Evaluation of a Freshwater Site For Aquaculture Potential

WRAC

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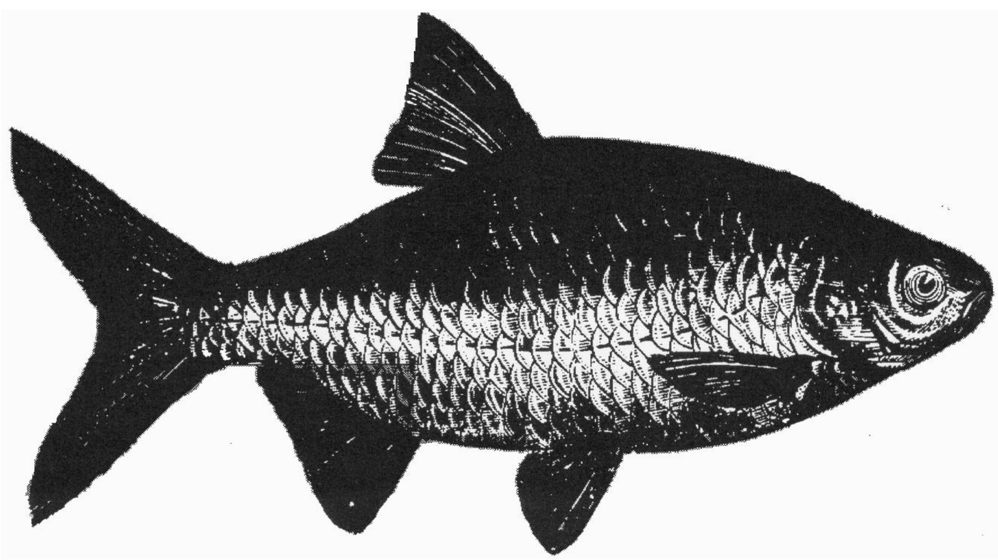

Western Regional Aquaculture Center

The Congress of the United States established five regional aquaculture research, development, and demonstration administrative centers to represent geographic regions within the U.S. and to develop and fund regional projects in cooperation with the U.S. Department of Agriculture. Congress recognized the opportunity for Regional Aquaculture Centers (RAC) in Title XIV of the Agriculture and Food Act of 1980 and the Food Security Act of 1985 (Subtitle L, section 1475[d]), in association with colleges and universities, State departments of agriculture, Federal facilities, and nonprofit private research institutions.

Subtitle L of the Food Security Act of 1985 is used by Congress as the U.S. Department of Agriculture (USDA) mechanism for implementing the National Aquaculture Development Plan prepared by the Joint Subcommittee on Aquaculture (JSA). The JSA, a statutory committee, operates under the auspices of the Federal Coordinating Council on Science, Engineering, and Technology in the Office of the Science Advisor to the President. It is permanently chaired by the Secretary of Agriculture.

The five regions and RAC regional offices are:

Tropical and Subtropical Regional Aquaculture Center (TSRC), Hawaii

North Central Regional Aquaculture Center (NCRAC), Michigan

Southeastern Regional Aquaculture Center (SRAC), Mississippi

Northeastern Regional Aquaculture Center (NRAC), Massachusetts

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EVALUATION OF A FRESHWATER SITE FOR AOUACULTURE POTENTIAL

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University of California and the United States Department of Agriculture cooperating.

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INTRODUCTION

Aquaculture is among the fastest growing segments of American agriculture. Its success and growing popularity have resulted in inquiries as to its potential as an investment, as a means to diversify production on traditional agriculture farms, and as a recreational opportunity. Potential growers need information that allows reasonable assessment of these opportunities, including information on selected species, their biological characteristics, and the resources necessary to sustain profitable production or recreational enjoyment.

This publication is designed to assist potential growers in assessing a freshwater aquaculture potential using basic aquaculture information and provides a format to evaluate the resources available at the proposed site. Of equal importance, the publication is designed to provide essential information necessary to others who might be asked to examine the site and assist in the evaluation process.

The first portion of the publication is structured to provide and/or direct the reader to information that allows differentiation between freshwater species and production systems that are currently economically profitable in the West and those that are in some phase of research and development (R&D). Also included is an interpretation of R&D species, R&D systems, and those R&D species and production systems in transition to economical viability. This allows the reader to make more informed choices as to what type of investment they wish to make, and in what stage of aquaculture development they wish to participate. The information on species requirements, types of production systems, and resources necessary to maintain a level of production defines the level of participation in aquaculture to be expected based upon the resources at the site; these levels being defined as exclusive aquatic production, integrated production using multiple aquatic species or a mix of aquatic and terrestrial crops, commercial fee fishing, and recreational aquaculture.

The second portion of the publication is designed to be used by the potential grower in combination with Extension personnel and/or any aquaculture consultant asked to evaluate the site. It is structured to assist in gathering information necessary for an evaluation and addresses information concerning legal and regulatory issues that are part of the assessment process. The potential grower is asked to provide specific information concerning the physical characteristics and other related resources at the site that make up the total aquaculture potential. The assessment of an aquaculture potential is complex, and the process requires a well structured exchange of information between those conducting the evaluation.

DETERMINING THE STAGE OF DEVELOPMENT OF AN AQUACULTURE BUSINESS

Aquaculture in the United States is a viable industry with large-scale production in both finfish and shellfish, and includes a wide array of animals produced for both food and recreation. Major foodfish species produced include channel catfish, oysters, trout, and crayfish; and recreational species include gamefish, baitfish, ornamentals and their support species such as feeder goldfish and Artemia. There is an array of minor species production and a rapidly expanding research and development (R&D) sector investigating new species for culture and new systems development.

The success of aquaculture, coupled with current and potential growth, has attracted investors seeking business profits and potential profits from R&D companies. Potential developers and investors interested in aquaculture need information that allows them to assess an existing or potential business. They need information that allows an intelligent assessment of the level of risk associated with establishment or investment in a viable business or in an R&D venture. Aquaculture is like any other agriculture business: there are inherent business risks, and success depends upon business judgment and the financial depth of the operation. Because R&D aquaculture is based on unproven technology, the risks are inherently greater.

R&D aquaculture may involve the development of the biological technology to culture a new species, the development of a new type of culture system, or a combination of both. If it is required to develop both, the magnitude of risk is increased significantly. As progress and success in both research and development are made, the company goes through a transition from the R&D status to economic viability. In this case, successful transition is defined as establishment of a plant or animal production system capable of deriving a profit from the plant or animal product produced.

It is useful for potential investors to separate aquaculture species and production systems into categories that are ultimately defined by their level of risk. To define and separate businesses by categories can lead to oversimplification, as most successful businesses have a well balanced mix of solid production and R&D development. This is how a business maintains economic viability and remains on the cutting edge for expansion and/or improvement. The categories used in this publication are defined in a way that provides separation, transition, and flexibility when describing a business. The three categories are: R&D aquaculture, transitional R&D aquaculture, and economically viable aquaculture. The potential investor should understand the three levels of development and understand the risk and potential return on investment for each. Our objective is to use definitions and information to help determine the status of a business, technology, or species-system within the context of the three categories. The following definitions provide a broad definition of each category based on production and basic financial structure and defines each in terms of risk, time associated with return on investment and/or successful transition to a viable business. The interpretation of the categories should be used with flexibility and only to provide general guidelines.

R&D Aquaculture Business: In an R&D aquaculture business income for salaries and operational expenses is derived primarily from venture capital investment. Additional revenues may include consultant services and/or government grants and the sale of tum-key systems in which only the seller has evidence of success. Less than about 30% percent of the total gross revenues are derived from sale of a species produced or a product resulting from a species produced. The level of risk is great. The commitment is long term, and the return on investment, if realized, may take many years. R&D is the necessary cutting edge for future aquaculture development.

Transitional R&D Aquaculture Business: An R&D aquaculture business in transition to economic maturity is one in which the primary gross revenues are still derived from investors, government grants, and consultant fees; however, about 30 to 70% of the gross income is from sale of a cultured product. Turn-key systems sales-promotion are discontinued or nonexistent. There is an established marketing and sales program for species cultured on site and an established program for transition of primary income from investments, grants, and consultant fees to sales of on-site cultured aquatic species. There is also an established track record based on a thorough business plan that gives evidence that the transition is being made toward a viable aquaculture production business.

Viable Aquaculture Production Business: A viable aquaculture production business is one in which income is primarily based on sales of the species produced, and one in which the company has an established financial track record. Investors are usually shareholders investing in the company's expansion using established technologies or new technologies to be incorporated into the established business. R&D and consulting, if present, are but one segment of the larger business and, if present, both make up less than about one-quarter of the gross income.

