyd, C.E. and T. Dhendup. 1995. Quality of Potential Effluents from the Hypolimnia of Watershed Ponds Used in Aquaculture. *The Progressive Fish-Culturist* 57:59-63. 1995.		Ponds, Watershed	Catfish	9,400 to 66,900 m^3 pond volume	Measurements taken July to September, -TAN 0.34 to 3.59 mg/l; NO_2-N 0.0 to 0.15 mg/l - BOD_5 8.5 to 20.6 mg/l	nutrients organic enrichment
Schwartz, M.F., and C.E. Boyd. 1994b. Effluent quality during harvest of channel catfish from watershed ponds. The Progressive Fish Culturist 56:25-32.	Primary	Ponds, Watershed	Catfish	0.92 to 1.32 hectare by 1.37 to 1.73 m deep, (ballpark 18,000 m^3)	Effluent loadings discharged per hectare of pond: 2.95 kg/ha TAN, 77.8 kg/ha TKN, 0.03 kg/ha NO_2-N, 3.95 kg/ha NO_3-N, 0.17 kg/ha soluble reactive P, 3.23 kg/ha Total P. Loadings discharged per metric ton (MT) of fish in pond: 0.74 kg/MT TAN, 18.6 kg/MT TKN, 0.01 kg/MT NO2-N, 0.95 kg/MT NO_3-N, 0.04 kg/MT soluble reactive P, 0.78 kg/MT Total P	nutrients
					9,362 kg/ha settleable solids. Loadings discharged per metric ton (MT) of fish in pond: 2,302 kg/MT settleable solids.	solids
					164 kg/ha BOD. Loadings discharged per metric ton (MT) of fish in pond: 39.3 kg/MT BOD.	organic enrichment

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Appendix F

Water Quality Standards and Nutrient Criteria

F.1 NUTRIENT CRITERIA

Tables F-1 and F-2 summarize nutrient criteria for total nitrogen and total phosphorus, water quality criteria for ammonia and dissolved oxygen, and guidelines for BOD and solids. EPA has developed criteria for each of the aggregate nutrient ecoregions for total phosphorus, total nitrogen, chlorophyll a, and turbidity. Criteria for these different parameters are presented for rivers/streams and lakes/reservoirs for each ecoregion in Tables F-1 and F-2, respectively. A range has also been included in these tables to present the minimum and maximum values for each parameter.

Table F-1

Nutrient Criteria for Rivers and Streams by Ecoregion

	Ecoregions for Rivers & Streams													
Parameter	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*14*	*Range*
TP Fg/L	47.00	10.00	21.88	23.00	67.00	76.25	33.00	10.00	36.56	128*	10.00	40.00	31.25	10.00 – 128
TN mg/L	0.31	0.12	0.38	0.56	0.88	2.18	0.54	0.38	0.70	0.76	0.31	0.90	0.71	0.12 – 2.18

Source: USEPA, 2000b. (Updated table from USEPA, 2002.)
Note: *This value appears inordinately high and may either be a statistical anomaly or reflects a unique conditions. In any case, further regional investigation is indicated to determine the sources, i.e., measurement error, notational error, statistical error, statistical anomaly, natural enriched conditions, or cultural impacts.

Table F-2

Nutrient Criteria for Lakes and Reservoirs by Ecoregion

	Ecoregions for Lakes & Reservoirs												
Parameter	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*11*	*12*	*13*	*14*	*Range*
TP Fg/L	8.75	17.00	20.00	33.00	37.5	14.75	8.00	20.00	8.00	10.00	17.50	8.00	8.00 – 37.50
TN mg/L	0.10	0.40	0.44	0.56	1.68	0.66	0.24	0.36	0.46	0.52	1.27	0.32	0.10 – 1.68

Source: USEPA, 2000b. (Updated table from USEPA, 2002.)

