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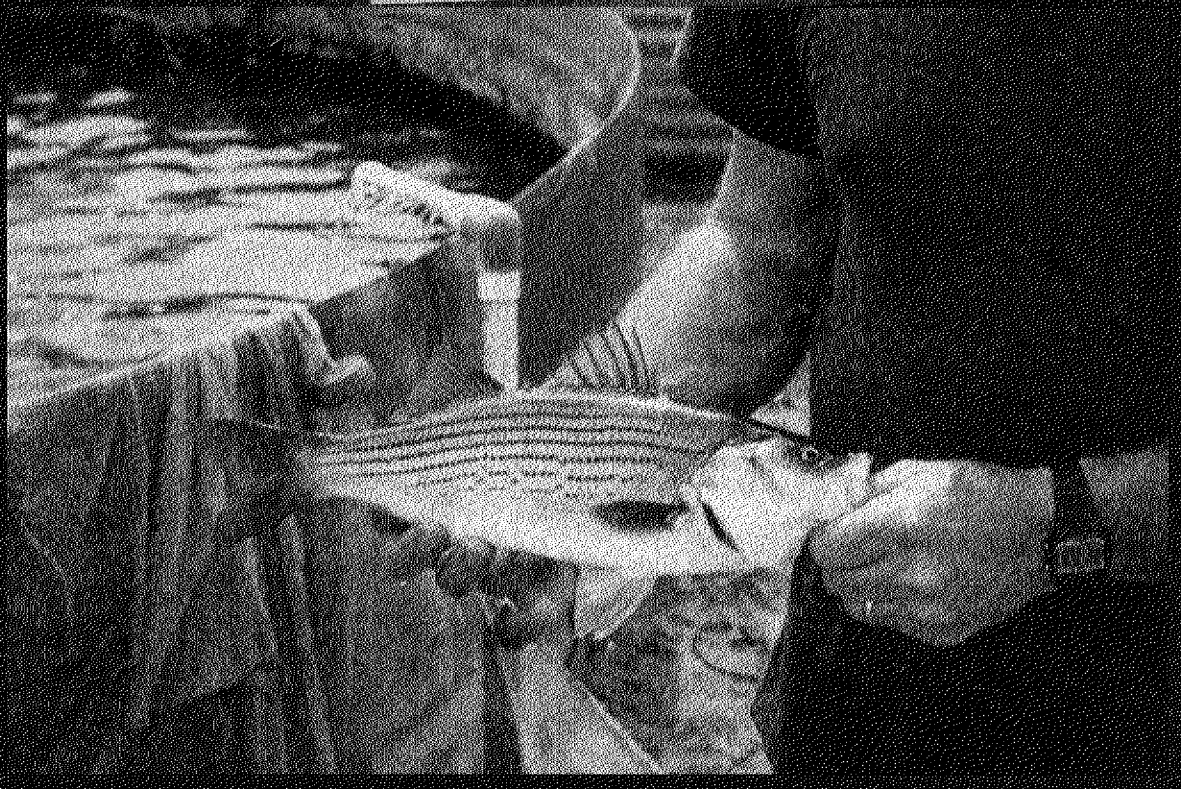
Issues in Aquaculture Regulation



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ISSUES IN AQUACULTURE REGULATION

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I. INTRODUCTION

PURPOSE OF THE GUIDEBOOK

This guidebook identifies key environmental regulatory issues for aquaculture and reviews options and recommendations for regulatory policy. The information presented in the guidebook is intended to:

- ***Foster the development of an aquaculture regulatory framework that promotes the growth of aquaculture and protects fisheries resources and the environment.***
- ***Assist aquaculture and fisheries industries, citizen groups, legislators, and federal, state, and local agencies to speed up implementation of sound aquaculture policies.***
- ***Give readers an introduction to the issues, informed analysis by reference to existing studies, and examples of options that can be tailored for state or regional variations.***
- ***Promote an understanding of the issues and constructive resolution of disputes and conflicting uses of natural resources.***

WHAT THE GUIDEBOOK COVERS

Aquaculture is the farming of aquatic plants and animals. The aquaculture industry in the United States produces:

1) foods (fish, shellfish, aquatic plants);
2) non-foods (such as ornamental fish, fish for pond weed control, and seaweeds for pharmaceutical and industrial applications); and
3) fingerlings for put-and-take fishing and stock enhancement for recreational and commercial fishing.

The guidebook focuses on the production of aquaculture food products. Each chapter addresses a set of public resource topic issues raised by aquaculture:

- **land use** (pond construction, impacts on wetlands),
- **use of water column and bottom in coastal and offshore waters**,
- **water and waste discharge**,
- **protection of wild species** (market distinctions, use of wild stock, predators),
- **nonindigenous species**,
- **aquatic animal health, and**
- **use of drugs and chemicals**.

Each chapter contains 1) a summary of the issues; 2) examples of state and federal regulatory approaches; 3) recommendations; and 4) references.

The guidebook does not cover water withdrawal (depends upon state water regime), local regulations such as zoning, fish processing and quality control issues applicable to seafood products, public health issues associated with the consumption of seafood, and trade laws.

WHO SHOULD READ THE GUIDEBOOK?

- State and federal natural resource managers, policy makers, and legislators.
- Public and private aquaculturists.
- Representatives of citizen, fishing, environmental, and farm groups.

NEED FOR THIS GUIDEBOOK

The need for the guidebook arises from several developments, trends, and constraints affecting the aquaculture industry:

- the size, rapid growth, and benefits of the aquaculture industry;
- the importance of environmental quality to the success of aquaculture;
- potential conflicts of aquaculture with competing uses and users of natural resources; and
- time consuming, costly, overlapping, and, in some cases, inappropriate regulations.

States that do not address problems with current regulatory approaches may lose aquaculture development opportunities to other states and countries and promote dispute rather than the mutually beneficial cooperation between aquaculture and other uses of natural resources.

Size, Growth, and Benefits of Aquaculture

Aquaculture is an important national and worldwide industry. The food and ornamental sectors of the United States aquaculture industry are approaching $1 billion in annual pond-side sales (see Table 1). Associated services, processing, equipment, and feed mills probably put the annual economic activity generated by the United States aquaculture industry at $3-$5 billion per year. The industry is one of the fastest growing agricultural sectors (Joint Subcommittee on Aquaculture 1992). Worldwide aquaculture production is projected to double during the next decade, stimulated by increasing demand for seafood, declines in wild catches in many areas, and advances in science and technology. The aquaculture industry produces healthy food, jobs and tax paying businesses that revitalize farm and fisheries communities, and scientific discoveries while providing an alternate source of supply that relieves stress on overfished wild stocks.

Some commercial and sport fisheries depend upon aquaculture. For example, 21% of Alaska's common property salmon catch in 1990 came from hatchery-produced fingerlings (Kron 1992). Trout, salmon, largemouth and smallmouth bass, and other panfish stocked as fingerlings make up a significant part of the fish anglers catch: one quarter of the United States population or 58 million anglers spent $28.2 billion in 987 million angler days in 1985 according to a U.S. Fish and Wildlife Service survey (1988).

Environmental Quality

The aquaculture industry depends upon the quality of the environment (land, water, nutrients) to produce a high quality product and, in some cases, depends on a few individual fish from stocks of wild aquatic species for broodstock. Aquaculture, like all activities, also involves some degree of impact or manipulation of the environment.

Relationship with Other Users of Natural Resources

As the aquaculture industry grows, so too does the potential for conflict as well as for mutually beneficial cooperation with other users.

Table 1. U.S. Private Aquaculture Production and Value for 1980 and 1990

	Production (1,000 pounds)		Value (1,000 dollars)	
	1980	**1990**	**1980**	**1990**
Baitfish	22,046	32,000	44,000	55,000
Catfish	76,842	460,000	53,572	370,000
Clams	561	4,000	2,295	14,000
Crawfish	23,917	90,000	12,951	55,000
Freshwater Prawns	300	250	1,200	1,000
Mussels	NA	2,500	NA	3,500
Oysters	23,755	25,000	37,085	50,000
Pacific Salmon	76,616	85,000	3,400	40,000
Shrimp	NA	3,000	NA	7,000
Trout	48,141	67,000	37,474	81,000
Other Species	NA	85,000	NA	85,000
Total	203,178	860,750	191,977	761,500

Source: All data from Economic Research Service, U.S. Department of Agriculture, except 1980 production data from National Marine Fisheries Service.

Sustainable Development Tradeoffs

Sustainable development has become a concept that everyone supports but no one defines consistently. Yet, the concept gets to the heart of the issues upon which the future of aquaculture depends. Sustainable aquaculture can be defined by culture practices that husband the natural resource base, limit environmental impacts, and provide for profitable long-term production (see Folke and Kautsky 1989). A sustainable aquaculture industry hinges upon reconciling environment and development tradeoffs. As in any use of natural or environmental resources, there are tradeoffs between food production, economic profitability, risk, and environmental preservation. Take the example of different types and intensities of shrimp farming. Extensive, semi-intensive, and intensive aquaculture describe varying densities and yields of the species cultivated, and the associated water management, feed, stocking or recruitment, and wastewater treatment methods. Shrimp are cultured under one of these practices in either tidal ponds (ponds built in wetlands) or upland ponds. The implications for uses of man made and natural inputs differ for each combination of use. Construction of upland ponds may cause less environmental destruction of coastal resources than impoundment of tidal marshes. Upland pond production uses a feedlot approach and requires greater inputs of artificial fertilizer, feed, and energy (water pumping and aeration) and causes greater impacts on water quality through withdrawal and discharge than tidal pond production. Tidal pond approaches use natural inputs as much as possible supplemented by man made inputs, minimizing artificial inputs and environmental impacts, but requiring more acreage to achieve profitability.

Some commercial fishermen, under pressure due to decreasing catch and increasing foreign competition and regulations, view aquaculture as a competitor. Industrial and residential development and wetlands preservation may compete with aquaculture for coastal land. Open water net pen or raft culture has been opposed by shoreline landowners for aesthetic reasons. Despite these instances of conflict, it can be argued that the advantages to cooperation outweigh any potential conflicts: commercial and sport fishermen, landowners, environmental groups, and aquaculture producers have a common interest in preventing environmental degradation.

Regulations and Management Practices

Preserving environmental quality, curbing potential negative environmental impacts (real and perceived), and allocating natural resources between competing uses have been addressed in our society by:

1) Government regulations.

2) Management practices (commonly called best management practices or BMPs) to avoid and reduce adverse impacts and achieve more efficient production. The use of BMPs in many areas of human activity has increased in response to regulations (and as a way to avoid the effects of regulation) and to capture the efficiency and cost savings benefits of improved production practices. BMP's are developed by state and federal agencies and by private producers and industry associations not as regulations, but as operational standards.

To preserve remaining natural habitats and to protect human and environmental health, governments have imposed increasingly stringent land use restrictions and air and water quality regulations on all users of natural resources, including aquaculture. The aquaculture industry is affected by (1) general regulatory programs for air, water, and natural resources that apply to all users of public resources and (2) specific aquaculture regulations.