INTERPRETATION OF THE STATUS OF AN AQUACULTURE BUSINESS

The interpretation of information used to determine the status of an aquaculture business is not a simple exercise. It requires a knowledge of the status of species and systems and access to the company's business plan and financial background. Access to a company's financial background and business plan is usually available only to prospective investors. To achieve the most accurate background concerning an R&D company, the potential investor must work with the company to review its financial perspective, but is also encouraged to use all resources available to determine the true status of the biological and/or production system being proposed. At best, the final decision as to the risk involved in a potential investment is the decision of the investor.

Interpretation of the status of a species or method of production is also based on where and how a species is being cultured. A few examples are useful to understand how interpretation of species and system status are determined. For example, the culture of channel catfish in ponds is not an R&D venture, however, culturing the same species in intensive tank systems using liquid oxygen is R&D because the economic return balanced with production cost is not yet cost-effective. Closed systems are used to grow ornamental fish and feeder fish, as the price per pound of product exceeds production cost and results in profitability; however, closed system production of a foodfish is still considered R&D because the product price is well below the capital investment and production cost necessary to maintain closed systems at stock densities required for self-supporting profitability.

R&D status may also be based on the translocation of the species being cultured, the system being used, or even the market. One of the most successful aquaculture farming enterprises is the Louisiana aquaculture crayfish industry based on pond culture and polyculture with rice. The same species and system adopted in the West would be considered R&D based on undetermined factors such as the impact of regional climates, including nighttime cooling, seasonality of crops, and unexplored market analysis for large-scale production.

INTEGRATION OF AQUACULTURE SEGMENTS TO LOWER R&D RISK

An aquaculture business may also reduce its R&D risk by integrating its operation to include a strong, viable commodity along with the R&D segments. An example in California is the combination of channel catfish pond culture with tank culture of another species such as striped bass or sturgeon. The same hatchery facility supports all three species with reasonable overlap seasonally. The channel catfish occupy a strong established market, striped bass are sold to the resource agency to be used in delta mitigation programs, and sturgeon are grown for the meat market. Neither the striped bass nor sturgeon can support the farm alone, but by combining the R&D segments with an established using shared resources, the combined sales can result in total profitability.

FRESHWATER AQUACULTURE IN THE WEST

Producers in the western states produce a large variety of aquatic products and have a large commitment to the application of R&D. Table I summarizes many of the freshwater species grown, their stage of development as a business, systems used, and where these aquaculture activities occur. The table serves as a quick reference to the status of aquaculture species in the West, the systems used, and where major activities have been occurring. The decision on the position of the species in the four categories, and culture systems used, was that of the author combined with input from other state representatives. The activity data for each state was provided by Extension and other University representatives for that state. The most difficult areas for consensus are those activities at the boundaries between R&D and transitional R&D, and between transitional R&D and viable aquaculture. Because of the

TABLE 1. Summary of the status of the primary freshwater aquaculture species grown in the western states, the status of production systems, and the states where aquaculture activity occurs.

	SPECIES				SYSTEMS				WESTERN STATES											
	CV	TNS	RD	IGD	CV	TNS	RD	IGD	AK[8]	AZ	CA	CO	ID	MT[13]	NV	NM	OR	UT	WA	WY
Rainbow Trout	Y	-	-	-	R,T,P	-	-	-	-	C	C	C	C	C	C	C	C	C	C	C
Brown Trout	-	-	-	Y	-	-	-	R,P	-	-	Hb	C	-	C	-	-	-	-	-	-
Brook Trout	-	-	-	Y	-	-	-	R,P	-	-	Hb	C	-	C	-	-	C	C	Hb	Hb
Cutthroat Trout	-	-	-	Y	-	-	-	R,P	-	-	-	-	-	C	-	-	-	-	b	Hb
Coho Salmon	Y	-	-	-	P,R	Tfo	-	-	-	-	-	-	-	-	-	-	-	-	C	-
Chinook Salmon	Y	-	-	-	R,Tf[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-
Sockeye Salmon	Y	-	-	-	R,Cc[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-
Chum Salmon	-	-	Y	-	-	-	R,Cc	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic Salmon	Y	-	-	-	R,Tf[2]	-	-	-	-	-	C[10]	-	-	-	-	-	-	-	C	-
Channel Catfish	Y	-	-	-	P,R[3]	-	-	Cc[4]	-	C[9]	C	-	C	-	C	C	C	-	Hb	Hb
Blue Catfish	-	-	-	Y	-	-	-	P,R[3]	-	-	C	-	C	-	-	-	-	-	Hb	Hb
White Catfish	-	-	-	Y	-	-	-	P	-	-	C	-	-	-	-	-	-	-	-	-
Fathead Minnow	Y	-	-	-	P	-	-	-	-	C	C	C	-	-	-	C	-	-	-	-
Golden Shiner	Y	-	-	-	P	-	-	-	-	C	C	-	-	-	-	-	-	-	-	-
Goldfish (Bait)	Y	-	-	-	P	-	-	-	-	-	C	-	-	-	C	-	-	-	-	-
Tropical Fish	Y	-	-	-	P,T	-	-	-	-	C	C[11]	-	Hb	-	-	-	-	C	-	-
Guppy (Feeder)	Y	-	-	-	Tcs	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-
Goldfish (Feeder)	Y	-	-	-	P	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-
Koi (Feeder)	Y	-	-	-	-	-	-	P	-	-	C	-	-	-	-	-	-	-	-	-
Koi (Ornamental)	Y	-	-	-	P,T	-	-	-	-	Hb	C	-	Hb	-	-	C	Hb	-	C	Hb
Hybrid Striped Bass	-	Y	-	-	-	Tfo –	Tfo[5]	-	-	-	C	C	Hb	-	-	-	-	-	-	-
Striped Bass	-	-	-	Y	-	-	-	P,Tf	-	-	C	-	Hb	-	-	-	-	-	-	-
Black Bass	-	-	Y	Y	-	-	-	P,T,R	-	C	C	C	-	-	-	C	C	-	Hb	Hb
Crappie	-	-	-	Y	-	-	-	P	-	-	C	C	-	-	-	-	C	-	Hb	Hb
Bluegill Sunfish	-	-	-	Y	-	-	-	P	-	-	C	C	C	-	-	-	C	-	Hb	Hb
Redear Sunfish	-	-	-	Y	-	-	-	P	-	-	C	-	C	-	-	-	-	-	Hb	Hb
Common Carp	-	-	-	Y	-	-	-	P	-	-	C	-	-	-	-	-	-	-	Hb	Hb
Sturgeon	-	-	Y	Y	-	-	-	Tf,R	-	-	C	-	-	-	-	-	C	-	C	C
Fresh Water Shrimp	-	-	Y	Y[6]	-	-	-	H,Tf	-	-	C	-	-	-	-	C	-	-	-	-
Salt Water Shrimp	-	-	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fairy Shrimp & Cyst	Y[7]	-	-	-	P	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-
Tubifix Worms	-	-	-	Y	P	-	-	-	-	-	C	-	-	-	-	-	-	-	C	-
Crayfish	-	-	Y	-	-	-	P,Tf -	-	-	C	-	-	-	-	C	C	-	C	-	
Grass Carp	-	-	Y	-	-	-	Tf,R,P	P	-	C	C[12]	-	-	-	-	-	-	-	C	-
Yellow Perch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Hb	-
Tilapia	-	Y—	Y	Y	-	Tfo—	Tfo	P,Cc R,Tf	-	C	C	C	C	-	-	-	-	-	C	Hb
Mosquitofish	-	Y—	Y	Y	-	P,R	P,R	P,R	-	-	C	-	-	-	-	-	C	-	-	-
Frogs	-	-	Y	Y	-	-	P	P	-	-	C	-	-	-	-	-	C	-	-	-
Fresh Water Algae	-	-	Y	-	-	-	T	-	-	-	C	-	-	-	-	C	-	-	-	-
Alligators	-	-	Y	Y	-	-	P	-	-	-	-	C	-	-	-	-	-	-	-	-

CV = Commercially viable
TNS = Transition from research & development to commercially viable
RD = Research and development
IGD = Integrated dependent with another commodity
Y = Yes
\- = Not applicable, or not pursued at this time
P = Pond
Pc = Pen culture in ponds or raceways
R = Raceway
Tf = Tanks using a flow through, one pass system

Tfo = Tanks using a flow through, one pass system supplemented with liquid oxygen
Tcs = Tank culture using a closed system
Cc = Cage culture
H = Hatchery
Hb = Hobby and/or recreational use. Where RD is applicable, it supersedes Hb
C = Commercial. It may be a viable, transitional, or R&D commercial endeavor. Check species and systems columns to determine status of development.

Note: The status information contained in Table 1 represents the status of the industry in each state at this writing, and is subject to change. Consult with your state Extension representatives for the most current information.

1. Chinook and sockeye salmon are grown by Native American communities in Washington for use in ocean ranching.

2. Juvenile Atlantic salmon are grown commercially in Washington for salt water, net pen growout systems.

3. Raceway culture of catfish using artesian geothermal water is conducted in Idaho.

4. Cage culture is integrated with other forms of agriculture by using irrigation water in aquaculture systems.

5. Where the key is linked across categories by a line indicates strong debate on the status of the system or species in combination with the system.