F.2 AMMONIA CRITERIA

Water quality criteria for ammonia are expressed as the Criteria Maximum Concentration (CMC or acute criterion) and the Criteria Continuous Concentration (CCC or chronic criterion). These values, which were finalized by EPA in 1999, are intended to be protective to aquatic life. The CMC and CCC are expressed in terms of milligrams ammonia nitrogen per liter (mg N/L) and they vary with pH. For the CMC, based on differences in species acute sensitivity, different CMC values were derived for waters where salmonids (e.g., trout and salmon) are present and waters where salmonids are not present. For the CCC, no substantial differences between salmonid and non-salmonid chronic sensitivity were apparent and consequently, the CCC does not vary with the type of fish present. Criteria concentrations for a few example pH values are shown in Table F-3. Refer to the *1999 Update of Ambient Water Quality Criteria for Ammonia* for the computational formula and for other example pH values between 6.5 and 9.0 (USEPA, 1999).

Table F-3

CMC and CCC (mg N/L) at a Few Example pH Values

pH	CMC (salmonids present)	CMC (salmonids absent)	CCC
6.5	32.5	48.8	3.48
7.0	24.0	36.1	3.08
7.5	13.3	19.9	2.28
8.0	5.60	8.40	1.27
8.5	2.13	3.20	0.57
9.0	0.88	1.32	0.25

Source: USEPA, 1999.

F.3 DISSOLVED OXYGEN CRITERIA

National criteria for ambient dissolved oxygen concentrations for the protection of freshwater aquatic life are presented in Table F-4. The criteria are derived from production impairment estimates found in the criteria document, which are based on growth data and information on temperature, disease, and pollutant stresses. Each criterion may be viewed as an estimate of the threshold concentration below which detrimental effects are expected (USEPA, 1986).

Criteria for coldwater fish are intended to apply to waters containing species of the family Salmonidae or other coldwater or coolwater fish deemed by the user to be closer to salmonids in sensitivity than to most warmwater species. The criteria for warmwater fish are necessary for protecting early life stages of warmwater fish as sensitive as channel catfish and to protect other life stages of fish as sensitive as largemouth bass (USEPA, 1986).

Table F-4

Water Quality Criteria for Ambient Dissolved Oxygen Concentration

	Coldwater Criteria		**Warmwater Criteria**	
	Early Life Stages[1,2]	Other Life Stages	Early Life Stages[2]	Other Life Stages
30 Day Mean (mg/L)	n/a[3]	6.5	n/a	5.5
7 Day Mean (mg/L)	9.5 (6.5)	n/a	6.0	n/a
7 Day Mean Minimum (mg/L)	n/a	5.0	n/a	4.0
1 Day Minimum[4,5] (mg/L)	8.0 (5.0)	4.0	5.0	3.0

[1] These are water column concentrations recommended to achieve the required intergravel DO concentrations shown in parentheses. The 3-mg/L differential is discussed in the criteria document. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.
[2] Includes all embryonic and larval stages and all juvenile forms to 30-days following hatching.
[3] n/a = not applicable.
[4] For highly manipulatable discharges, further restrictions apply (see page 37 of the dissolved oxygen criteria document).
[5] All minima should be considered as instantaneous concentrations to be achieved at all times.
Source: USEPA, 1986.

F.4 BIOCHEMICAL OXYGEN DEMAND

There are no national in-stream criteria for BOD. However, ambient levels for BOD vary by state. EPA has established effluent limitations guidelines for discharges such as wastewater treatment plants. These guidelines are based on the ability of technologies to economically and effectively remove

BOD from waste streams, which can vary depending on location and site-specific considerations. In any case, minimum secondary treatment effluent concentration limits for BOD_5 have been established for wastewater treatment plants. The average value during a 30-day period shall not exceed 30 mg/L and the average 7-day value shall not exceed 45 mg/L (USEPA, 2000a).

Furthermore, BOD (together with dissolved oxygen (DO), fecal coliforms (FC), and total suspended solids (TSS)) has been used as an indicator of the recreational use value of a water body. Changes in the recreational use value of a water body, as indicated by changing values of BOD, DO, FC, and TSS, can then be monetized (USEPA, 2001).