Environmental regulations are designed to protect the environment and can be beneficial to the aquaculture industry (e.g. by curbing industrial, agricultural, and urban wastes). However, the permitting process can be time consuming, costly, and confusing because of the trend towards more regulation, the lack of coordination between agencies at all levels of government, insufficient staff (and budget) at the agencies, and lack of accommodation or conflict resolution mechanisms (see for example, U.S. Advisory Commission on Intergovernmental Relations 1992). Examples of significant regulatory costs borne by producers include the permit review and studies required for net pen farming in Washington State and Maine, disease testing for movement of salmonids, costs of studies and permit process for effluent discharge permits in Hawaii, and effluent discharge and wetlands permitting in Maryland. The State of Maine estimated that, in 1990, its permit processing took an average of 16 months and cost approximately $50,000 per permit (Eichenberg 1992); a survey of salmon farmers indicated costs in excess of $100,000 for fees, research, and legal costs to obtain the permits (Bettencourt and Anderson 1990). This compares favorably to Washington State where permit processing costs on average between $150,000 and $400,000, not including costs for the preparation of an environmental impact statement, if required (Eichenberg 1992).

Although aquaculture is a form of agriculture, regulation of aquaculture has been conducted with an amalgam of fisheries, water resources, industrial, and agricultural regulations. Because they were not designed for aquaculture, some regulations do not accurately reflect the needs and impacts of aquaculture. For example, nearly all coastal states delegate aquaculture regulations to fish and game agencies; aquaculture regulations are then written and implemented by wildlife managers rather than by (or in consultation with) government personnel responsible for agriculture. In other cases, regulatory difficulties arise because of inadequate planning, improper sitting, and lack of knowledge on the part of some permit applicants and regulators. Some states do not have basic aquaculture regulations in place to protect both the aquaculture industry and the environment.

REGULATORY FRAMEWORK FOR AQUACULTURE

Much work has been done during the past decade to study and recommend improvements in aquaculture regulations and BMPs. Examples include model BMPs and regulations for aquaculture effluents, industry BMPs for net pen culture, recommended lease program features for public waters, a proposed joint/coordinated federal and state permitting and lease process for net pen culture, aquaculture parks, development of "specific pathogen free" shrimp broodstock, and the establishment of state aquaculture coordinators. Many states have adopted some of these recommended features. Much work remains to be done. Constructive aquaculture policies and regulations can accentuate the benefits of cooperation and head off potential problems.

General recommendations that apply to most of the chapters in the guidebook include the following:

- Define aquaculture as agriculture in state and federal laws.
- Identify a lead agency in each state to coordinate aquaculture regulations.
- Streamline the permitting process.
- Adopt conflict resolution mechanisms.
- Include aquaculture in government planning.
- Formulate regulations in consultation with representatives of aquaculture industry and other affected constituencies.

- Encourage the adoption of best management practices (BMPs).

- Expand and support research, education, and extension efforts.

Aquaculture regulation also needs to be considered within the broader context of alternate uses of natural resources and of food production. Resolving conflicts over aquaculture's use of coastal waters, for example, may depend in part on how badly aquaculture products are needed. Over $100 million worth of salmon are annually imported into the United States; the same quantity of fish could be produced in less than 100 acres of the three million acres of Puget Sound (Ziemann et al. 1990). The environmental effects of aquaculture regulations need to be considered in relation to the regulatory efforts applied to other domestic fisheries and livestock production and to imported products.

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II. LAND USE

This chapter addresses aquaculture land use policies and regulations for both inland (non-coastal) and coastal land. Federal wetlands regulations are presented in greater detail because they have become a focal point for land use regulations applied to aquaculture. Although state wetland and land use regulations vary widely around the country, the types of state land use regulations likely to be encountered by aquaculture operations are outlined.

ISSUES

Land-Water Connection

As the need for suitable land and high quality water often go together, many aquaculture operations are located near water at coastal or riparian sites. As pressures increase to develop land for urban and industrial uses, the ecological importance of the remaining undeveloped land increases. This is especially true for "high value" ecosystems, such as wetlands, that help to maintain environmental quality and serve as habitat for many species. Wetlands are "a little bit of water and a little bit of land" characterized by terms such as marsh, bog, fen, mudflat, and swamp (see Kusler 1992). Use of these sites is determined by market forces (sale of private land), government restrictions on private land use (zoning, environmental regulations), and policies governing private use of public lands.

Government Regulation

Ponds, canals, and structures for aquaculture alter the associated environment and land to some degree. Ponds may replace farm fields and forest plantations, for example. Environmental and land use regulations in the United States act to curb potential adverse impacts of aquaculture by (1) limiting the available sites to preserve natural and wetland areas (making it difficult to site ponds in some parts of the United States), (2) encouraging avoidance of environmentally sensitive areas when sitting ponds and facilities, and (3) specifying what type facilities may be constructed and how the facilities may be operated to reduce or mitigate impacts.

Differences Between Inland and Coastal Land

Some wetlands regulations apply to both upland and tidal land. However, the distinctions between upland (or nontidal) and tidal or coastal land influence regulatory issues:

***Inland (Noncoastal) Areas*:**

- Likely to be privately owned land, often farmland.
- Freshwater.
- New pond construction in certain types of wetlands requires federal and state permits.

***Coastal land*:**

- Usually adjacent to public land or water, raising public trust issues.
- Brackish and saltwater with a high probability of involving wetlands.
- Comes under state and federal critical area or coastal zone provisions and new construction in tidal areas is now virtually prohibited in the United States by federal and state laws.

REGULATIONS

Overview

Existing approaches to land use regulation for aquaculture include *local* zoning and land use statutes; *state* wetlands, coastal, and critical area laws; and *federal* laws and regulations pertaining to wetlands, coastal zone management, and land/water use. The complexity of permit and review pathways are illustrated by South Carolina's requirements in Figure 1. In practice, applicants, and government agencies work together before formal permit applications are submitted to make an initial determination of the applicability of wetlands, water, or other regulations. Agency staff may suggest design and location modifications to eliminate the need for a permit or to mitigate possible adverse impacts.

Federal Wetland Regulations

Aquaculture operations must satisfy federal and state wetlands regulations like other land and water users. Wetland regulations represent perhaps the most critical regulatory step for pond aquaculture because they can open a Pandora's box of many other federal, state, and local review and permit requirements.

Current Requirements

Current federal wetlands regulations under Section 404 of the Clean Water Act are outlined in the adjacent box. Many wetlands issues for aquaculture operations in the lower Mississippi catfish producing region and in some other states were resolved by the Corps decision in 1990 to not require a Section 404 permit for pond construction on "prior converted" farmland (defined as land in agricultural production before 1985). Many ponds in this region are built on farmland. State permits may still be required, however.

Concerns with Current Regulations

Despite the "prior converted" farmland change, wetlands permitting is considered a constraint to aquaculture development in many areas of the country outside of the lower Mississippi Valley (Rubino 1992; Kusler 1992). In Maryland, for example, it is difficult to site aquaculture ponds on the Eastern Shore, where much of the land is classified as jurisdictional wetlands. Concerns with current federal regulations include the following:

Delays and Costs. The wetlands permitting process can be time consuming, costly, and confusing (see for example, U.S. Advisory Commission on Intergovernmental Relations 1992).

Taking of Private Property. Some landowners argue that denial of a wetlands permit is a form of "taking" of private property.

Frequent Changes. Federal wetlands policies and regulations have changed several times during the past few years and are likely to continue to do so with changes in administrative policy and new judicial actions and legislation.

Mitigation. Finding places for mitigation and determining what is appropriate mitigation can be difficult.

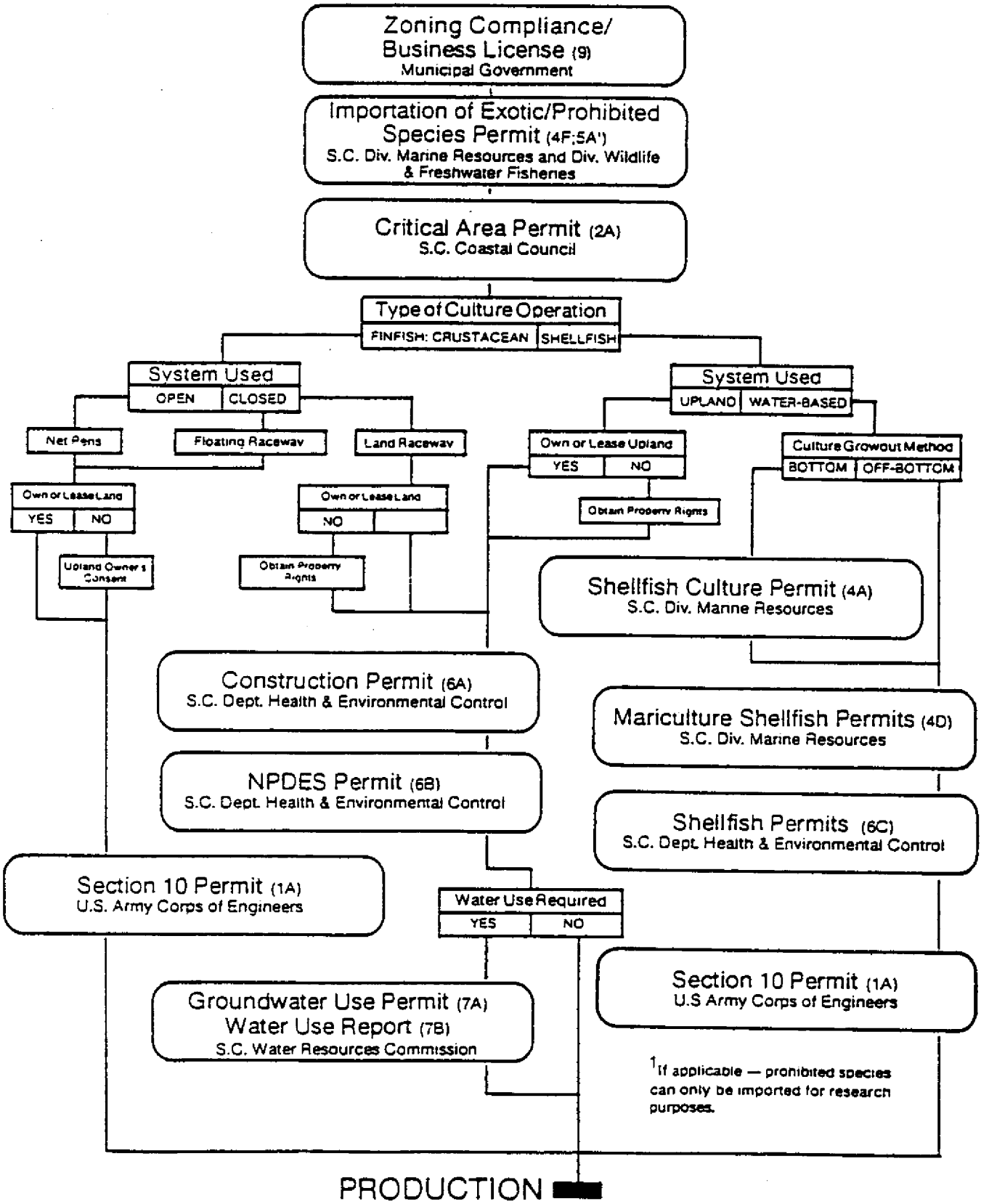
Reactive Policy. Government policy is made by granting or denying permits on a case-by-case basis.