6. Viable commercial hatcheries for Macrobrachium exist in the western U.S. and supply postlarval shrimp nationally and internationally. The hatcheries are integrated with production of other aquaculture species. Commercial growout is limited to research and development.

7. Inland salt ponds or lakes where Artemia is harvested are included in this publication for information purposes.

8. No commercial freshwater aquaculture is being conducted in Alaska. All fish are considered public domain. If a person growing freshwater species plants the species on private property, then that property is mandated to have public access. There are no provisions in Alaskan law which provide for transfer of public domain fish to private ownership.

9. The major source for Arizona channel catfish is California markets. California does not allow importation of live channel catfish into the state unless a cooperative program is established to assure introduction of fish free of catastrophic disease. Arizona growers have obtained channel catfish broodstock and fingerlings from inspected sources within California and have maintained these stocks on farms that hold only California-approved animals for reproduction and/or growout.

10. Atlantic salmon research and development is for broodstock and egg development.

11. The aquarium industry in California is not considered aquaculture by the lead agency.

12. Sterile triploid grass carp are produced in California by commercial growers through special licenses issued through the Fish & Game Commission and are restricted to southern California to control aquatic vegetation.

13. Trout dominates production in Montana, however, salmon, perch and walleye are grown on a limited scale.

interpretive nature of the material there will be disagreement among those using the evaluations. Understandably, this is commonly expressed by those with a financial investment already incorporated with a business venture. It is asked that the reader accept the different interpretation, but that the acceptance be based upon information provided by the business prospectus and relevant to the criteria expressed in the four categories.

MARKETS: THE KEY RESOURCE

Markets are the key resources to commercial aquaculture. Market identification and characteristics should be determined before a species is chosen or the final site selection is made. With the exception of segments of larger industries and a few innovative companies, marketing development is not well established in western aquaculture. Most moderate and small companies rely on their own initiatives to identify and develop markets. While most producers will share or trade production and related information, individual marketing practices and market identification more often fall within an area of guarded competition. General information on market outlets is available through periodic state industry overviews, trade association literature, and state and regional aquaculture associations. Covered here are a few principles that should be initiated early in an analysis of aquaculture potential with additional information available through producer associations. The following is not all-inclusive but should be among the first steps when addressing aquaculture markets.

Market Identification and Access: Market identification and access are among the first principles of good business. This includes the location of the market, who wants the product, and how the grower enters the loop. Early in the process the potential grower should determine where to fit in the market framework. Among the choices are as a wholesaler, retailer, a satellite farm within a cooperative agreement with a larger operation, farmers' markets, supplier to a finishing grower, or a combination of the above.

Also critical to identification and access is how the market wants the grower to package or handle the product, with options including processing, fish delivered as fresh dressed to retail outlets and restaurants, and delivered live as stocker animals or live to retail outlets. Each choice requires additional information on the seasonal condition and carrying capacity of on-farm roads and public roads leading to local and regional markets, or to air and other freight transport to distant markets. Also important is information on time and distance to markets and the ability to consistently meet scheduling agreements for delivery.

Status of Market: Information on the status of aquaculture markets is more difficult to obtain, especially for potential growers who are not receiving input from customers and other related sources. Useful information includes the market size and whether the market is static, expanding, or contracting. Critical to the analysis is the potential for market expansion and the mechanisms necessary to facilitate market growth. Also essential is information on market price structure. This should include information on the impact of entry into the market at the projected production level, and how future production expansion and others entering the market with additional products will impact market price.

Competition is a component of market status. In addition, because aquaculture is so diverse, the type of competition will depend on the nature of the product such as food, bait and recreational species. Competition within the bait and recreational fish industry primarily consists of the percentage of market captured by the producer delivering a few similar species. Competitive factors include quality of product, consistency of delivery in volumes required, and with many recreational fish the competitive bid process. Competition within food fish markets includes other producers of the same or similar species, and the commercial fisheries.

The competitive relationship between aquaculture and commercial fisheries is unique. Aquaculture benefits from fisheries because of the market exposure and visibility fisheries products command in food markets. On its own, aquaculture does not possess the diversity of product in volume to command similar exposure. In its present role it captures a niche of the larger aquatic foods market, and serves to expand that niche as aquaculture production increases. The impact on local aquaculture production of foodfish from both fisheries and other aquaculture production can be national and international in origin. A good market analysis follows seasonal variations, price fluctuations and projections through statewide, regional and national aquaculture and fisheries trade associations and trade journals.

Market Impediments: Two major impediments to aquaculture markets are caused by the relationship of aquaculture species to what could be considered natural species, and impacts of state and national disease regulations. Although aquaculture species may have genetic characteristics that promote faster growth and more efficient food utilization, they are the same species as those found in the wild and subject to the same parasites and diseases. The regulatory process is viewed by industry as a mixed blessing; established to protect both the wild and cultured species, it more often does not have the necessary budget to enforce its total mandate. Faced with these limitations regulations may often focus on the more easily controlled segments under the regulatory agency's jurisdiction. While debate continues, those responsible for market analysis try to position the company in ways that lessen the impact of a disease capable of closing the entire market structure. This is often accomplished through stringent disease management protocols, well established disease inspection and certification programs, and diversification of product lines that allows cash-flow through other market outlets.

A second potential impediment to markets is regulations that prevent transport of live animals across state lines without certification that the stock is free of catastrophic disease. States which employ these regulations have mechanisms that allow import of live animals, and arrangements for market access can be accomplished through cooperative efforts of the grower with one or more of the state regulatory agencies. Information on intrastate transport of live fish can be obtained from the state agency responsible for aquatic disease regulations.

Market Diversification: There is never total protection in a dynamic market. There are, however, actions that reduce impacts of temporary market closures due to factors such as disease and reproductive failure. Diversification of product line or company structure offers one of the strongest protections against the disruption of cash flow. This may be accomplished through production of multiple species allowing different market outlets, diversification of investments such a fish production combined with the operation of fee fishing lakes, or production of fish rations or industry equipment.

Where possible, maintenance of market outlets for both live, fresh delivered, or processed product does offer some market protection. Fish with catastrophic disease that are excluded from live markets are often of value in the dressed fish market. The manifestation of the disease may be potentially lethal to the fish but does not impact humans, and the flesh may be of high quality if early market decisions are made. If these alternate markets are not maintained on a regular basis, it may be difficult to arrange market outlets in either a timely or profitable fashion. Companies that opt for diversification and maintain multiple outlets for product also maintain a competitive advantage in the marketplace.

WATER AS A RESOURCE

A primary step in the evaluation of a freshwater site is an assessment of water volume, quality, and temperature. Because water and its characteristics are principle limiting factors to production, this information should be gathered before time is invested in obtaining other site criteria. The value of water quantity is self-evident as commercial operations require an abundance of water. Seasonal fluctuations in water volume and characteristics are essential pieces of information as they will impact total production capabilities.

Sources of Water: Obtaining water from sources where the headwater is not under the control of the grower increases risk to the operation. For example, the water could be temporarily diverted or accidentally contaminated by upstream users without the knowledge of the grower, thereby causing fish mortality or total loss. Another risk is associated with obtaining water from streams and rivers containing wild fish. The wild fish can be carriers of pathogens or parasites easily transferred to the production fish. Although the wild fish may not show significant mortalities, the production fish grown under higher densities in these same waters, if stressed, will often contract disease and/or parasitic infestation.

Most commercial growers have total control over their water source. Depending on the species and type of production facility used, these water sources include artesian springs, well water, and irrigation water not subject to chemical aquatic weed control measures or significant populations of wild fish.

Water volume also influences the type of production system used and the level of production activity. Trout and other freshwater salmonid growers prefer artesian springs delivering an abundance of relatively constant temperature water to be used in raceways or circular tanks.

Because of the high volume needed, pumping the water is not considered an economic option by most trout growers. Channel catfish growers use well water or water supplied by managed irrigation canals. Most catfish are grown in ponds which, once filled, only require makeup water due to evaporative loss or when flushing the ponds because of algal buildup, low oxygen, or other water quality degradation. Pumping is kept to a minimum, and therefore production is economically feasible. A few catfish producers have access to geothermal, warm, artesian water of sufficient flow and are capable of growing channel catfish in raceways and tanks receiving abundant flow. The water requirements of baitfish, goldfish, and ornamental fish such as koi are about the same as channel catfish.

Water Temperature Requirements: When considering water requirements for aquaculture potential it is useful to have some idea of the general requirements of water temperature ranges and water volume necessary when used with the targeted species and production systems. Table 2 lists some of the more common species cultured in the western states. Also provided is information on temperature ranges for survival, optimal growth, and spawning.