F.5 SOLIDS[1]

There are no national water quality criteria for solids. However, many AAP facilities with NPDES permits must control and monitor their discharge levels of solids. In Idaho for example, NPDES permits specify a maximum average of 0.1 mL/L for settleable solids and 5 mg/L for total suspended solids (IDEQ, n.d.). According to the U.S. Army Corps of Engineers *Fisheries Handbook*, streams with silt loads (e.g., settleable solids) averaging between 80 and 4,000 mg/L should not be considered good areas for supporting fresh water fisheries. Additionally, streams with less than 25 mg/L may be expected to support good fresh water fisheries (Bell, 1986). High turbidity can also prove fatal to fish. Fatal turbidity levels for various fish species are presented in Table F-5.

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[1] Total suspended solids are the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids." Settleable solids include material heavy enough to sink to the bottom of a wastewater treatment tank. Silt is sedimentary material composed of fine or intermediate-sized mineral particles. Sediment is defined as soil, sand, and minerals washed from land into water, usually after rain (USEPA, 1998).

Table F-5

Turbidity Levels Fatal to Various Fish Species

Common name of fish	Range of temperature (°C)	Average time of test (days)	Fatal turbidity in mg/L		
			Minimum	Average	Maximum
Golden shiner	20-29	7.1	55,000	166,000	200,000
Mosquito fish	20-28	16.5	120,000	181,500	225,000
Goldfish	24-32	12.0	90,000	197,000	270,000
Green sunfish	20-29	5.5	50,000	166,500	225,000
Black bullhead	22-32	17.0	175,000	222,000	270,000
Red Shiner	22-32	9.0	175,000	183,000	190,000
River carpsucker	24-32	9.6	105,000	165,000	250,000
Largemouth bass	16-32	7.6	52,000	101,000	150,000
Pumpkinseed	16-22	13.0	16,500	69,000	120,000
Orangespotted sunfish	22-32	10.0	100,000	157,000	200,000
Channel catfish	24-32	9.3	—	85,000	—
Blackstrip top-minnow	22-26	19.3	—	175,000	—
Black crappie	28-29	2.0	—	145,000	—
Rock bass	—	3.5	—	38,250	—

Note: 1 ppm is assumed to equal 1 mg/L.
Source: U.S. Army Corps of Engineers *Fisheries Handbook.* Bell, 1986.

F.6 REFERENCES

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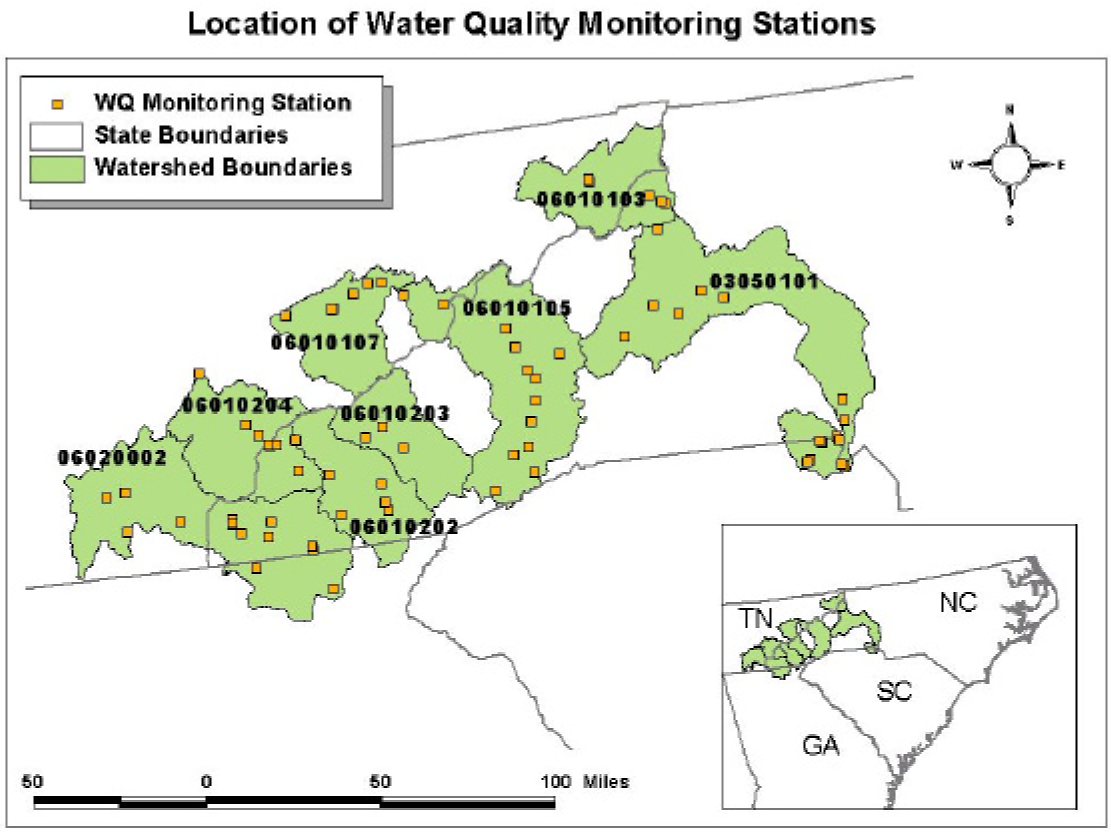
Appendix G