Proposed Revisions

Proposed revisions to wetlands policies and regulations may affect where and how aquaculture activities may be conducted (for a summary of issues see Kusler 1992). The scope of future regulations is being contested by environmental, landowner, developer, farm, and oil and gas groups. Changes may

Figure 1

Permit Structure: The "Critical Area"



Source: DeVoe and Whetstone, 1987

Federal Wetland Regulations

Under Section 404 of the federal Clean Water Act, a landowner must receive a permit from the U.S. Army Corps of Engineers before adding dredged or fill material to a wetland. An area must possess three criteria to be regulated as a wetland: wetland hydrology, hydrophytic vegetation, and hydric soils. Section 404 permit decisions are in part based on a sequence of criteria: 1) Can the proposed project be avoided or moved elsewhere? 2) Have environmental impacts been minimized? 3) Can the wetlands losses be mitigated? The first criterion must be satisfied for the second criterion to be considered. As part of the process of obtaining a 404 permit, the landowner must also satisfy all other federal, state, and local requirements (such as the federal Endangered Species Act and state water quality certification) and the permit application is distributed for review by other federal agencies such as the Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), Soil Conservation Service (SCS), and the Environmental Protection Agency (EPA). While many applications are processed within 60 days, the review process for complex or environmentally sensitive projects can be much longer. If construction of aquaculture facilities in a wetland is allowed, mitigation measures may be required; for example, one or more acres of new wetland may be required to be created for every acre of wetland converted.

occur in three areas: the definition of jurisdictional wetlands, policy, and legislation. "Jurisdictional" wetlands, are those that are subject to federal regulations. In 1991, the four federal agencies involved in wetlands regulations proposed changes to the 1989 Federal Manual for Delineating Wetlands which in turn proposed changes to a 1987 version of the Manual (U.S. EPA 1991). While the 1991 proposals may reduce regulated areas substantially, especially for "drier-end" wetlands (Kusler 1992), they have yet to be implemented. The federal government expects to use a new definition being developed by a National Academy of Sciences panel (Johnson 1993). Some of the considerations include the number of days an area needs to be saturated or inundated to be defined as jurisdictional wetland, whether indicators of all three parameters used in defining wetlands (hydrology, vegetation, soils) are required, and whether the burden of proof is to be shifted to the government to prove that an area is a jurisdictional wetland.

Other areas of federal wetlands policy include funding for wetlands acquisition and reserve programs, efforts to streamline the Section 404 permitting process, encouragement to states and localities to assume a larger role in the 404 program, and exemptions for agricultural activities. Some legislative proposals would make sweeping changes in Section 404 by redefining "wetland," broadening permit exemptions, classifying wetlands (high, medium, and low value), requiring compensation for protection of high value wetlands, and establishing a mitigation banking program.

State Wetland and Land Use Regulations

Aquaculture operations are also subject to state government land use and wetland regulations:

State Government Actions Under the Federal Clean Water Act

Actions listed in a proposed Section 404 permit application must be consistent with state laws. Any activity that requires a Section 404 permit from the Corps also requires a Section 401 (of the federal Clean Water Act) certification from the state water quality agency that the proposed activity would not violate state water quality standards. In Texas, for example, the Corps and the Texas Water Commission (TWC) have developed a joint process whereby the 404 permit application

serves as a request for TWC water quality certification (Hightower et al. 1990).

State Wetland Permits

State laws regulating activities in wetlands usually differentiate between coastal and inland wetlands (material on state programs is drawn from Kusler 1983; U.S. Congress, Office of Technology Assessment 1984). All coastal states have laws regulating activities in their tidal wetlands. often in conjunction with coastal zone management programs. By contrast, state regulatory efforts have provided less protection for inland or nontidal wetlands. However, most states do not have permitting programs solely concerned with wetlands. Instead, they rely on federal programs, state influence on federal programs, state wetland acquisition programs, and other state programs that incidentally cover wetlands. Many state wetland regulatory programs overlap with federal programs (Section 404 permit; state certification of projects through section 401 actions).

State Coastal Zone Management Programs

The national Coastal Zone Management Act of 1972 established a program to develop the capacity within the states to manage the country's coastal resources. Federal matching funds help states meet the costs of implementing state led coastal zone management (CZM) programs (which include regulatory, research, education, land acquisition, planning, and other activities). Another federal incentive to foster state participation is the federal consistency authority, which requires that federal actions and permitted activities in the state's coastal zone be consistent with a state's CZM program. To date, 29 states and U.S. island territories have developed federally approved CZM programs, encompassing 94 percent of the nation's coastline (U.S. Department of Commerce 1992).

A state regulatory authority formed under a state coastal zone management plan (following state laws and the federal CZMA) may have the authority to disallow proposed aquaculture activities in the coastal zone. For example, all wetland use permit applications (including aquaculture uses) in the eight coastal counties of South Carolina are subject to review by the South Carolina Coastal Council.
In the 1990 reauthorization of the CZMA, Congress further defined the national interests in the coastal zone by providing incentives for states to address "national interest enhancement objectives" in their coastal management programs (see U.S. Department of Commerce 1992):

- coastal wetlands management and protection;
- natural hazards management;
- public access (to beaches and shorefronts) improvements;
- reduction in marine debris;
- management of cumulative and secondary impacts of coastal growth;
- special area management planning;
- ocean resource planning; and
- facilitation of coastal energy and government facility sitting.

Earlier reauthorizations of the CZMA had included fisheries and minerals development and ports and marinas sitting and improvement as national interests. The National Research Council (1992) recommended that states include aquaculture within the broader state framework of coastal planning and management activities that receive federal CZM funds. The NAS also recommended that aquaculture be added to the list of "coastal dependent uses" that are identified for priority consideration in coastal planning and management (and federal funding) under the CZM program.

BEST MANAGEMENT PRACTICES

The environmental land use impacts of an aquaculture operation can be avoided and

Comparison of Tidal Pond Regulations in South Carolina and Louisiana

Different state approaches to uses of altered wetlands can be illustrated by comparing South Carolina and Louisiana. Tidal impoundments in South Carolina can be screened and used to trap and culture wild shrimp or to stock shrimp or other aquaculture species. These ponds are remnants of rice plantations or were built for waterfowl management. Property owners are allowed to maintain and use existing tidal ponds but federal and state regulations prohibit construction of new tidal ponds or impoundments and make it difficult to obtain permits to repair old unused tidal ponds with breached dikes (DeVoe and Whetstone 1987). Nevertheless, some 40,000 acres of privately owned impoundments could be converted to shrimp, shellfish, and other seafood farming in South Carolina alone. Currently, 3,000 acres are used for shrimp farming. Louisiana, by contrast, has 50,000 square miles of impounded waters but current regulations prohibit the interference of passage of marine organisms. The state does allow construction of levies and weirs in the marsh to reduce saltwater intrusion into freshwater areas. In 1989, the Louisiana legislature established ten experimental "permits" to allow "farm" organisms in coastal impoundments. The permits exempted these operations from state fisheries regulations.

mitigated by use of BMPs: avoid or design around the wetlands (don't build ponds in "jurisdictional" wetlands) and other sensitive areas; retain wetlands on a property adjacent to ponds for water treatment and as a buffer area.

RECOMMENDATIONS

1. Policies

The aquaculture industry will be affected by the larger debates and policy making process concerning land uses. The following longer term policy approaches to natural areas, wetlands, and coastal zones have been proposed by various studies and commissions to balance environmental and land use needs, including the following (The Conservation Foundation 1988; Water Quality 2000 1992):

- Adopt comprehensive proactive statewide and regional wetlands, coastal, and point and nonpoint source pollution programs (planning, land use and coastal land/water use designations, conservation easements and incentives) including watershed and whole basin management approaches.
- Address agricultural conversions of wetlands that have accounted for over 80 percent of wetlands conversions.
- Provide environmental agencies with enough budget and staff to handle the volume of work they are being asked to do by federal and state laws, reduce permit delays, and encourage interagency cooperation.

2. Strategic Planning

Conduct state strategic planning for aquaculture development. Several states have developed state aquaculture plans. The State of Hawaii, in addition, conducted a study to identify the "best" areas for aquaculture production in the state (Fassler 1982). Some of these areas might be designated as aquaculture industrial parks or enterprise zones. Within the zone, activities would be "pre-permitted" so that individual permits would be unnecessary or reviewed under a streamlined permit process. State and private commercial aquaculture parks have been started in Hawaii and proposed in Texas and Maryland (John Corbin, Hawaii Aquaculture Development Program, personal

National Energy Laboratory Authority of Hawaii

Located on 600 acres of ocean front on the Big Island of Hawaii, NELHA has been masterplanned for commercial and research aquaculture and ocean sciences. The site takes advantage of nutrient rich deep ocean water pumped from a depth of 2,000 feet for an ocean thermal energy project. Warm surface seawater is also available. Land is leased to private ventures that are producing salmon, lobster, rainbow trout, nori seaweed, abalone, sea urchins, microalgae, and strawberries. Master permits were obtained by the state for the site to streamline land use and discharge requirements and to allow for tenant-initiated water delivery systems. The park also provides other infrastructure requirements such as power, communications, freshwater, an ocean disposal system, and roads.

communication; Jack Boettcher, Texas General Land Office, personal communication; Maryland Department of Agriculture, et. al. 1988).

3. Regulations

The aquaculture industry needs to actively participate in land use and wetlands policy debates so that government regulators and other interest groups understand the industry's needs and the impacts and benefits of aquaculture. Regulations should include a streamlined permitting process, allow some regional flexibility for site specific issues, and balance food production, environmental, and socioeconomic objectives. For example:

- A consolidated permit process, where the aquaculture applicant works directly with only one lead state agency (with one set of studies and one public hearing) could reduce the complexity, cost, and time delays of the permit process. The lead state agency would be authorized by legislation and interagency agreements to coordinate all state and federal (and local if necessary) permits and reviews. Such an approach is being considered for net pen leasing in the State of Maine (see Eichenberg 1992) and has been recommended in several state aquaculture plans.

- The Corps issues national or regional "general permits" to allow certain classes of activities to proceed in wetlands without the need for an individual permit. The Vicksburg District of the Corps (which covers the heart of the catfish farming region) adopted General Permit #48 in early 1990 to allow certain aquaculture activities on prior converted cropland. Regional general permits for certain aspects of aquaculture operations may be possible for other areas of the country.

- As they are more dependent on water than most activities, aquaculture operations might be allowed to use certain "less valuable" wetlands or be given priority of use over urban and industrial land uses. For example, aquaculture, if conducted in an environmentally sensitive manner, can be an appropriate use of an altered and managed wetland such as an impoundment or tidal pond.

- In cases where mitigation measures are required as part of a permit, aquaculture operations offer possibilities for effective mitigation measures (e.g., discharge water ponds and marshes, buffer land, vegetation, etc.) that might require less than one (or more) for one mitigation (create/restore one acre or more of wetlands for every acre of wetlands used for ponds).

4. Best Management Practices

Uncertainty concerning the future of federal wetlands permitting and land use policy is likely to continue. At the same time, state wetland, water discharge, and coastal regulations may grow in importance. Consideration of a variety of environmental factors, avoidance of high value wetlands, and close cooperation with government agencies will continue to be important in the design, sitting, and operation of aquaculture activities.

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III. USE OF THE WATER COLUMN AND SUBMERGED LAND IN PUBLIC WATERS

Aquaculture uses of the water column and submerged lands in offshore and coastal waters (marine areas and freshwater lakes) present a variety of regulatory, environmental, and public use issues. Use of public waters is regulated because the private property rights and needs of the aquaculture operation must be balanced with the rights of other users of the resource such as fishermen, boaters, and shipping. Regulatory approaches to address these issues include leasing programs and best management practices.