Temperature information should only be used for general guidelines as different genetic populations will vary in their temperature requirements. For example, many populations of channel catfish have optimal growth rates at a temperature of 84'F, and have been grown to market size in R&D systems and artesian geothermal raceways at that temperature within one year. Pond cultured channel catfish are exposed to seasonal and diurnal temperature fluctuations, and the optimal growth range usually falls within the ranges given in Table 2. Growers with intentions of spawning their own broodstock should note that successful egg development and spawning of this species require a winter exposure of water temperatures of about 46'F followed by the spring and summer temperature rises. The temperature requirements of each species and variety should be examined independently and the ranges given here used as general guidelines.

WATER VOLUME REQUIREMENTS

The quantity of water available is also a major criteria for determining the aquaculture potential of a site. The nature of the market being serviced, however, is often directly related to water volume and is a major influence on economic viability. For example, in California where there is a variety of markets for channel catfish the price for the product may vary in each market, and profitability is often based on the grower's success in capturing various market segments. There is no processing industry in the state, and fish are distributed to restaurants, local food markets, fee fishing lakes, and retail outlets selling live fish from holding tanks. In a given year the price received for fee fishing stock might be $1.75/pound, whereas the tank wholesale price might be $2.80/lb. Growers, therefore, often equate water as a monetary resource. A given amount of water will generate a given amount of cash depending on the target market and market price received.

TABLE 2. List of common freshwater species grown in the western states along with temperature ranges for survival, optimal growth, and spawning[1]. *(Modified from Piper et al., 1982; Bell, 1991)*

	TEMPERATURE IN °F		
Species	SURVIVAL RANGE	OPTIMUM RANGE	SPAWNING RANGE
Channel Catfish	33-95	70-85	72-82
Rainbow Trout	33-78	50-60	50-55
Brook Trout	33-72	45-55	45-55
Chinook Salmon	33-77	50-57	45-55
Coho Salmon	33-77	48-58	45-55
Atlantic Salmon	33-75	50-62	42-50
Brown Trout	33-78	48-60	48-55
Striped Bass	35-90	55-75	55-71
Black Bass	33-95	55-80	60-65
Bluegill	33-95	55-80	65-80
Golden Shiner	33-90	50-80	65-80
Goldfish	33-95	45-80	55-80
Fathead Minnow	33-95	45-80	55-80
Common Carp	33-95	55-80	55-80
Flathead Catfish	33-95	65-80	70-80
White Sturgeon	33-78	65-69	57-63

1. Temperatures given are general ranges for the species, and individual genetic populations may vary.

EXAMPLES OF SPECIES AND PRODUCTION SYSTEMS

The following are examples of water use by species grown and systems used for more common commercial species grown in the West. The cage culture information is presented as an option, and this method is often applicable for hobby and recreational growers.

Rainbow Trout: The most common system used to culture rainbow trout is either concrete or soil raceways receiving a high volume of appropriate water, with the volume measured in second feet (sec-ft): 1.0 sec-ft = 1.0 ft'/sec = 448.8 gal/minute. A typical raceway production facility may consist of a series of production units with each individual unit measuring about 10' wide x 100' long and 3" deep (Figure 1). A typical series may consist of four linked units flowing into a settling pond followed by four more units that flow into a terminal settling pond before release.

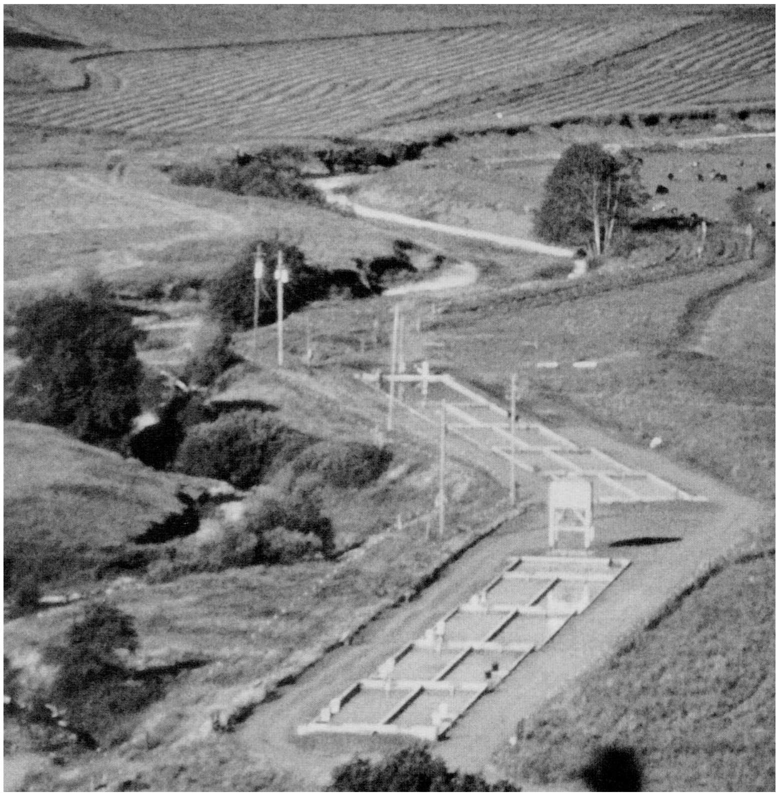

Figure 1. *Trout raceways consisting of two sets of units separated by a settling pond. Each unit consists of two parallel systems in a four-unit series.*

The flow of water within a raceway begins at the upper end of the facility and drops to the next unit in the series. If there is more than one series of units, and the units are located side by side, they are said to be in parallel (Figure 1; 2). The amount of production per sec-ft of water depends on factors such as fish density, water quality, temperature range during the growing period, and amount of fall between production units. Stocking densities vary at different sites because of differences in water quality. A typical stocking density might be 2 to 3 lbs of fish/Ft^3 of water in a 10' x 100' unit.

The amount of fall is the distance the water drops when passing from one unit to another within a series. Greater fall allows water quality recovery between units.

Average production per sec-ft of water is about 10,000 pounds of trout per year; and in some areas where water quality is high, the average may reach 15,000 pounds per year. Annual production has been recorded as high as 30,000 pounds per sec-ft per year where the fall between units is several feet and the water quality excellent.

A large Idaho production facility supplying a processing plant may have over 1500 sec-ft of available artesian water. The facility may consist of over 100 raceways set in four to six units in a series, and 100 parallel units. in contrast, a typical California or Washington facility supplying trout to recreational lakes and local fresh markets may have two parallel systems each in an eight-series design, with about 12 sec-ft of available water. Most commercial producers feel that it takes a minimum of 9 to 12 sec-ft of water for a facility to be self-supporting. Most water sources are from artesian springs, and many trout farmers feel that pumping water at a trout production facility is not economically feasible.

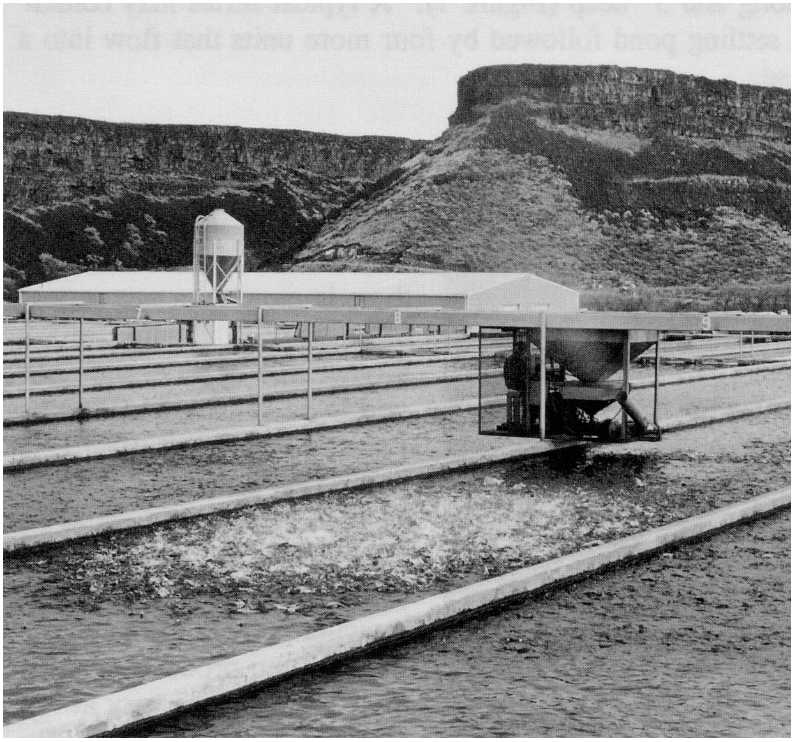

Figure 2. *Trout raceways showing multiple parallel units set in a two-unit series.*

Channel Catfish*:* Most channel catfish are grown in earthen ponds (Figure 3). A typical pond may be 5' deep at the deep end and 3' deep at the shallow end. The ponds should be designed for total draining. The size of the pond is measured in surface acres, and production ponds may range from 5 to 40 surface acres. A common stocking density in the West targets for a carrying capacity of 2500 to 3500 lbs/surface acre. Most producers feel a minimum of 80 to 100 surface acres of production water is required for a facility to be self-supporting. Small-scale producers integrate catfish production with other agriculture activities on their land to maintain economic viability.