Water Quality and Flow Data from Selected Streamgage Stations in NC

EPA performed a detailed analysis of stream pollutant background concentrations for several watersheds in Western North Carolina to assess the appropriateness of the water quality modeling assumptions. Specifically, EPA determined whether the ranges of stream background concentrations used in the prototype model account for a variety of other feasible watershed conditions, such as varying levels of population, land uses, and point sources, that might exist for the watersheds of streams on which concentrated aquatic animal production (CAAP) facilities might be located. Eight watersheds in the Western North Carolina area were selected for review of in-stream water quality monitoring information during 1995-1997. These watersheds were chosen because they contained at least one CAAP facility that reported to PCS. All of the dischargers reporting in PCS within each of the eight watersheds were also summarized according to type of SIC code. EPA reviewed land use data for these watersheds to determine the presence of water quality monitoring stations located in urban areas, forested, and agricultural areas. A map of the analyzed watersheds is provided in Figure G-1.

Figure G-1

Location of Water Quality Monitoring Stations



EPA selected representative water quality parameters, including BOD_5, total suspended solids, ammonia, dissolved phosphorus, and dissolved oxygen to compare actual watershed conditions with model stream background conditions. EPA found 86 water quality monitoring stations in these watersheds for the statistical analysis.

EPA performed a statistical analysis of the available data from the 86 water quality stations to obtain a range of concentrations to compare to the original stream background concentrations used in the prototype model. Each of the five parameters was analyzed in the same manner, with the weighted mean, standard deviation of the weighted mean, and the minimum and maximum concentrations calculated for each.

Every station reported the number of samples taken (i.e., the number of observations) and the mean concentration of those observations. The number of observations differs for each station; some stations reported the average concentration from two observations while other stations monitored their streams continuously, resulting in a much larger number of observations. Because the means are based upon different numbers of observations, the weighted mean was calculated for each station. The weighted mean varies the contribution of an individual station's mean value proportionally according to the number of sample points that make up the individual station mean. Thus, a station mean value with 10 observations carries less weight than a station with several hundred observations.

EPA calculated the weighted means by multiplying the station's mean by the number of observations that the respective station recorded. These values were then added together for all of the stations that reported data; and lastly, the resulting value was divided by the total number of observations for the particular parameter, thereby producing the weighted mean. The standard deviation for the weighted mean was also calculated in order to better understand the spread of the data for each parameter. Finally, the range (minimum and maximum values) of the mean concentrations reported by the stations was found for each parameter. This range was then used to support the range that was used for modeling purposes.

The results of the statistical analysis are available in Table G-1, along with the original stream background concentrations used in the prototype model. The results show that the weighted means for the stream observations fall within the range of values used in the water quality modeling for BOD_5, ammonia, and dissolved phosphorus. The range of in-stream BOD values falls within the range of values used in the water quality modeling. The range of in-stream ammonia values is wider than the water quality modeling values. The range of in-stream phosphorus values falls within the range of values used in the modeling. The weighted mean for TSS was lower than the range of values for the prototype case study stream. However, the range of values for the case study stream was narrower than the range of the monitored streams for TSS. The value for dissolved oxygen used in the modeling fell within the range of in-stream values and was slightly greater than the weighted mean value.