Major current and potential forms of aquaculture in public waters include:

- shellfish culture on submerged lands;
- shellfish culture on rafts and trays;
- salmon and other finfish net pen culture;
- abalone and seaweed culture on structures in the water column;
- ocean ranching (release of finfish fingerlings which return to the hatchery/release area after several years at sea).

ISSUES

The key issues are: 1) balancing uses and rights in the public domain, 2) environmental impacts, and 3) environmental (water) quality.

Balancing Uses and Rights in the Public Domain

Most aquaculture activities which use the water column or submerged land are conducted in the public domain (*res communis*). Exclusive private use of federal and state *land, submerged bottom, and the water column adjacent to shoreline is common*: the U.S. Department of the Interior leases federal land for logging, grazing, and mining; states lease shellfish beds for oyster culture and harvest; piers, docks, and marinas extending into public waters may be built by riparian landowners. Exclusive use of the *water column away from the shoreline is less common* in the United States because such public waters have traditionally been open to all to use.

However, to commit resources to production in public waters, an aquaculture producer needs a regulatory framework that conveys a long term property right and some degree of exclusivity (protection against theft, trespass, and water quality degradation from current and future uses of the surrounding environment) and ownership of product. From the government's perspective, the framework must balance the exclusive use of the water or submerged land with other traditional and potential uses of the area and the needs of the public.

As the demand for aquaculture uses of the water column and submerged land increases, use conflicts can be expected to intensify. Conflicts may prohibit the establishment of aquaculture or may curtail efficient production. Proposed new uses of public waters have encountered opposition from existing users. Examples include opposition to salmon net pen culture in the Puget Sound by local landowners, in Maine by local landowners and lobster fishermen, and in the George's Bank area by fishermen and environmental groups. A net pen applicant in Washington State can expect protracted and divisive permitting battles with a significant chance of local permit refusal. Only 11 net pen operations exist in Washington State compared to about 200 such

operations in nearby British Columbia where the regulatory climate has been more receptive to the industry (J. Pitts, Washington State Department of Agriculture, personal communication). Private finfish aquaculture is not allowed in Alaska in part due to opposition by commercial fishermen.

As new technologies and species suitable for water column culture are developed, the need to create a suitable regulatory framework will increase. For example, redfish and hybrid striped bass cage culture has been attempted in the Gulf of Mexico. Technological advances will allow net pen culture to move further offshore. For example, a company applied for a Section 10 U.S. Army Corps of Engineers permit to establish a 47 square mile salmon farm 37 miles offshore east of Cape Ann, Massachusetts, near George's Bank (National Research Council 1992). Currently, there is no federal leasing or management policy for aquaculture in federal waters (3-200 miles offshore) or for large-scale exclusive use of ocean space located beyond coastal areas.

Environmental Effects

The environmental effects of water column and submerged bottom aquaculture depend upon 1) size of facility, 2) intensity and type of culture (animals in production), 3) amount of water circulation (current, depth, and volume of receiving waters), and 4) treatment of effluent (see Weston 1986; Gowen and Bradbury 1987; Gowan et al. 1991; Iwama 1991). Perhaps the most oft cited environmental concerns with offshore aquaculture in the United States target salmon and finfish net pen culture. The real or perceived concerns include water quality degradation and bottom fouling from feces and excess feed; possible transmission of diseases to wild fish; possible creation of resistant strains of bacteria from medicated feeds; and effects on the genetics of wild fish that may interbreed with escaped cultured fish.

A review of studies on salmon net-pen culture indicate that water quality and sediment impacts of salmon net pen culture are slight (relative to the assimilative capacity of the receiving waters and the small proportion of the sea bed affected), localized, and reversible, especially if net pens are located at sites with ample current to allow for flushing of effluents (Weston 1986; Gowen and Bradbury 1987; Parametrix 1990; National Research Council 1992). In the United States, there are few salmon farms relative to the size of the receiving waters. For example, fish net pens cover only about 50 acres of 3 million acres of the Puget Sound (J. Pitts, personal communication).

In some instances water column aquaculture may create significant local environmental effects relative to the receiving waters (see examples in Weston 1991). In a few cases outside the United States, the biomass of aquaculture production is high relative to the surrounding body of water: more than 10% of the surface area of water bodies have been covered by the structures for fish culture in the Laguna de Bay in the Philippines, in bays filled with net pens for yellow tail culture in Kagoshima, Japan, and for shellfish culture in the Ria de Arosa in Spain (Iwama 1991; National Research Council 1992).
There are also potential beneficial effects of aquaculture on the environment. Oysters, which filter water, help to maintain high water quality in estuaries and this is one of the reasons cited for efforts to revive oyster culture in the Chesapeake Bay (Mann, et al. 1992). Finfish culture can decrease pressure on overfishing of wild stocks.

Environmental Quality

The 1990 National Shellfish Register of Classified Estuarine Waters reported that the acreage of approved shellfish growing waters continues to decline due primarily to the impacts of expanding coastal development: urban runoff, faulty septic systems, increased numbers of marinas (many of which do not have facilities to collect and process sewage), and buffer zones around sewage treatment plants (U.S. Department of Commerce 1991).

The rate of decline in approved acreage is highest in the most productive areas such as Chesapeake Bay, the Mississippi Delta region, and Puget Sound. The 1990 Register report concluded that "continued decline in the water quality of productive estuaries in combination with overharvesting and disease, may eventually eliminate the natural harvest of shellfish." The report noted an increasing role for aquaculture but cautioned that aquaculture also requires access to high quality water.

In response to increasing coastal pollution, several aquaculture producers and states have taken legal and regulatory actions. The Pacific Coast Oyster Growers Association, representing 120 companies, and a leading oyster growing company in Washington State sued 27 property owners over alleged discharges of untreated sewage (from septic tanks). The suit sought compensation if the association members lost their next harvest (Catfish Aquaculture News 1991). The Washington Department of Health had closed Case Inlet on May 15, 1991, citing high levels of fecal contamination primarily resulting from the defendants' defective septic tanks (Seafood Leader 1991). Washington's state legislature approved a law establishing shellfish protection districts and allowing counties to fund programs for the control of nonpoint source pollution, a primary cause of shellfish bed closures (Waterlines 1992). The Puget Sound Water Quality Authority and the state Department of Ecology also fund state and county programs and make low interest loans available to the private sector for water quality improvement activities.

REGULATIONS

The regulatory framework that affects offshore aquaculture includes many state, local, and federal requirements: lease and permit applications, environmental assessment and monitoring, and public hearings. The complexity of the framework can be seen in the chart listing permit and review requirements in the State of Maine (Table 2).

As noted in earlier chapters, permit application procedures and monitoring can be expensive. BMPs, often included as provisions in a lease, have been promoted by industry groups.

State Policies and Regulations

Several states have adopted regulatory and management approaches to aquaculture uses of public tidal and offshore waters and submerged lands, including sitting, leasing, and management practices. State programs have also addressed ocean ranching, the release of fingerlings which return as grown fish.

Leasing

Most states require a general submerged land lease or a specific aquaculture lease for aquaculture operations in public waters (see DeVoe and Mount 1989; DeVoe, et al. 1989; Cato 1991; and Eichenberg 1992a, 1992b). Submerged land or water column leasing practices for aquaculture in the United States include traditional shellfish harvesting leases and newer leasing programs for net pen, raft, and other off-bottom culture.

A leasing program combines the features of a lease (a real estate transaction) and a permit (permission to do something in a certain way). The features of a leasing program, drawn from several states and countries, are listed in the recommendations section of this chapter below. The lease is the primary method used by states to balance the private property rights and needs of the aquaculture lease holder with rights of other users of the public resource. The lease is usually part of a regulatory framework that conveys a long term (five to ten years) property right, some degree of exclusivity (protection against theft, trespass, and pollution), and ownership of product: these are the conditions required by private enterprises for the commitment of financial and other resources. In turn, the aquaculture operation must abide by certain management practices, conduct environmental assessments, and report production data to the state.

Table 2. Government Regulation of Finfish Aquaculture

	Local Govt	State Agencies						Federal Agencies					
	Local	DMR	DEP	DIF & W	BPL	BPC	SPO	ACOE	EPA	USCG	USFWS	NMFS	FDA
Permits	Zoning Mooring	Leasing Marine Import Wholesale Seafood	Wetlands Waste Discharge License**	Freshwater Import Disease free certification	Submerged Lands**	Pesticide Use	Federal Consistency	Section 10	NPDES* Ocean Dumping	Aids to Navigation			
Fees/Terms		X	X**					X					
Hearings	X	X	X**					X**	X*				
Site Inspections		X						X	X*				
Siting Criteria	X	X						X		X	X	X	
Water Quality Certification			X						X*				
Use Conflicts	X	X			X**			X		X	X	X	
Environmental Monitoring		X	X	X				X	X*				
Stock Restrictions		X						X					
Disease Control		X		X									
Drugs/Antibiotics	X		X			X							X
Quality Control		X											
Endangered Species				X							X	X	

KEY: * Requirements Pending
** Waived with DMR Aquaculture Lease

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State Agencies:

DMR	Department of Marine Resources
DEP	Department of Environmental Protection
DIF&W	Department of Inland Fisheries & Wildlife
BPL	Bureau of Public Lands
BPC	Bureau of Pesticide Control
SPO	State of Planning Office

Federal Agencies:

ACOE	Army Corps of Engineers
EPA	Environmental Protection Agency
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
NMFS	National Marine Fisheries Service
FDA	Food and Drug Administration

Typically, the aquaculture site must be located in areas not frequented by traditional users of public offshore waters (shipping, fishing, boating) and must not affect ecologically significant flora and fauna.

Several states such as Maine, Washington, and California and countries such as Canada, New Zealand, and Norway have experience with leasing programs for water column aquaculture. DeVoe and Mount (1989) and DeVoe et al. (1989) reviewed and compiled data for leasing programs in the United States for "traditional shellfish" and "contemporary aquaculture" (water column) leases (see Table 3). A number of off-bottom operations are ongoing in the states of Maine, Massachusetts, California, and Washington. These states also have water column leasing programs with many of the recommended features of a leasing program. The mid and south Atlantic states generally have only leasing programs for traditional shellfish culture but several are considering water column leasing.

Other State Permits

In addition to a lease, aquaculture operations in public waters may be required to comply with state water quality certifications, discharge permits, environmental monitoring requirements, and disease certifications. These topics are covered in later chapters.

Planning and Sitting Programs

Sitting studies and planning exercises have been used to develop information bases, find the "best" sites or to avoid poor sites for aquaculture, designate where offshore aquaculture leases may occur, set priority uses for certain areas (akin to land use planning), involve the public in the decision process, avoid or reduce use conflicts, and design management practices to mitigate or reduce potential negative effects of the culture operation. The states of Washington and Maryland and the province of British Columbia have conducted sitting studies to map the characteristics of offshore areas and to identify possible locations for net pen and oyster culture (Science Applications International Corp. 1986; Black 1991; unpublished work of the Maryland Department of Natural Resources).

Ocean Ranching

Ocean ranching, such as the release of salmon fingerlings which return as grown fish to the hatchery area after living one or more years at sea, is another aquaculture use of open public waters. States along the West Coast of the United States have adopted different management approaches (see National Research Council 1992 for review):

- Alaska allows fishermen-owned, private nonprofit cooperatives to produce fingerlings for ocean ranching stock enhancement. A percentage of harvest revenues are returned to the cooperatives. Private, for-profit operations are prohibited (Kron 1992). In 1990, 21 cooperative hatcheries were in operation, generating 87.2% of the total state salmon enhancement production (state hatcheries accounted for the rest); all had returns.