Commercial producers using wells as a water source employ a backup system of multiple pumps and have the capability of at least 25 gpm of water per surface acre. The system usually has the capacity to deliver a large volume of water to any single pond that has oxygen or other water quality problems.

Baitfish: Baitfish, such as fathead minnows and golden shiners, are grown in ponds and have about the same water requirements as channel catfish. The ponds may be 2.5 to 10.0 surface acres and are constructed with the same design. Many catfish growers in the West stock fathead minnows in channel catfish broodstock ponds for supplemental nutrition, then harvest and sell the excess minnows to recreational fee-fishing lakes.

Tank Culture: Tanks used in fish culture are usually square, rectangular, or circular; the shape used is usually determined by availability, cost, and available labor for maintenance and cleaning. The most preferred tanks are circular with a center drain that facilitates a measure of self-cleaning. Closed system tank culture for foodfish is R&D. Flow-through tank culture, however, is used for commercial culture of fish such as rainbow trout, where the

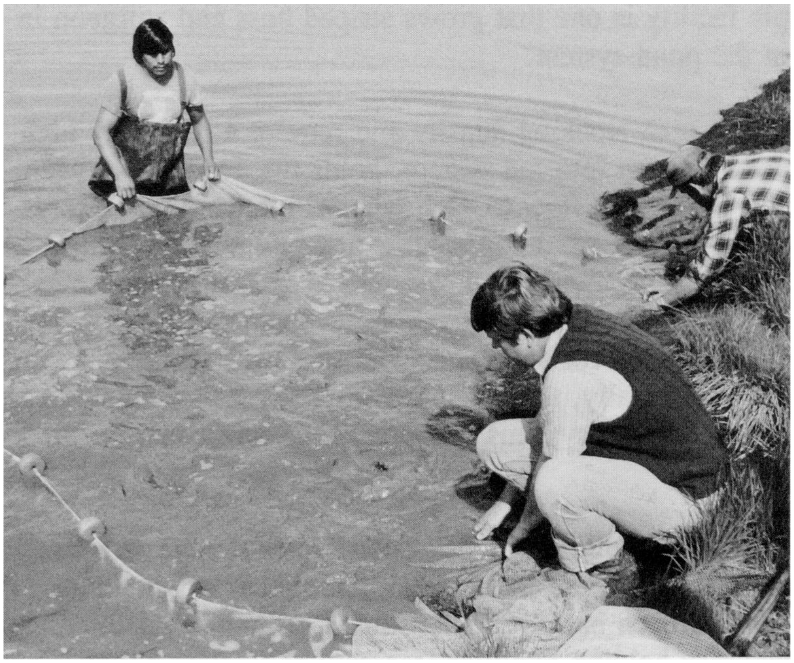

Figure 3. *Seining an earthen catfish pond.*

facility receives a substantial flow of artesian water. The reasons commonly given for their use include adaptability to space, terrain, portability, and simply preference.

Striped bass, hybrid striped bass, and tilapia are also grown intensively in tank systems. Often a grower will integrate a tank farm to grow an R&D, or transitional R&D, species with a pond culture system to grow an established, economically viable species. A common design incorporates water pumped into an elevated, reservoir-pond capable of holding a 24-hour reserve for the total tank farm if both the main pump and backup pump fails. The water flows by gravity through the tanks and into a settling pond and then into the production pond system (Figure 4). It then flows from the production ponds to collection canals where water is drawn for other

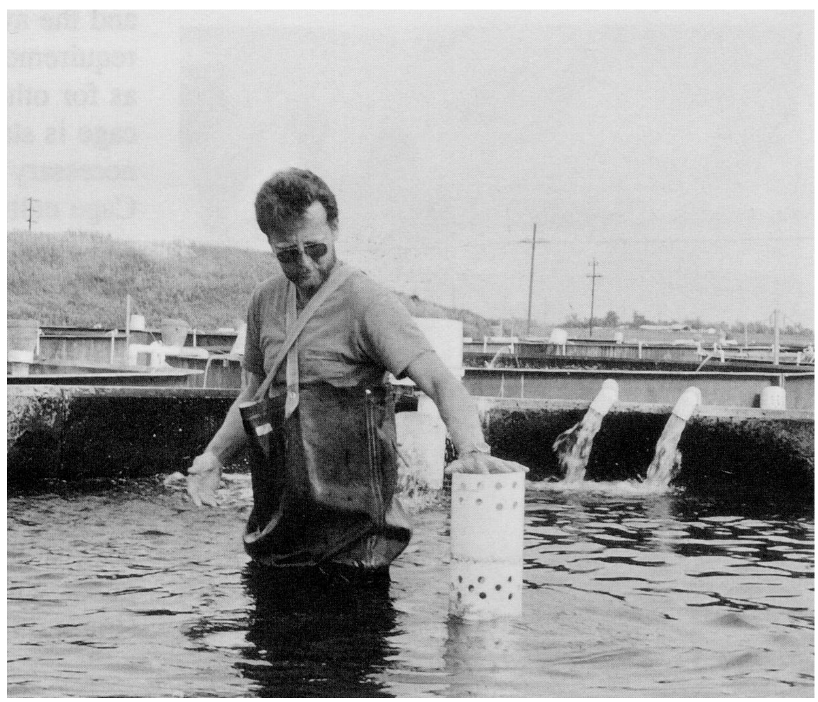

Figure 4. *Intensive tank culture showing removal of the center drainpipe and elevated reservoir in the background.*

agricultural enterprises. An example facility is one that grows striped bass and sturgeon in the tank farm and channel catfish in the pond system.

Tanks usually incorporate a moderate to high stocking density and require a relatively high water flow. The water flow transports oxygen into the system, holds the available oxygen, and removes waste with the outflow. The water flow to each tank will depend on factors such as species, size of fish, volume of tank, water temperature, pH, and oxygen content of the water. Commercial stocking densities may range from 1.5 to 3.0 lbs/gallon, and may require 5 to 10 water exchanges per day depending on temperature, oxygen, and other water quality criteria. Some farms use liquid oxygen for supplementation. Commercial tank farming requires large volumes of water. Ideally, the water is from an artesian source or, if pumped, used several times on other production systems to increase the profit margin for water used.

Cage Culture: There is relatively little cage culture of freshwater fish in the western states. Several attempts have been made to establish large, commercial, freshwater cage culture production facilities but, to date, this approach has not demonstrated economic viability. Most efforts are established as temporary holding facilities, recreational and/or hobby activities, and educational demonstration projects.

Cage culture may hold promise for the future but, again, success will depend on site selection and the available resources. The water requirements for cage culture are the same as for other forms of culture. Because the cage is stationary in the body of water, it is necessary that the water move past the cage. Cage culture requires sufficient water depth and current-to prevent accumulation of food and animal waste beneath the cage that can impact growth and fish health. It also requires movement of water to remove the lens of water containing metabolites that will accumulate around the cage where there is no current and to provide an influx of new, oxygen-rich water. Typical sites for cage culture include lakes, canals, and large ponds with the above characteristics (Figure 5).

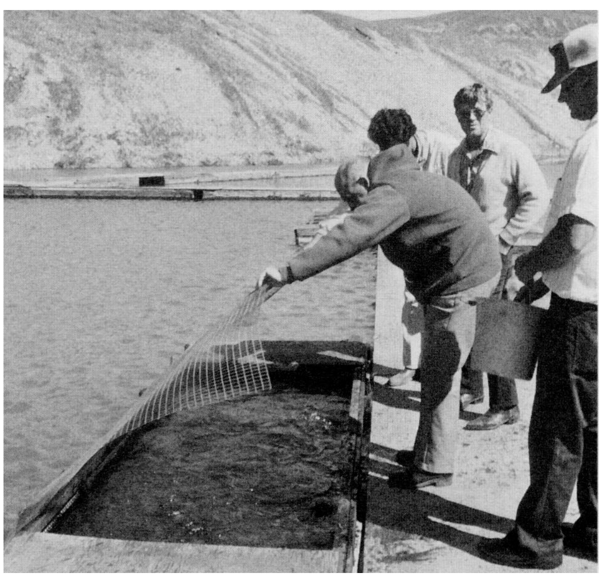

Figure 5. *Cage culture of rainbow trout.*

Closed Systems: Closed systems for foodfish production are still considered R&D and not yet economically profitable. The cost of capital construction, combined with the operational expense, exceeds the price per pound of product. Closed systems are used successfully with production of aquarium fish and aquarium feeder fish because the profit margin per pound of product is much higher. Foodfish production of species such as hybrid striped bass and tilapia using high density tank production supplemented with liquid oxygen is also considered R&D, perhaps transitional R&D, but only if the price per pound of product rises and remains high. The same systems used to produce channel catfish have not proven successful because of the relatively lower profit margin.