Table G-1
Comparison of Background Concentrations

	BOD_5 (mg/L)	TSS (mg/L)	NH_3 (mg N/L)	Dissolved P (mg P/L)	DO (mg/L)
Range used to represent background flows in prototype case study stream	0.4 – 3.86	15 – 45	0.04 - 0.28	0.001 – 0.159	6.63
Water Quality Station Analysis (from eight watersheds)					
No. of Water Quality Stations	6	39	39	2	69
Total No. of Observations	149	1,094	1,160	15	61,803
Weighted Mean	1.970	12.903	0.118	0.051	5.711
Standard Deviation of Weighted Means	0.701	12.764	0.315	0.346	3.221
Parameter Range (Min and Max)	1.343 - 1.636	0.300 - 64.918	0.014 - 1.789	0.0412 - 0.087	3.629 - 10.584

To assess the stream flow characteristics of the model system, USGS stream flow gages located in eight watersheds in the North Carolina mountains were reviewed. These watersheds are the same ones used in the analysis of stream background concentrations. A map of the analyzed watersheds and tributaries is provided in Figure G-2 below. AAP facilities identified in BASINS were present in these watersheds and are located primarily on tributaries of the RF1 stream coverage. Therefore, all USGS stream gages located on tributaries, or starting stream reaches of RF1, were selected from the collection of gages under review. The stream gages were checked to assure locations below lakes were not included, since such obstructions to the natural stream flow would affect results from the analysis. Two additional gages were removed from analysis because of location at a main stem river reach juncture with a tributary. Of the remaining 29 stream gages, the 7Q10 flows ranged from 0.71 to 43.20 cubic feet per second (cfs) and the mean flow ranged from 10.62 to 285.48 cfs. The same stream gages were also reviewed for summer flow, which is considered as July 1 through September 30 for this analysis. Of the original 29 stream gages, 28 gages provided values for summer flow. The resulting average summer flow was 58.96 cfs. A summary of the flow data, including ranges, means, and standard deviations, is provided in Table G-2.