- In Washington State only several small, nonprofit ocean ranching operations have been allowed. Legislation proposed to allow private ocean ranching has not been enacted.

- California passed a law allowing private ocean ranching and then issued only one permit.

- Oregon passed laws in the early 1970s for private ocean ranching and became a testing ground for the concept. During 1974-1977, 12 permits were issued. In 1977, Crown Zellerbach applied for a permit, litigation ensued, and the permit was rejected by the court. The case prompted the current

Table 3. Aquaculture Leases in 15 Coastal States

	Type of Lease			Lease Size and Duration			Number of Acres Leased		
	Shellfish	Culture	Residency	Size (Acres) Min	Size (Acres) Max	Duration (Years)	Shellfish	Culture	Remarks
ME		Y	N	5	150	10 (Renewable)	0	1,003	66 Leases
MA	Y	Y	Y	VAR.	VAR.	10 (Renewable 10/15)	~70	~630	Town Leases
RI		Y	N	VAR.	VAR.	Variable	0	67	7 Leases
CT	Y		N	VAR.	VAR.	3-10 (Renewable)	38,520	0	"Franchises"
NY	Y		Y	50	?	10 (Renewable)	Private	15	Assignments
NJ	Y		Y	0/5	2/200	1 (Renewable)	24,355	?	7 Hatcheries
DE	Y	?	N	50	100	1 (Renewable)	7,000	0	MSX
MD	Y		Y	1/5	30/500	20 (Renewable)	10,300	0	MSX
VA	Y		Y	1	5000	10 (Renewable)	104,900	0	MSX
NC	Y	Y	Y	1	5/10	10 (Renewable)	2,360	~25	Traditional
FL	Y	Y	N	VAR.	VAR.	10 (Renewable)	2,076	10	No Traditional
TX	Y		N	1	100	?	2,356	0	Moratorium
MS	Y		Y	5	100	1 (Renewable, Max = 25)	~2,000	0	Oysters/Relay
CA		Y	N	VAR.	VAR.	25 (Renewable) 20 (For Kelp)	0	2,203	Moratorium
WA	Y	Y	N	1	40+	5 (Renewable)	3,000	423	Variety

Source: DeVoe, Mount, and Dubois, 1989.

state moratorium on new or expanded permits.

Federal Permits and Policies

Of the several federal laws that can apply to offshore aquaculture, two are of note: Section 10 and the National Pollution Discharge and Elimination System (NPDES) permits.

The U.S. Army Corps of Engineers, under Section 10 of the Harbors and Rivers Act of 1899 (33 USC 403), oversees the federal interest in maintaining the navigability and ecological integrity of navigable waters. The Corps requires a Section 10 permit for structures in navigable waters such as floating fish pens. In reaching decisions on Section 10 permits, the Corps uses a "balancing process" (similar to Section 404 permits for wetlands) to consider the effects of the proposed net pen on navigation, fish and wildlife, water quality, and recreational and other uses. Many federal agencies may be consulted and public hearings may be held during the permit review process. The Corps has instituted permit review, sitting, and monitoring guidelines to evaluate new and existing permits. Permit applicants must gather and present detailed information about the site, operational design, and effects on existing uses and the environment and meet all state and local approvals (for example, lease and water quality certification or permit).

The NPDES, administered by the federal EPA under Section 402 of the Clean Water Act, requires permits for certain point source discharges. The NPDES program and regulations pertaining to aquaculture effluents and wastes are outlined in Chapter IV.

BEST MANAGEMENT PRACTICES

BMPs for water column aquaculture include both site selection and facility operating standards. A variety of sitting practices can be followed to reduce the environmental effects of net pen and raft culture. Farm discharge is best managed by selecting deep water locations with strong currents. Additional site criteria include avoidance of navigation channels and placement and production methods to mitigate aesthetic concerns. Production density and feeding guidelines might be tailored to site specific conditions to reduce effluent discharge problems (see Aure and Stigebrandt 1990). Highly digestible, slow sinking feeds that do not fragment can be used to reduce feed waste. Other examples of practices could include quarantine and disinfection measures to minimize disease transfers and the development of a regional brood stock to eliminate the need to import salmon eggs.

Several industry associations have developed codes of practice. The Fish Growers Association of Washington State has designed BMPs for net pen operations (see box). The Irish Salmon Growers Association codes of practice, "Good Farmers, Good Neighbors," first published in 1988, is being revised to address additional environmental issues (such as treatments for lice, alternatives to antibiotics). The Irish association has also organized training courses on BMPs (Fish Farming International 1993).

RECOMMENDATIONS

Recommendations are drawn from current practices in effect in several states (e.g., leasing and BMPs) and proposed practices (e.g., consolidated permit process).

1. Leasing

The recommended features of a state leasing program for off bottom culture in net pens or on rafts are drawn in part from DeVoe and Mount (1989); Van Houtte, Bonucci, and Edeson (1989); and Eichenberg (1992a and 1992b):

Review Process: The lease approval process should include a review of site information and

Washington Fish Growers Association BMPs for Net Pens

The Washington Fish Growers Association (1991) has developed BMPs to "foster and maintain high facility operating standards in the salmon net-pen industry ... to maximize production of the highest quality aquaculture product in an environmentally responsible and humane manner." The guidelines include site selection and operating standards:

Factors to consider when selecting and applying for a new farm site:

- compliance with all state, local, and federal laws;
- pre-application agency consultation;
- good neighbor policy (consult with local citizen and Indian tribes to resolve any conflicts;
- aesthetic considerations.

Operational categories addressed in the guidelines include:

- introduction of fish stocks;
- feed and feeding;
- mortality removal and disposal;
- net cleaning, facility maintenance;
- predator control;
- harvesting;
- medication and chemical application, spill prevention, chemical storage;
- waste collection and disposal;
- environmental monitoring and reporting;
- navigation aids, emergency plans, safety;
- aesthetics and noise;
- employee education;
- public education and involvement.

studies, production plans, company/individual financial capabilities, environmental effects, economic benefits, mitigation measures, and local, state, and federal requirements and permits. Public hearings are part of the lease review process in most states. Environmental study requirements should be designed to avoid excessive costs and yet be adequate to judge potential adverse impacts.

Scope: A lease program should address both bottom and water column leasing.

Duration: A lease term should be long enough for aquaculture operation to establish and earn an attractive return and provide the state with enough flexibility to reassign or terminate leases for just cause (such as no active operation for several years). A term of 10 years (renewable every five years) may be appropriate.

Size: The size (acreage) of the lease will depend upon the type of culture, area available, type of water body, and other uses of the area.

Exclusivity: The lease should convey a long term property right, some degree of exclusivity (protection against theft, trespass, and pollution), and ownership of product to the aquaculture operation. Penalties for theft, in particular, need to be severe enough to deter poaching.

Fee: Rental fee, royalty payment, and/or performance bond amounts may be needed to defray the administrative costs of the leasing program, to encourage productive use of the lease area, and for cleanup of the site if the operation becomes insolvent.

Eligibility: State legislatures need to determine what individuals or corporate entities are eligible for a lease. Some states and localities have residency requirements or limit leases to individuals (as opposed to corporations) in an effort to reserve lease areas for local residents. Other states may decide to have few eligibility restrictions to attract new investments and jobs.

Bidding Process: Bid specifications need to be developed because it is likely that two or more applicants are likely to want a lease area.

Conflict Resolution: Procedures for resolving conflicts between aquaculture lease holders and other marine or public water resource users may promote public acceptance of the aquaculture activity (also see Black 1991 for Canadian and Eichenberg 1992b for Maine examples).

Management Practices: Certain operating practices might be made a condition of holding a lease.

Reporting Requirements: Reporting and monitoring requirements should be designed to avoid excessive costs and yet be adequate to detect adverse impacts.

2. *Consolidated Permit Process*

Adopting a single consolidated lease/permit application procedure should be a major regulatory objective as it streamlines the permit/lease process. Leasing legislation should designate a lead state aquaculture agency and consolidate and coordinate federal, state, and local reviews and requirements to eliminate duplication. Much of the baseline environmental data, impacts assessment, public comment, and other review procedures required for federal, state, and local approvals are the same or very similar. The State of Maine and federal agencies have drafted a consolidated permit and lease review and approval process for net pen applications in that state (see Burrowes 1988, Eichenberg 1992a and 1992b for a discussion of Maine's experience and Eichenberg 1992b for the draft of the consolidated permit). Memoranda of understanding between state and federal agencies can establish procedures to coordinate aquaculture permitting (see Eichenberg 1992b for Canada-New Brunswick example).

"General" permits, such as those used by the Corps, might be appropriate for certain aquaculture activities. Although the Corps has a nationwide "general" permit for fish harvesting techniques, the agency decided in 1991 not to include small aquaculture activities such as net pen farms (Federal Register, 56(226):59120, November 22, 1991). The Corps received many objections to including aquaculture activities during the public comment period. However, the Corps did leave the door open for regional general permits noting that "small aquaculture activities...can be accomplished in most cases with minimal adverse effects on the environment, including the aquatic environment, and may be appropriate for a regional general permit under certain conditions."

3. *Marine Zoning*

The creation of aquaculture enterprise zones in designated offshore waters, similar to the aquaculture parks discussed in Chapter II for onshore facilities, has been considered by several states. Special considerations, protections, and lease programs might steer aquaculture activities to predesignated areas selected by a sitting program (see Black 1991). Special zones for certain types of fishing, exclusion zones, or areas with fishing restrictions are common.

4. Policy and Planning

A comprehensive study of a coastal or offshore area geared to mapping the suitability, in biological and physical terms, of coastal areas for fisheries, aquaculture, and other marine uses can be an extremely valuable, yet perhaps expensive, planning tool. Such studies can assist policy makers to establish appropriate areas for lease or aquaculture enterprise areas.

5. Best Management Practices

Aquaculture producers should implement industry-designed standards for sitting, operational features (density, feeding, effluent, disease management practices, etc.), community relations, and reporting.

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IV. WATER AND WASTE DISCHARGE

During the past 20 years, federal and state water pollution control regulations have become increasingly stringent. Manufacturing industries and agriculture are subject to greater scrutiny by regulators, and aquaculture is no exception. This chapter covers water and waste discharge regulations and management practices that pertain to aquaculture.

ISSUES

Effluent and waste discharge issues for aquaculture include:

- Environmental effects of aquaculture waste products.
- High costs of permit application.
- Classification of aquaculture in the industrial permit category.
- Stringent water quality standards.
- Design and implementation of cost effective BMPs.

Regulations governing aquaculture are imposed in response to the environmental effects of waste products. The primary waste products are suspended solids, nutrients from unused feed, and feces discharged in the facility's water effluent or disposed of as solid waste (see Boyd 1982; Iwama 1991). Ammonia is the primary end product excreted by fish, crustaceans, and mollusks and its release generally is proportional to the feeding rate. Many of these byproducts are assimilated and recycled by planktonic and benthic organisms. The byproducts are eventually flushed from the system by water exchange, deposited in more stable sediments, volatilized to the atmosphere, or assimilated by organisms large enough to be consumed by the fish or aquaculture crop.

Waste discharges from aquaculture may contribute to the eutrophication of the receiving water (tied to nutrient enrichment and subsequent increased production of algae), affect benthic and other species (due to increased algal growth, lowered dissolved oxygen (DO), smothering by solids/sludge), and increase water temperature. The severity of the environmental effects depend upon:

1) size of facility, intensity of culture (biomass in production), type and efficiency of feeding, amount of water recirculation, and type of water treatment;

2) relationship of the output to the depth, volume, flow rates/current, temperature, and geographic location of receiving waters.