Closed systems with makeup water are being used to produce rainbow trout for fee-fishing lakes where the product is used by the growers to stock their own lakes. Growers also use stand-by net pens in the lake to hold stocks if the biological load in the system becomes excessive and outstrips the capabilities of the production system, or in case of system failure.

Because of their water saving qualities and characteristics such as almost unlimited site location potential, all of these production systems will be extremely valuable to aquaculture when they are developed.

NON-PRODUCTION SYSTEMS

Fee fishing: Successful fee fishing operators maintain ideal conditions for fish in their fishout operations but, in addition, maintain conditions at the site that attract and encourage returning patrons. With respect to the needs of the fish, marginal conditions are not satisfactory. Water conditions must be ideal as the fish are maintained in higher densities than in farm ponds, but less than in production facilities. The ideal conditions are necessary as only healthy fish take hooks, and this concept is essential to the operator's success. If the customers do not catch fish, they will not return.

Fee fishing ponds and lakes are operated in the same manner as a low intensity fish production facility with a fast changing inventory. These ponds and lakes are susceptible to problems including excessive algal blooms, aquatic weeds, inadequate oxygen, bird predation, and fish disease. Water quality is just as important to these systems as it is to a production unit, and a good volume of fresh water must be available for water exchange, pond flushing, temperature regulation, and emergency aeration. It is also advisable to have pump equipment and emergency power available for emergency aeration and water movement. Where feasible, small to moderate ponds should be constructed to drain completely for maintenance. Each lake or pond should be a separate entity so that problems can be kept separate when they occur. Ponds should also be constructed to provide water inlets separate from water drains.

The basic principles apply to fee-fishing operations that provide channel catfish, rainbow trout, or other available species. Many facilities will keep a mix of species seasonally as water temperatures change, or mixed populations if the system is large enough to accommodate different temperature strata and environments. Successful fee-fishing operations are run by individuals who like the general public and welcome them on their land. Another option is to operate a private fishing club that utilizes a lease or other means that limits access to the landowner's property.

Farm Ponds: Farm pond aquaculture requires the least resources of the systems described. Typical systems can include livestock watering reservoir, irrigation ponds, and small ponds designed for recreational enjoyment. Good water quality is required, but the lower density of fish in the pond will not deplete the resources that are used under more natural conditions. There is little or no water exchange, and the water source is usually provided from a small volume well, seasonal rain, or other water runoff.

WATER QUALITY CRITERIA

Water quality as a resource refers to the chemical makeup of the water at its source. Additional criteria to be considered are the impacts on the chemistry of water caused by the type of system used, management practices, and the state of the water as it leaves the system. Taken one at a time the criteria are as follows:

Chemistry of water at its source: Aquaculture requires high quality water, usually defined here in relationship to its effect on finfish. The impact of water on finfish results from both its soluble components (chemical attributes) and insoluble components (suspended material). The primary water source should be free from significant amounts of suspended material, therefore emphasis in this section will be on soluble components that define the water chemistry.

One of the simplest tests of water quality is it potability. If a person can drink it and live with it, usually a fish can grow in it. If it is distasteful, irritating, or bacterial laden, then it is most likely a poor choice for fish culture. A second test commonly used is a simple fish bioassay. A very small population of the fish to be grown are caged or otherwise contained in the water flow, provided good aeration, and their condition checked over time. These methods are usually employed by landowners who do not want the expense of water analysis, do not intend to develop a commercial operation, yet want some information on the applicability of the water for low culture density and recreational use.

Investment in commercial aquaculture requires investment in the chemical analysis of water. The short tests described above provide some measurement of the potential or immediate impact of water on fish. These methods, however, do not measure the sublethal impact of water with chemical imbalances that can stress fish over time, resulting in poor growth, poor reproductive performance, and lower resistance to parasites and disease.

Table 3 reflects suggested water quality standards for both cold water and warm water aquaculture facilities. The data are combined from multiple sources. Some chemical characteristics such as oxygen and nitrogen content may be easily correctable, but others such as mineral and alkalinity may exclude the water source from further consideration.

TABLE 3. Suggested water quality criteria for aquaculture hatcheries or production facilities. Salmonid quality standards with modifications for warmwater situations. Concentrations are in ppm (mg/l). ***(Source: Modification from Wedemeyer, 1977, Piper, et al. (Larsen), 1982)***

Chemical	Upper Limits for Continuous Exposure and/or Tolerance Ranges
Ammonia (NH_3)	0.0125 ppm (un-ionized form)
Cadmium[a]	0.004 ppm (soft water < 100 ppm alkalinity)
Cadmium[b]	0.003 ppm (hard water > 100 ppm alkalinity)
Calcium	4.0 to 160 ppm (10.0-160.0 ppm[d])
Carbon dioxide	0.0 to 10 ppm (0.0-15.0 ppm[d])
Chlorine	0.03 ppm
Copper[c]	0.006 in soft water
Hydrogen sulfide	0.002 ppm (Larsen - 0.0 ppm)
Iron (total)	0.0 to 0.15 ppm (0.0-0. 5 ppm[d])
Ferrous ion	0.0 ppm
Ferric ion	0.5 ppm (0.0-0.5 ppm[d])
Lead	0.03 ppm
Magnesium	(Needed for buffer system)
Manganese	0.0 to 0.01 ppm
Mercury (Organic of inorganic)	0.002 ppm maximum, 0.00005 ppm average
Nitrate (NO_3^-)	0.0 to 3.0 ppm

[a] To protect salmonid eggs and fry. For non-salmonids 0.004 ppm is acceptable.
[b] To protect salmonid eggs and fry. For non-salmonids 0.03 ppm is acceptable.
[c] Copper at 0.005 ppm may suppress gill adenosine triphosphatase and compromise smoltification in anadromous salmonids.
[d] Warm water situations.
--Many freshwater species are grown in waters with low salinity (1-3 ppt), but low salinity can interfere with maturation and/or reproduction of species such as black bass.

(Continued page 18)

TABLE 3. (cont'd.) **Suggested water quality criteria for aquaculture hatcheries or production facilities. Salmonid quality standards with modifications for warmwater situations. Concentrations are in ppm (mg/l).**

Chemical	Upper Limits for Continuous Exposure and/or Tolerance Ranges
Nitrite (NO_2^-)	0. 1 ppm in soft water, 0.2 ppm in hard water (0.03 and 0.06 ppm nitrite-nitrogen)
Nitrogen	Maximum total gas pressure 110% of saturation
Oxygen	5.0 ppm to saturation; 7.0 to saturation for eggs or broodstock
Ozone	0.005 ppm
pH	6.5 to 8.0 (6.6-9.0[d])
Phosphorous	0.01 to 3.0 ppm
Polychlorinated biphenyls (PCBs)	0.002
Total suspended and settleable solids	80.0 ppm or less
Total alkalinity (as CaCO3)	10. 0 to 400 ppm (50.0-400. 0 ppm[d])
% as phenolphthalein	0.0 to 25 ppm (0.40 ppm[d])
% as methyl orange	75 to 100 ppm (60.0-100.0 ppm[d])
% as ppm hydroxide	0.0 ppm
% as ppm carbonate	0.0 to 25 ppm (0.0-40.0 ppm[d])
% as ppm bicarbonate	75 to 100 ppm
Total hardness (as $CaCO_3$)	10 to 400 ppm (50.0-400.0 ppm[d])
Zinc	0.03 ppm (Larsen - 0.05 ppm)

[d] Warm water situations.

Water sources with chemical characteristics similar to those presented in Table 3 are of hatchery quality, and depending on temperature and volume may be used for production of eggs, fingerlings and other market fish. Water quality declines as the chemical constituents deviate from those presented, and the impact on quality depends on the chemicals involved and the extent of deviation. Information on the toxicity of individual chemicals and their ranges can be provided by those providing the assessment. The direct harm caused by chemical imbalances impacts such physiological functions as ionic regulation, gill and kidney function, or destruction of the mucous membrane which is a primary protection of the fish's integument. The impacts may be rapid and lethal, slow and lethal, or nonlethal effects on growth and other performance.

Chemistry of water in the system: That water quality is affected and chemical changes occur in the culture system is presented here only to introduce the next section on effluents. The changes are primarily the result of the fish using the water to obtain oxygen and trace elements, fish excretion, and the chemical breakdown of uneaten food and fecal waste. The principal changes are in the concentrations of oxygen, ammonia, nitrate, nitrite, pH, and the amount of suspended solids in the water.