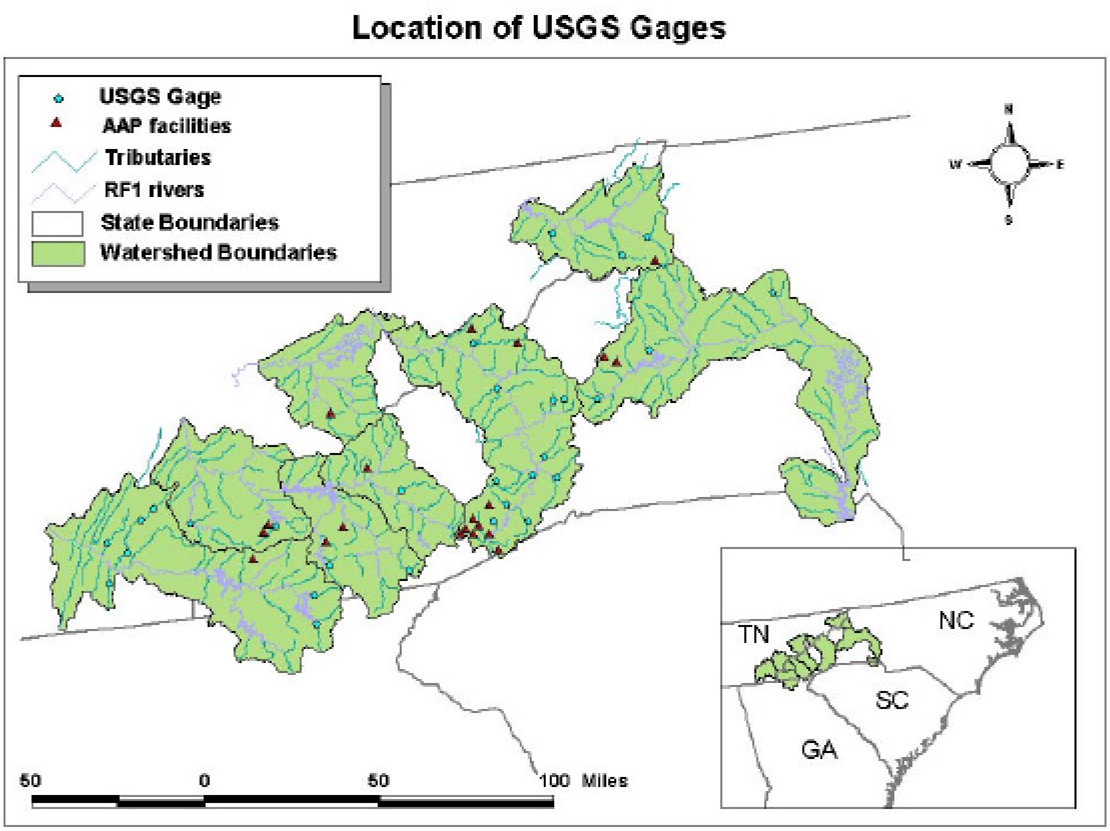
Table G-2

Summary of Flow Data

Flows	Minimum	Maximum	Mean	Standard Deviation
7Q10 Flow (cfs)	0.71	43.20	14.1	11.42
Mean Flow (cfs)	10.62	285.48	94.43	66.71
Summer Flow (cfs)	5.14	192.72	58.96	40.38

Figure G-2

Location of USGS Gages



Appendix H

Method for Converting Model Facility Pollutant Loads into Effluent Concentrations

H.1 GENERAL EQUATION

Pollutant loads, in units of pounds per year (lb/yr), are calculated by EPA's engineering models (see USEPA, 2002, Chapter 10). These may in turn be converted into effluent concentrations by dividing the annual mass load by the annual flow volume from a particular model facility. Facility flow rates in units of gallons per minute (gal/min) are also available from EPA's engineering analysis (see USEPA, 2002, Chapter 10). That is,

$$[\text{Pollutant } X](mg/L) = \frac{\text{Load}X\,(lb/yr) \times 453{,}000\,mg/lb}{\text{Flow}\left(gal/\text{min}\right) \times 3.785\,L/gal \times 525{,}600\,\text{min}/yr}$$

where *[*Pollutant*X]* = the concentration of the pollutant of concern (mg/L)

Load*X* = the annual mass load of Pollutant X (lb/yr)

Flow = the flow rate of the model facility under consideration (gal/min)

H.2 EXAMPLE CALCULATIONS

The calculation, using the above equation, for the "raw" (i.e., in the absence of treatment) effluent scenario for medium trout stocker flow-through systems is provided as an example below. The BOD_5 load of 108,228 lb/yr for this model facility was calculated by EPA as described in the CAAP Development Document. The effluent flow rate of 2,208.7 gal/min was also determined as described in the CAAP Development Document.

$$[BOD5] = \frac{108{,}228 \text{ lb / yr BOD5 } * \text{ } 453{,}600 \text{ mg / lb}}{2{,}208.7 \text{ gal / min } * \text{ } 3.785 \text{ L / gal } * 525{,}600 \text{ min / yr}}$$

$[BOD_5]$ = 11.172 mg/L for "raw" effluent from a medium trout stocker flow-through system

A second example for the Option 1/Option 2 load for "large" striped bass recirculating systems is provided as an example below.

$$[BOD5] = \frac{590{,}400 \text{ lb / yr BOD } * \text{ } 453{,}600 \text{ mg / lb}}{123{,}000 \text{ gal / day } * \text{ } 3.785 \text{ L / g } * 365 \text{ day / yr}}$$

$[BOD_5]$ = 1,575.3 mg/L for large striped bass recirculating systems under Option 1/Option 2

H.3 REFERENCE

USEPA (U.S. Environmental Protection Agency). 2002. *Development Document for Proposed Effluent Limitations Guidelines and Standards for the Concentrated Aquatic Animal Production Industry Point Source Category*. U.S. Environmental Protection Agency. EPA-821-R-02-016.