As the intensity of the operation increases, the volume of waste products per gallon of water used rises, increasing the need for water treatment or increasing the volume and concentration of waste products discharged. Examples of aquaculture facilities that may be subject to effluent regulations include:

- a fish hatchery or production facility that discharges into a cold water stream that provides habitat for trout,
- operations that produce more than 100,000 lbs per year of product and use large volumes of water such as a large trout raceway or salmon net pen operation, and
- facilities located in states with very stringent ambient water quality

standards such as Hawaii (Ziemann, Pruder, and Wang 1990).

REGULATIONS

Aquaculture operations are subject to federal and state discharge regulations. While there are few specific federal water quality requirements for aquaculture, the federal Clean Water Act (CWA) of 1977 and later amendments (33 U.S.C. 1251 *et seq.*) form the basis of federal and most state water quality policies and permits. The goals of the CWA are to eliminate the discharge of pollutants into the waters of the United States, to provide for recreation, and to protect fish, shellfish, and wildlife. These goals are to be achieved in part through the National Pollutant Discharge and Elimination System (NPDES) permits (outlined in Section 402 of the CWA) issued by EPA or delegated state agencies for "point source" discharges. The NPDES program was designed to: (1) limit discharge according to federal "technology-based" discharge standards or state water quality standards; (2) provide schedules for compliance; and (3) require monitoring and reporting of effluents. Because many states (39 to date) have been delegated the authority to issue federal NPDES permits, these states usually issue joint federal/state permits. In writing a discharge permit, federal or state permit issuers apply the following:

1. Federal (EPA) *technology based standards (*industry specific process or end-of-pipe discharge standards or effluent criteria required for any plant in that industry).

2. More stringent state *water quality based standards* if the discharge is likely to affect the water quality based objectives for the receiving waters--under the CWA, states designate uses for bodies of water (such as swimming, fishing, and drinking water) and may establish stricter standards than the federal ones to maintain those uses and to prevent water quality degradation.

Federal Regulations

Federal water pollution discharge regulations apply to all aquaculture dischargers regardless of size. Under EPA's regulations, aquaculture operations must obtain a NPDES permit if they exceed a certain amount of production per year (see box). Also, a small aquaculture facility may be required to obtain a NPDES permit if EPA or the state agency determines that "it is a significant contributor of pollution to the waters of the United States." EPA is not likely to develop technology based standards for aquaculture facilities because the agency has yet to develop standards for many industries with far greater impact on the environment (e.g., petroleum refineries). Therefore, individual permit requirements are established on a case-by-case basis (Bastian 1991).

Other federal regulations that apply to aquaculture discharges in certain cases include ocean dumping and solid and toxic waste disposal (see Bastian 1991).

State Regulations

Water discharge permits are generally triggered by state, not federal, requirements as few aquaculture producers are large enough to come under the production cutoff points listed in the federal regulations. In many states, aquaculture operations must obtain a state water quality permit for effluent discharges. The permit may be issued as a NPDES permit or as a separate state permit. The State of Washington, for example, is one of the states approved by EPA to administer the federal program: the state government requires NPDES permits for net pen operations and the permit requirements are essentially state requirements. In many states, effluent permits are negotiated on a case-by-case basis between the aquaculture operation and the state agency. Important considerations are the available treatment methods and the ability of the receiving water to assimilate the effluent.

Federal NPDES Program for Aquaculture

The U.S. Environmental Protection Agency regulates discharges of pollutants into U.S. waters under the Clean Water Act (33 U.S.C. 1251 *et seq.*). Section 402 of the Act requires that a National Pollutant Discharge Elimination System (NPDES) permit be issued by EPA (or delegated state agency) prior to certain discharges. Regulations for "concentrated aquatic animal production facilities" were published in June 7, 1979 (Federal Register, Vol. 45 (122) p. 111) (regulations listed in 40 Code of Federal Regulations, Part 122, Subpart B, 122.24(a)&(b)). EPA rule 40 CFR, Part 122, Appendix C, applies to facilities raising:

- cold-water fish species or other aquatic animals (e.g., trout and salmon) in ponds, raceways, or other similar structures that discharge at least 30 days per year but exempts facilities which produce less than 9,090 harvest weight kg (about 20,000 lbs) of aquatic animals per year and feed less than 2,272 kg (about 5,000 lbs) during the calendar months of maximum feeding;
- warm-water aquatic animals (e.g. catfish, sunfish, minnows) that discharge at least 30 days per year but exempts facilities which produce less than 45,454 harvest weight kg (about 100,000 lbs) of aquatic animals per year and facilities with closed ponds that discharge only during periods of excess runoff.

State discharge permits are also tied to federal permits issued under Section 404 of the Clean Water Act by the U.S. Army Corps of Engineers. State water quality certification under Section 401 of the Clean Water Act is required as part of the Section 404 permit process.

Some states classify all water bodies by stream water quality parameters and the effluents from aquaculture may not exceed the parameters. Very high ambient water quality standards exist in a few states; for example, all aquaculture discharges to the coastal waters of Hawaii exceed ambient water quality standards (Ziemann et al. 1990).

Aquaculture discharges are classified as industrial discharges in many states because separate criteria or classifications have not been developed for aquaculture. In Florida this classification scheme is not meant to put aquaculture activities in the same category as major industrial operations and the state Department of Environmental Regulation recognizes "that aquaculture operations are by nature fairly benign" (Florida Aquaculture Association Newsletter, March 1990). In some states, however, small aquaculture facilities may be subject to the same costly permit fee, monitoring, and discharge requirements applied to large industrial facilities. The fee structure can be adjusted by size of operation. The Maryland Department of Environment, for example, requires permits for any aquaculture operation (considered an "industrial" discharge) which discharges effluent and bases permit fees on volume of discharge and other factors including the type of business and water use.

The effect of state discharge regulations on the aquaculture industry varies by species and region of the country. Some examples follow:

Lower Mississippi Catfish Production Region: There appears to be few state regulatory conflicts or problems concerning effluent discharge from catfish ponds in the lower Mississippi region (see Ziemann et al 1990).

Washington State Net Pen Culture: The guidelines for obtaining a net pen lease in Washington State are designed to mitigate

water quality impacts and include minimum depth, limits on production to avoid eutrophication, site survey, and annual monitoring (see Science Applications International Corporation 1986). The state issues NPDES permits for net pen operations. Three permits issued in 1990 and 1991 required water quality and sediment chemistry monitoring, sediment trap collections, macrofaunal community analysis, underwater video survey by diver or remotely operated vehicle, and the measurement of antibiotic resistance in the sediment microbial communities under the net pens (Weston 1991).

Maine Net Pen Culture: In Maine, net pen operations must meet state requirements that pertain to effluents: conduct site studies to obtain a lease, obtain a state Water Quality Certificate, adhere to sitting constraints (depth, currents), provide feed in pellet form, not dump dead fish, and use only state-registered antifoulants (Maine Department of Marine Resources, undated). The U.S. EPA may require NPDES permits for net pens in Maine and is drafting a general permit for aquaculture in Maine, but the requirements may not be determined until ongoing studies are completed and discussions concerning a consolidated permit/lease process with the State of Maine and the U.S. Army Corps of Engineers are resolved. The State of Maine has chosen not to administer the federal NPDES program.

Hawaii: Two aquaculture facilities in Hawaii, one private and one state, have received state-issued NPDES permits allowing discharges into the ocean. Case studies prepared for the University of Hawaii Sea Grant Extension Service show that the process to obtain effluent discharge permits in Hawaii is time consuming, expensive for a private producers, and should be streamlined (AECOS, Inc. 1991). Obtaining a discharge permit for an intensive shrimp farm took three years and cost at least $300,000 in environmental studies and monitoring. Study and monitoring expenses for the Waikiki Aquarium have been borne by state university or government agencies. Because aquaculture wastewater concentrations are almost always above the criteria limits specified for natural coastal waters by the state, a "mixing zone" is defined to allow for dilution and/or assimilation wherein receiving water concentrations may exceed the applicable criteria. Defining this mixing zone has been one of the most difficult and contentious parts of the permit process (AECOS, Inc. 1991). The Hawaii studies are part of an ongoing effluent research effort coordinated by the Center for Tropical and Subtropical Aquaculture, based near Honolulu, Hawaii, to develop guidelines for zones of mixing and technical responses.

Shrimp Culture Discharge Permits: Shrimp farmers in Hawaii, Texas, and South Carolina have experienced significant delays or denial of operating permits due to potential impacts of pond effluent on estuarine or near-shore ecosystems (Hopkins et al. 1992). A shrimp farm in South Carolina has encountered state discharge permit problems because the farm's water discharge parameters are lower than the current quality of the receiving waters but higher than the state standards for that body of water (D. Cannon, personal communication). In South Carolina, an application for a shrimp farm discharge permit includes computer modeling of dilution of pond effluent and possible impacts on the water quality of the receiving stream (Hopkins et al. 1992). If predicted changes are "significant" (in some cases as little as 0.1 mg/l overall change in dissolved oxygen of the stream), a permit may be denied. Thus, large farms can only be permitted adjacent to large bodies of receiving water with high tidal velocities and rapid effluent dilution (Hopkins et al. 1992).

BEST MANAGEMENT PRACTICES

The aquaculture community is devoting significant attention to the design and implementation of BMPs to reduce effluent and waste discharges. The federal Joint Subcommittee on Aquaculture recognized the

importance of these issues by forming a Task Force on Aquaculture Waste Management to coordinate research, education, and public policy activities. The USDA-funded Regional Aquaculture Centers and universities have effluent and water quality research projects underway. These efforts have been undertaken not only in response to regulations but also to capture the efficiency and cost savings benefits of improved production practices. Catfish culture practices, for example, have changed during the past decade to cut water use and effluents from ponds and ponds are now seldom fully drained.

Aquaculture water quality BMPs include:

- Management techniques such as more efficient feeds and feeding methods, monitoring intake water chemistry, water aeration and mixing, and monitoring of pond dynamics.
- Reduced water use.
- Effluent treatment and reuse through holding/settling ponds and other recycling.
- Use of waste solids as fertilizers.

These management practices generally are combined to reduce effluents, turn waste products into production inputs, and reduce water pumping costs. Some of these measures are an extension of traditionally recommended good pond management practices; others require a rethinking or retooling of production cycles. A redesign of a pond and/or hatchery production system may entail substantial short term costs but create long term benefits in terms of improved production and operating cost savings. Examples from Maryland and South Carolina are presented in the adjacent boxes. BMPs for net pen culture are listed in Chapter III. Producers may adopt some or many aspects of closed recirculating systems in response to pressures from regulators to reduce discharge, competing demands from other water users, and the development of more cost effective recirculating systems (see Hopkins and Manci 1993).