Chemistry of water discharged from the system: The chemical analyses of water discharges from fish farms are becoming just as important as analyses of the water source. Present and/or future government regulations mandate that water from fish farms meet prescribed discharge standards; and these standards may be set by county, regional, state, or federal jurisdictions. With proper design and post-culture treatment, the effluents can meet these criteria.

An increasing number of farms are using the effluents in secondary crop production by integration of aquaculture with more traditional forms of agriculture. The aquaculture effluent contains elements of low grade fertilizer that, if treated properly, can be of benefit to terrestrial agriculture. Nutrients that would otherwise be considered pollutants become a valuable asset as the water is used in plant crop production.

Obtaining a water analysis: A water analysis may be obtained from a commercial analytical laboratory and, in some cases, through university services. Not all universities can provide such services. Extension personnel and others providing an assessment can provide information as to where water and other analyses can be obtained.

A fist step is to obtain agreement on what analyses are to be obtained. Preferably, a full spectrum analysis is desirable as it provides the maximum information base. Because water analysis can be expensive, the depth of evaluation will also be influenced by the nature of the site and the potential investment projected by the site owner. Recreational and hobby aquaculture and fisheries are less critical than commercial production. The cooperating evaluator will work with the individual requesting an assessment and identify the more critical data necessary to make the evaluation.

Pre-analysis agreements should be made before an investment is made. Locations of samples and how samples are treated are important to the success of an assessment. In addition, some chemical analysis can be determined from samples taken at the site and transported to a laboratory before analysis. Other analyses may have to be performed at the site, or fixed so that the target substance is not lost or changed between the time of sampling and analysis. Do not assume that the analytical laboratory will automatically adhere to these protocols, but discuss the analysis with the assessment team and laboratory before samples are taken. Information on how to fix samples for analysis can be obtained from the assessor or from the literature (Stirling, 1985). Analytical laboratories should have this information or prescribe to a similar protocol.

Analytical data forms for water analysis can be found on page F of this publication. Most laboratories provide their own data forms for reporting results, however, those conducting an aquaculture assessment may insist on the data forms provided in this publication. Because you are paying for the analysis, obtain a pre-analysis agreement with the laboratory to furnish the information on the form you have requested.

SOIL ANALYSIS

A soil analysis is necessary in the evaluation of a site if ponds or reservoir are to be used as production facilities or water impoundments. The principal criteria of soil being examined are the ability to hold water with a minimum of seepage, suitability for use in construction of levees and roadways, and impact on the impounded water. Effects on impounded water may include potential turbidity from suspended or colloidal clay, adverse chemical changes with alkalinity and pH, or even contamination with toxic materials from past industrial or agricultural activity. Although rare, if a soil contaminant is suspected, samples should be handled carefully and in cooperation with an analytical laboratory. The soil analysis can identify problems that are easily addressed in the construction phase, thereby avoiding more serious approaches once production is initiated. Assistance with soil analysis can be obtained through the Soil Conservation Service (SCS). If the SCS cannot provide direct assistance, they and local county Extension offices can provide contacts where an analysis can be performed.

The primary resources of soil in pond culture are clay content, depth and volume of clay strata, and soil compaction. These characteristics influence factors such as water holding capacity, levee construction, and road building. Representative samples for analysis should cover the proposed area of construction with samples taken from representative depths from which soil extraction will be performed.

Soil profiles also provide information about location and extent of sand-lens and gravel strata that often cause water loss through seepage. Soil analysis and profiles are also essential if the proposed site is to be an intensive tank or raceway facility. The analysis is valuable in planning road construction, determining substrate stability, and the site's potential for terraced facilities for gravity flow. If intensive culture using oxygen injection with U-tubes is planned, information about potential rock strata is essential because of the equipment depth required.

Page I is a form to be used in the construction of a site map if an adequate topographical map is not available. Please provide such information in sketch form such with reference to the relation of the site to public roads, activities on adjacent properties, water sources, soil profiles, elevations, slope of the land, support buildings, and location of proposed facility. Please add any other information which might be critical to the analysis. Page J is a soil analysis data sheet to be used in conjunction with the site map. The sample results should be recorded on this sheet, then referenced by number on the map in page 1. Again, please add any information which might be critical to the analysis.

REFERENCES AND SUGGESTED READING

Included below are references to the citations contained in this publication. The additional literature is for the reader seeking information on common species cultured and production systems used in North America. The books chosen offer a broad range of production systems from backyard farming to full scale commercial application. The list is intentionally small to maintain emphasis on the evaluation process.

Those seeking additional literature or publications that present an in-depth coverage of aquaculture are encouraged to narrow their focus on a few species with potential application to their site resources and make requests through the appropriate state's Cooperative Extension offices. Services can be provided that lead to appropriate references, including electronic databases in the western region and the National Aquaculture Library.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program. Corps of Engineering, North Pacific Division, Portland, Oregon.

Boyd, C.E. 1979. Water quality in warmwater fish ponds. Craftmaster Printers, Inc. Opelika, Alabama. 359 pp.

Dupree, H.K. and J.V. Huner (editors). 1984. Third report to the fish farmers: the status of warmwater fish farming and progress in fish farming research. USDI, U.S. Fish Wildl. Serv., U.S. Government Printing Office. 270 pp.

McLarney, W. 1987. The freshwater aquaculture book: a handbook for small-scale fish culture in North America. Hartley & Marks, Pubs. 583 pp.

Piper, R.G. et al. (editors). 1982. Fish hatchery management. USDI, U.S Fish Wildl. Ser., Washington, D.C. 517 pp.

Stirling, H.P. (editor). 1985. Chemical and biological methods of water analysis for aquaculturists. Institute of Aquaculture, University of Stirling, Stirling FK9 4LA, Scotland. 119 pp.

Wedemeyer, G.A. 1977. Environmental requirements for fish health. <u>In</u> Proceedings of the International Symposium on Diseases of Cultured Salmonids. Tavolek, Inc., Seattle, Washington. p. 41-55.

EVALUATOR'S QUESTIONNAIRE

The aquaculture options available to a grower will depend on the level of resources at a potential site. Based on the magnitude of the resources, these options may include raising ornamental fish, recreational fishing, fee-fishing, small to large scale commercial aquaculture production, and integrated aquatic and terrestrial farming operations.

Potential commercial growers who are not locked into a particular site or have not selected a site are in an advantaged position. They can match the species of choice against the resources necessary to grow the animal at a given production level. By knowing the basic requirements of aquaculture species, potential growers can then examine various land sites and select from those that have the necessary resources. In contrast, if a site is already in the possession of the potential grower, the type and size of the facility and level of aquaculture participation will be limited by the resources available at that site.

Before an evaluation of a site can be made, a complete resource inventory must be completed and the information provided to the persons conducting the evaluation. The property should be assessed in terms of its total available resources, including communication as to how the owner would like to partition the resources for various activities such as aquaculture and any other activities from which income may be derived. Assessing the potential profitability of a proposed facility that is the sole monetary generator on a property is different from the assessment of an integrated operation where the total resources are used to generate cash flow from production of several commodities. The following sections are designed so that persons seeking the evaluation can provide the necessary information.

There are two sets of questions included in this packet. The first is designed to provide information to those conducting the evaluation of the proposed aquaculture site. This set should be discussed with the evaluator, completed, then returned. The second set is a standard questionnaire often provided persons contemplating aquaculture and is designed to test one's compatibility with the activity. These are questions which should be asked before proceeding with any aquaculture venture, but they do not have to be returned to the evaluator.

Please read the total set of questions before providing the information requested. Use the forms provided, but feel free to add additional information as required on separate sheets and attach those sheets to the questionnaire. The more information provided, the more it will assist in the evaluation process. Please provide any information that is not requested on these sheets, but which you feel will potentially impact the decision process. This information should relate to the resources present on or associated with the site.

Return to Evaluator

EVALUATOR'S QUESTIONNAIRE

1. Please indicate the present objective of the venture.

Recreational fishing	___
Commercial fee fishing	___
Ornamental and aesthetics	___
Integrated commercial production facility	___
Commercial production facility	___

2. Are you considering integrating the aquaculture with other agricultural activities and, if so, what activities?

3. Is the site to be exclusively an aquaculture venture?
What other activities will be occurring on the property?

4. What is the intended source of your water supply, and does it vary seasonally?

Reservoir (irrigation), and surface acres	___
Pumped well, and capacity	___
Artesian well, and capacity	___
Stream or river	___
Other (please describe)	___

5. What is the temperature of the water source and the annual variation and range?

7. Is it possible to secure the necessary water permits for the needed volume of water, or is a permit necessary?

8. Do you need a water discharge permit? If so, who have you contacted regarding the permit? If not, why?

9. Will your discharged water impact a natural body of water such as a stream, river, or wetland? Will your discharge impact other private, state or federal property? If so, please describe.

10. Has a chemical water test been conducted on your water source to assess its compatibility to fish culture?

11. What pumped wells are on the property? What are their volumes, depth, draw-down rates, and location on the property? (Please mark location on the map.)

12. What is the distance between your water source and the proposed facility site?

13. What is the elevation and fall between the water source and the prospective production site? (Please indicate on the map.)

14. What other use demands have to be considered for your water source?

15. Is the aquaculture operation to receive first-use water? Can the discharge water be used for other agricultural activities and, if so, what?

16. Please use the water quality forms enclosed to provide water data information. If the information is provided by a private water analysis company, have the chemists transfer that information to these forms. The extent of information requested will vary depending on the proposed activities at the site and the nature of the water source. The categories of analysis requested will be marked on the form by the evaluator. Data sheets are provided at the end of this section.

17. How much land is available for the proposed fish farming operation?

18. What is the elevation of the land and the associated climatic conditions such as prevailing winds, diurnal and annual temperature fluctuations, and annual snowfall?

19. Is the prospective site subject to flooding and, if so, from what source?

20. How close is the property to public roads, and what is the carrying capacity of the public roads? Can the roads on the property be used by heavy trucks in all seasons?

21. Does the property allow for on-site, live-in management, and allow observation of the facility from the living area?

22. Is electricity available at the production site? What are the electrical rates in that area and can agricultural rates be obtained?

23. What support structures are available at the site (houses, barns, storage facilities, etc.)? Can support facilities be shared with other agricultural pursuits?

24. Are ponds, raceways, or tanks being considered?

25. If ponds are planned, what is the soil profile of the site? Please provide a soil analysis report with this form based on representative core samples prescribed by the evaluator. A work sheet is provided on page 11.

26. Are other agricultural activities being conducted on or adjacent to the property that require and use agricultural chemicals? if so, what crops are grown, what chemicals are used, and how are they applied?

27. Have agricultural crops or other mechanized activities been conducted at the site that may have resulted in toxic chemical accumulation in a portion of soil at the site? If so, what chemicals are potentially present?

Return to Evaluator

CHEMICAL ANALYSIS DATA SHEET FOR EVALUATION OF WATER FOR AQUACULTURE POTENTIAL

Name:___________________________________

Address:_________________________________

____

____

____

Phone: (____)_____–_________

Unless otherwise indicated, chemical concentrations should be expressed in parts per million (ppm), which is comparable to concentrations expressed as milligrams per liter (mg/I).

Chemical	Concentration	Notes
Ammonia (NH_3)	________ ppm	
Cadmium[a]	________ ppm	
Cadmium[b]	________ ppm	
Calcium	________ ppm	
Carbon dioxide	________ ppm	
Chlorine	________ ppm	
Cooper[c]	________ ppm	
Hydrogen sulfide	________ ppm	
Iron (total)	________ ppm	
Ferrous ion	________ ppm	
Ferric ion	________ ppm	
Lead	________ ppm	
Magnesium	________ ppm	
Manganese	________ ppm	
Salinity	________ ppm	

Return to Evaluator

Chemical	Concentration	Notes
Mercury (organic or inorganic)	_______ ppm	
Nitrate (NO_3^-)	_______ ppm	
Nitrite ($N0_2^-$)	_______ ppm	
Nitrogen, max. total gas pressure	_______ % of saturation	
Oxygen (dissolved)	_______ ppm, at source	
Ozone	_______ ppm	
pH	_______ range	
Phosphorous	_______ ppm	
Polychlorinated biphenyls (PCBs)	_______ ppm	
Total suspended and settleable solids	_______ ppm	
Total alkalinity (as $CaCO_3$)	_______ ppm	
% as phenolphthalein	_______ %	
% as methyl orange	_______ %	
% as ppm hydroxide	_______ %	
% as ppm carbonate	_______ %	
% as ppm bicarbonate	_______ %	
Total hardness (as $CaCO_3$)	_______ ppm	
Zinc	_______ ppm	

Date water samples taken: ____________________

Evaluation performed by: ____________________

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Additional Notes:

Please record any additional information which might impact the water analysis or should be considered when evaluating the aquaculture potential of the site. This might include additional chemical analysis or other factors not listed in this form, or such factors as land run-off including agricultural manures. If any agricultural chemicals are a factor, please list the chemical, concentrations, and probable source.

Chemical	Concentration	Notes

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SITE MAP

Please provide a survey map of the proposed site showing location, elevation, water sources, and any other critical information. Include information concerning activities surrounding the site such as other agricultural or urban activities. If a survey map is not available, please use this form to provide a good sketch of the site. Show contours, water sources, elevations, buildings, and other prominent features. If this is an existing water site, please provide a sketch map of the impoundments, noting location in relation to roads, the water sources, where samples were taken, and any other information which might be considered appropriate.

N

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SOIL ANALYSIS DATA FORM

Name: ______________________ Address: _________________________________

Phone: (____)____–___________ _________________________________

Soil Analysis Performed by: ____

GENERAL

1. Type of soil: ____

2. Percentage clay and depth of clay strata: _______________________________________

CORE SAMPLE RESULTS (Please indicate location on site map)

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

(Use additional sheets if necessary)

Please provide additional information and use the site map provided to indicate slope direction, topography, proposed facility superimposed over samples, and indications of sand, gravel, and rock strata.

SELF-QUESTIONNAIRE

The following questions are designed to remind the potential farmer of parameters that should be addressed before a financial commitment is made to begin an aquaculture investment. Similar questions appear in many commercial and Extension publications. The questions have been reformatted to assist the potential grower in addressing the type of information essential to aquaculture and to determine if the grower is prepared to continue with the development of the aquaculture potential. The questions are for individual's use and do not need to be returned to those assisting with the overall assessment.

Has a full market analysis for the product been conducted, and is an analysis of where the product fits into the total regional and/or state fisheries market segment been included?

Will the product be marketed by the farmer, a distributor, or another producer? Will the grower control the markets? Are there alternate market outlets?

Have commercial operations been visited to become familiar with the commitment necessary to run a successful aquaculture business?

Have the state and/or national producer associations been contacted to see what resources are available?

Has the regulatory structure for aquaculture in the state being considered been researched? What county or state registrations or permits are required to conduct aquaculture, and what are the regulations concerning the species of interest?

Have the requirements and regulations concerning processing, food safety, and interstate shipment of the product been researched?

Can the site be protected from theft and poaching?

Has a business plan for the proposed operation been developed? Does it include equipment and maintenance costs?

Does the business plan include cost of obtaining the necessary permits? Have other individuals who have experience in developing business plans participated in developing this plan?

Self-Questionnaire
Do Not Return to Evaluator

Have all your operational and associated costs that will affect your ability to compete in the market and make a profit been considered?

Will the operation produce a seasonal product or plan to diversify to reduce seasonality? Is the management plan structured so the operation produces the earliest possible cash flow?

Are there adequate utilities including three-phase electrical power, sewage, and potable water? Is there a stable power source in the area?

Is there an inventory of necessary equipment, including backup equipment, such as additional wells, pumps, generators, and aeration equipment? How fast can a pump motor be obtained or water sources switched in an emergency?

What are the business tax structures, workman compensation liabilities, and other related health and safety criteria necessary to employ temporary or permanent help?

Has the necessary knowledge to understand the basic biological parameters for reproduction and/or rearing the targeted aquaculture species been gathered? Is there access to necessary skilled help to run the operation? Will a manager be needed?

Where will the initial disease-free aquatic stocks come from? How will information on the history and health-related condition of stock you plan to introduce into the system be gathered? Has a management plan to protect your facility from introduced fish disease been developed?

Will the broodstock be maintained on-site and produce seed stock or will another producer-supplier provide the broodstock and seed?

Where can assistance for disease and parasite diagnostics and treatment aquatic animals be found? What are the regulations that apply to chemical treatment of aquatic animals and production systems?

Is there the financial depth for capital outlay and operating expenses for a period of a year or more until marketing the first harvests? Will the farm survive a break-even or financial loss situation for the first year or two of operation?

Will the fish be live-hauled to market? What is known about transporting fish, including equipment, backup systems, avoidance of stress to the fish, and sanitizing equipment? What about density, water temperature, elevation, acclimation, and hauling time impacts on the success of fish transport?

Obtain information on sources of aquatic rations, including proper constituents, sizes, and feeding protocol. Determine where to get information on aquatic nutrition, types of rations, and their use in fish management?

Plan and coordinate a potential feed delivery schedule with feed mills, and plan for adequate ration storage and rate of turnover?

What is the relationship of algal blooms, photosynthesis, and plant respiration to oxygen in pond systems? What are the impacts and relationships of turbidity, feeding, pond fertilization, and weather on phytoplankton cycles and oxygen?

What will be the harvesting technique? What are the planned holding facilities for fish delayed from market?

Will there be retail sales at the site, and if so, what are the plans for public access, holding tanks and on-site processing? Will there be fee-fishing at or near the production facility? Has information on insurance and public liability that accompanies public access been obtained?