Redesign of Hunting Creek's Water Management

Hunting Creek Fisheries near Thurmont, Maryland, is one of the larger ornamental fish producers in the United States. For decades, the farm's ponds and hatchery had discharged effluent into a nearby stream (with little measurable impact on the stream). In the late 1980s, a report of "green" water discharged from the farm into the stream prompted a visit from the Maryland Department of the Environment (MDOE). The MDOE imposed (and then rescinded) a fee for "industrial" water use and discharge and asked for data on water effluents in part to determine applicable effluent discharge standards. The process of monitoring the farm's water quality and the negotiations with the MDOE convinced the farm owners to redesign their water management system from a flow through to a partial recirculating system. Prior to entering the pond system, the intake water is analyzed and minerals may be added to achieve a desired water chemistry. Very little water is discharged from the ponds and pond water quality parameters are maintained with a combination of pond management techniques (aeration, recirculation, optimal feeding). The hatchery effluent is discharged into a ditch for natural cooling before the water goes into the stream. Water temperature, dissolved oxygen, and suspended solids are monitored regularly. Although the new water management system required a capital investment, the system has improved the production yields and cost-effectiveness of production (E. Tresselt, T. Hopkins, personal communications). The operation was found in compliance with Maryland regulations in 1992.

Effect of Water Exchange Rate on Shrimp Production

The Waddell Mariculture Center in South Carolina conducted studies to determine the effects of normal (25%/day), reduced (2.5%/day), and no (0%/day) water exchange on water quality and production in intensive shrimp ponds stocked with *Penaeus setiferus* at 44 postlarvae/m2 (Hopkins et al. 1992). Growth and survival were excellent in ponds with normal and reduced exchange, and a combination of low density with no water exchange. A combination of high stocking density and no water exchange caused mass mortalities. Results indicate that typical water exchange rates used in intensive shrimp farms can be drastically reduced resulting in a cost savings to farms and reduced potential for environmental impact from effluent.

RECOMMENDATIONS

1. Best Management Practices

Aquaculture producers should continue to implement BMPs for economic and environmental reasons. Funds for additional research, education, and extension work will be required to design, test, and apply new/modified designs and BMPs.

2. Regulations and Permits

Regulatory changes for aquaculture effluent permitting might include the design of state effluent regulations specific to aquaculture, the exemption of small scale aquaculture producers from permitting in certain situations, the removal of aquaculture from industrial discharge category under some state regulations, development of general permits for aquaculture, streamlining the permitting process with "one stop" permitting coordinated by a lead state agency, and the identification of appropriate aquaculture sites or zones. Another idea is to name aquaculture as a "designated use" for certain receiving waters in a state (R. Bastian, personal communication).

General permits, already used extensively by the Corps for certain common practices, can be tied to BMPs. General permits can streamline the permit process and reduce a state's permit case load. A few states have introduced general permit approaches for a limited number of aquaculture facilities. Florida has a general permit for freshwater fish farms (see box). The State of North Carolina worked with the federal EPA to set up a model permit that also reduces permit processing to 30 days (T. Ellis, North Carolina Department of Agriculture, personal communication). In Pennsylvania, a coalition of the aquaculture community and state agencies are working toward model permitting and BMPs with the Department of Environmental Resources (R. Colantuno, T. Hopkins, personal communications).

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General Permit for Discharges from Florida Fish Farms

A general permit for freshwater fish farms in Florida (Rule 17-660.820, Florida Administrative Code) designed by the Florida Department of Environmental Regulation became effective April 30, 1992. The general permit applies generally applies to medium to small size fish farms that discharge little water. Individual discharge permits are required for farms that discharge from ponds or raceways more than 30 days per year (excluding storm-induced discharges), have 300 acres or less of fish ponds at one site, and discharge directly or indirectly into Class I, Class II, or Outstanding Florida Waters. General permit requirements include:

- Pond construction in accordance with U.S. Soil Conservation Service specifications.
- A water detention facility providing either one- or five-day residence time for all pond discharges depending upon amount of standing crop.
- Criteria for the design of the detention facility (length, width, distance between inlet and outlet, vegetation, side slopes).
- State rules for containment of restricted species must be followed.
- Maximum feed rate and pounds of standing crop for one- and five-day detention rates.
- Only registered chemical use allowed.
- Fertilizer application rates limited to recommended rates.
- Dead fish and sludge disposed of following several rules.

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V. PROTECTION OF WILD SPECIES

The culture of aquaculture species poses several wildlife management issues that challenge natural resource managers and aquaculture producers to work together:

- Culture, possession, and sale: distinguishing aquaculture products from wild stock.
- Taking of wild stock for broodstock or seedstock (fingerlings, larvae).
- Elimination of predators.
- Deliberate release (stocking programs) or escape into the wild of nonindigenous, hybrid, domesticated, hatchery-produced, and genetically altered species.
- Aquatic animal health.

Because of their growing regulatory importance, nonindigenous species and aquatic animal health are the subjects of the next two chapters. The other wildlife protection issues, although interrelated, are addressed separately in subsections below. Each subsection briefly covers issues, regulations, BMPs, and recommendations.

Several issues and recommendations are common to most wildlife-aquaculture interactions that are addressed in this and the next two chapters:

Common Issues: Concerns and perceptions about the interaction of aquaculture and wildlife occur in part because -- as opposed to many other agricultural products -- aquaculture plants and animals have only been farmed in the United States for the past 100 years. Stocks of many of cultured species are present in the wild and, in some instances, wild stocks are the principal source of broodstock for the cultured species. Also, the water discharged from public and private operations and aquaculture operations in open waters can be avenues for contact between cultured and wild species. Natural resource agencies concerned with safeguards for public resources, like wildlife, seek to control and prohibit (in the form of regulations) aquaculture activities that might negatively affect wildlife. Some features of these regulations, in turn, are important to the long term viability of the aquaculture industry. In fact, it is in the aquaculturists' best interest to prevent interactions between wild and cultured stocks.

Common Recommendations: Restrictions should be reasonable and reflect valid ecological and biological considerations, rather than differences based on political jurisdictions (two or more states may share a watershed), state and federal agency bureaucratic "turf battles," or political influence of those seeking to keep an aquaculture product from possibly competing with their product (e.g., fishermen). Regulations and requirements should be consistently and fairly applied to both private and public sectors involved in aquaculture.

POSSESSION, OWNERSHIP, CULTURE AND SALE

Issues

In most states, laws have been modified or regulations developed to allow the possession, ownership, culture, and sale of aquaculture species also present in the wild in those states as food products, bait, or for restocking. However, a few states still have restrictions on the possession, culture, and sale of aquaculture species that are also present in the wild in their states. Although the reasons are many and vary from state to state, there are some common threads:

American Fisheries Society Position on Aquaculture

The American Fisheries Society (Robinette et al. 1991) supports the continued development of commercial aquaculture as an important source of food, potential fisheries enhancement, and business opportunity. To protect both the viability of the aquaculture industry and the integrity of native aquatic communities, the Society advocates the following principles:

1. Federal, state, and provincial agencies should cooperatively promulgate and enforce regulations to ensure both the health of aquatic organisms and the quality of food products. Animals that are to be moved from one geographic area to another or to natural waters should be quarantined to prevent disease transmission. Processing plants and fresh and processed food products should be inspected regularly to safeguard human health.

2. To prevent disruption of natural aquatic communities should cultured organisms escape confinement, the use of organisms native to each facility's region is strongly encouraged.

3. When commercially cultured fish are considered for stocking in natural waters, every consideration should be given to protecting the genetic integrity of native fishes.

4. Public and private aquaculture facilities should meet prevailing environmental standards for wastewater treatment and sludge control.

- Aquaculture is not classified or considered a form of agriculture under some or many aspects of state (and federal) law. As a consequence, fisheries (wildlife) management regulations have been extended to aquaculture.

- Resource managers, perhaps wanting to be as conservative as possible in regulating any possible effect of aquaculture on wild or hatchery stocked fish and shellfish, have been reluctant to allow the possession, culture, and sale of some aquaculture products.

- A few people fear that the culture of species that are also classified as game, protected, or endangered species may encourage the illegal capture of these fish from the wild (Sharpe and Moore 1987; Parker 1988). However, there is no evidence (found by the guidebook authors and workshop participants) that illegal sales of poached fish--in any significant volume that might damage wild stocks--are likely to accompany aquaculture production of those species. The reverse occurred in Scotland where aquaculture production of salmon largely removed the incentive to poach wild salmon (J. Pitts, personal communication 1992).

The effect of applying fisheries management regulations to aquaculture products creates situations in some states where an aquaculture producer cannot legally own, raise, or sell some species even though these restrictions cannot be supported for ecological or wildlife conservation reasons (see state regulation examples below).

The catfish industry offers some historical perspective (see Parker 1988). For many years, catfish aquaculture was restricted or prohibited in many states. As the size of the catfish industry and economic and political influence of catfish producers grew, wildlife

managers and the public began to perceive of catfish aquaculture as a form of agriculture and catfish a "domesticated" farm animal.

Regulations

State Regulations

Laws governing possession, ownership, culture, and sale of aquaculture products vary from state to state:

- Most states allow the possession, ownership, culture, and sale of aquaculture species also present in the wild in those states as food products, bait, or for restocking.

- Most states require aquaculture producers to receive a permit from the state natural resources agency. The permit may include reporting requirements to track issues important to wildlife management.

- Catfish and rainbow trout, two of the most commonly cultured fish, are defined as agricultural crops in some states: catfish in Mississippi, trout in Idaho, and all farm-raised aquatic organisms in Missouri. These farm raised fish are not regulated by departments of conservation and natural resources in these states (Parker 1988). Likewise, in Louisiana, crayfish and catfish do not require permits from the state wildlife agency and are under the regulation of the agriculture department.

- In other states, regulations still prohibit the sale of game fish as food fish (even if raised in aquaculture), but do not limit the possession, culture and sale of fish for restocking (Sharpe and Moore 1987; Parker 1988). For example, two fish farmers applied to the Delaware Department of Natural Resources in late 1991 to obtain state permits to culture and sell largemouth bass to specialty restaurant markets and as recreational stock for fish ponds. Permits were initially issued only for sale as recreational stock (Morgan 1992). Louisiana allows the culture of gamefish for sport but not for sale as a food product.

- Size limitations on sale of oysters and other shellfish are enforced in several Atlantic coast states and in Louisiana regardless of source (wild or cultured).

- In Alaska, private aquaculture production of finfish is prohibited (Kron 1992). Yet nonprofit corporations may engage in salmon ranching and stock enhancement.

- In Alabama, Arkansas, and Missouri, anglers fishing in private waters for farm raised fish are exempt from state licensing requirements (Parker 1988)

Federal Law

The Lacey Act and Lacey Act amendments of 1981 (Title 16, U.S.C. 3371) were enacted to protect indigenous species and prevent trade in endangered or threatened wildlife. Enforced by the U.S. Fish and Wildlife Service, the Act has been used to regulate the movement of fish between states. The Act has been invoked by some state governments to prevent the culture of some aquaculture species that the state considers a game fish or threatened or endangered species in the wild. Critics maintain that the Act, in these cases, is unfairly and unreasonably applied to fish farmers. Also, the designation of state borders as geographic control points can result in an arbitrary restraint of trade. For example, the transport of live fish a few miles from one state to another within the same watershed may violate the Act if state regulations differ between the states or if one of the states imposes shipment restrictions. The Act has also been used to prevent the import into a state of certain species (e.g., grass carp). Four fish farmers have been prosecuted by

U.S. Attorneys under provisions of the Lacey Act (USDA-USDI 1990). A FWS law enforcement memorandum on Lacey Act enforcement involving aquaculture shipments establishes violations concerning aquaculture shipments as low priority unless:

(1) Evidence exists that illegally taken wild fish are involved;

(2) The shipments may carry fish pathogens in violation of state codes; or

(3) The species involved is considered harmful to wildlife (USDA-USDI 1990).

A USDA-FWS workgroup recommended that the two agencies work together to establish policy defining and elaborating the dual role of fish as livestock and as a public resource, to coordinate with the states to develop consistent state and federal laws and regulations, and to share information so that the interests of resource conservation and aquaculture are both served (USDA-USDI 1990). The agencies subsequently signed a memorandum of understanding to carry out these recommendations.

Best Management Practices

There are a variety of options available to distinguish wild and cultured products such as paper trails, individual marks or tags on products, and use of different genetic stocks. New techniques are becoming available to mark or tag fish and shellfish. For example, fluorescent markers in calcified tissue have been tested (Wilson et al. 1989) but would require federal Food and Drug Administration (FDA) approval for use, magnetic coded wire tags have been used as markers, and genetic marking has been proposed for identifying red drum. So far the costs of these techniques are prohibitively expensive for aquaculture producers who object to the proposed requirements for individually marking fish.

The Lacey Act

The purpose of the Lacey Act is to prohibit commerce in wildlife taken in violation of state, tribal, federal, or foreign government law and to prevent the introduction of injurious species of wildlife in the United States. The Act makes it unlawful for any person "to import, export, transport, sell, receive, acquire, or purchase any fish or wildlife or plant taken or possessed in violation of any law, treaty or regulation of the United States or of any Indian tribal law." Violation of state conservation law or federal law, commercial interstate movement of wildlife (of at least $350 value for felony level action), and prior knowledge of the law are required for invoking the Lacey Act. The Act can be invoked through complaints by FWS, states, or individuals. The FWS conducts investigations and can make arrests on behalf of the U.S. Attorney, who makes the decision on whether or not to prosecute.

Recommendations

1. The wide range of state regulations about which species may be cultured and sold poses problems for aquaculture producers, market development, and natural resource law enforcement. Efforts should be made to develop consistent state, regional, and national approaches and definitions.

2. In states that have not already done so, laws and regulations should be modified or developed to allow the possession, ownership, culture, and sale of aquaculture species, also present in the wild, as food products, bait, or for restocking. Aquaculture products and activities should be defined as agricultural. Reasonable restrictions administered by the state natural resources agency to protect

wild species should reflect ecological and biological considerations.

3. Marketing labels or tags identifying aquaculture products should not, in general, be required as a method to protect wild species. Distinction between wild and cultured products, if necessary for wildlife protection, can be accomplished with a paper trail: record keeping by producer and marketer, labeling of boxes, and spot checks by regulatory authorities. The State of Maryland has taken this approach. If deemed necessary, the threat of potential state fines, suspension of permits, or other penalties could be used to encourage compliance with paper trail methods. Costly individual marks or tags on aquaculture products should not be necessary.

4. Aquaculture should be exempted from the Lacey Act as recommended by the National Aquaculture Association.

WILD STOCK AS AQUACULTURE STOCK

Issues

Aquaculture producers would prefer not to depend upon wild stocks for brood or seed stock. Acquiring and maintaining wild stock is expensive and wild stocks may introduce diseases not present in the culture facilities. However, until domesticated brood stocks are developed for several species, some aquaculture producers must depend upon wild stocks for broodstock, larvae, or fry. It is in the farmer's long-term interest to work closely with resource managers to protect these stocks from exploitation, non-endemic disease impacts, and adverse genetic alteration. Even if and when domestication occurs, wild stocks represent a genetic reservoir pool that could be used to enhance the gene pool of domesticated stock.

There are several examples of wild sources of broodstock. Shrimp hatcheries rely either on gravid females caught by fishermen or on maturation facilities that maintain broodstock. Although post-larvae produced in hatcheries with captive broodstock are more expensive to purchase than wild caught post-larvae in areas such as Ecuador where wild post-larvae are plentiful, the hatchery approach impinges only slightly on wild stocks. There are a few extensive shrimp operations (ones that rely on trapping and growing out wild post-larvae in a tidal pond) in South Carolina and Louisiana. Some producers of white sturgeon depend on access to wild broodstock from the Sacramento and Columbia rivers. Producers of both striped bass and sturgeon are working on domestication and have had some spawning success with domestically reared broodstock. Alligator farmers in Louisiana rely on wild alligator nests as a source of eggs.

Regulations

State regulations for taking fish from the wild vary from state to state. A specific permit allowing the aquaculture producer to catch a certain number of fish may be required or state fish and game laws must be followed. There are instances of strict limitations or prohibitions placed on the capture of wild stocks for use as broodstock or for stocking in aquaculture facilities, especially if the species is classified as "endangered" or "threatened" by the state or federal government. Taking striped bass for aquaculture broodstock is limited, prohibited, or regulated in many states because striped bass is classified as a threatened species (Jenkins 1987). On the West Coast, catch limits and handling conditions are placed on sturgeon. California Fish and Game require that farmers, who source eggs from wild female sturgeon, return the adult (after C-section) and a certain number of fingerlings. Louisiana permits the removal of wild alligator eggs for growout, but farmers are required to release 20 percent of the wild-sourced young when they reach their juvenile stage. In South Carolina, striped bass may be captured by hook and line and

killed for sport, but the same fish cannot be kept alive for use as aquaculture broodstock.

Recommendations

1. State regulations should allow aquaculture producers to take limited numbers of wild stock for brood or seed stock. These selective harvests are not likely to affect wild populations unless the aquaculture industry grows very large. If scientific studies show that the taking of wild stock for broodstock negatively affects wild populations, then a limited number of wild stock could be auctioned or allocated by some other method.

2. The mechanism for taking fish by legal means should be consistent, regardless of the fish taken for commercial, sport, or spawning use.

3. As domesticated broodstock will play a critical role in the successful culture of most species, producers, government agencies, and universities should continue to encourage and support domestication programs.

BIRD AND ANIMAL DEPREDATION

Issues

Some forms of aquaculture (e.g. catfish) attract piscivorous birds and migratory waterfowl and thereby create a conflict between a farmer's profit and the fate of the avian predator. "If not kept under control, birds such as the migratory double-crested cormorant can eat a fish farm right out of business" (Mason 1991). The cost of bird predation was estimated at $10,000 to $15,000 annually per catfish farmer (Stickney 1990; Mason 1991). Bird predators also affect fish farms and government hatcheries in other parts of the country (Mason 1991). Complicating the control problem is that several of the birds are federally protected migratory waterfowl and some environmental groups object to bird control practices. Coincidental with the growth of the catfish industry in the 1970s and 1980s, the numbers of double-crested cormorants in the Great Lakes region and in Canada began to increase with the decline in pesticide use and greater protection from hunters/fishermen who raided colonies (Stickley and Andrews 1989). With the increase in the number of catfish farms, more and more cormorants began stopping off in the Delta area of Mississippi rather than continuing to previous wintering areas along the shore of the Gulf of Mexico.

Regulations

The U.S. Fish and Wildlife Service (FWS) is one of the agencies responsible for the enforcement of the federal Endangered Species, Lacey, and Migratory Bird Treaty Acts and therefore oversees the issuance of "depredation" permits. Allowable bird kill limits are based in part on fish farm depredation information collected by the Animal Damage Control office of USDA and provided to the FWS.

Best Management Practices

A variety of methods (noise, pyrotechnics, barriers, nets) are used to frighten predators or to prevent them from wading, landing, or diving into ponds. The USDA Southern Regional Aquaculture Center has issued several publications on predator control (Littauer 1990a; 1990b). One of the more successful techniques is the use of perimeter netting and plastic wire grid systems tested over catfish ponds.

Recommendations

Continued support for the USDA/Animal Damage Control Research program on aquaculture predators and cooperation between aquaculture and wildlife groups is needed to 1) develop and test nonlethal control methods and 2) document the effects of bird predation on

aquaculture and the effects of depredation on bird populations.

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VI. NONINDIGENOUS SPECIES

This chapter addresses regulatory issues associated with nonindigenous species including exotic (species cultured outside of their native range), hybrid, domesticated, hatchery-raised, transgenic, and genetically modified species used in aquaculture. The word "nonindigenous" is used as a general term for these species in the chapter.

ISSUES

Use of nonindigenous species in agriculture and aquaculture is widespread (see Bixby 1992, Courtenay 1992, and Steirer 1992) and the culture of many of these species is recognized as beneficial. Examples include beef, poultry, pigs, and other livestock; European honey bees used for pollination; and fish stock enhancement for recreational and commercial fishing; and many plants. Many aquaculture operations also use nonindigenous species such as channel catfish, various species of crayfish, atlantic salmon in Pacific net pen culture, tilapia, hybrid striped bass, *Penaeus vannamei*, *P. monodon*, and a few other shrimp species for marine culture, and *Macrobrachium rosenbergii*, a freshwater shrimp. A significant portion of American bivalve production is composed of nonindigenous Pacific oysters and Manilla clams. Hybridization has provided new species with excellent aquaculture potential such as hybrid striped bass and biotechnology will be used to create fast growing strains or sterile fish.

There are advantages and disadvantages, costs and benefits, of using nonindigenous species in aquaculture (see DeVoe, ed. 1992 for a collection of articles on the subject). Some of these species are successful in culture, have little or no effect on the surrounding aquatic or marine environment, and provide reliable supplies for markets. The negative effects include the environmental impacts of intentional or accidental releases into the wild of nonindigenous species.

Sources of Introduced Species

Many introductions of nonindigenous species into the wild in the United States were intentionally undertaken by government agencies and universities (and still are) for stock enhancement (primarily for sport fishing and to supplement depleted native stocks) or were due to the intentional or unintentional release of ornamental or aquarium fish. A review of introduction sources showed that of the 69 species of nonindigenous fish established in the United States, 51% are escaped or released aquarium fish (primarily in Florida) and 22% are from authorized introductions (primarily for sport fishing) (Courtney and Stauffer 1990; Courtney 1992). Introductions made for weed control, escapes of fish cultured for food or weed control, and species discharged in ship ballast water (such as the zebra mussel) make up far smaller percentages (Carlton 1992; Courtney 1992).

Aquaculture is the source of a few introductions. For example:

- The North American red swamp crawfish, *Procambarus clarkii*, and the signal crayfish, *Pacifasticus leniusculus*, have become established outside of their native range in several parts of the world (Thompson 1990).
- The Japanese oyster, *Crassostrea gigas*, is cultured in open waters in Europe and on the West Coast of North America.

- *Penaeus vannamei*, a Pacific white shrimp, and *P. monodon*, the Indo-West Pacific black tiger prawn, were accidentally released from a few South Carolina and Texas culture facilities (both private and state government) during the past decade (see Wenner and Knott 1992; Hightower and Treece 1992). Some of the released shrimp turned up in the commercial shrimp harvest during the year following these releases. However, there is no evidence that they became established in the wild.

Environmental Impacts

There are potential negative impacts associated with the introduction of any nonindigenous species. These animals could:

- compete with native organisms for food and habitat;
- introduce non-endemic pathogens or parasites to native species;
- alter native gene pools through interbreeding, hybridization, and ecological interaction;
- change the food web and modify the environment due to competition, overgrazing, or habitat alteration.

There is limited information about the short- and long-term impacts of introduced aquaculture species. Although some of the introduced species have had detrimental effects and some are considered beneficial (e.g. brown trout), the effects of the majority of fish introductions have not been examined (Courtney 1992). In a review of fish introduction in the United States, Courtney (1992) asserted that:

Every introduction will result in changes to the receiving system. These changes may be dramatic and detrimental, they may occur quickly or often not for several decades following introduction, and they may range from major to almost neutral.

Evaluating positive and negative impacts of introductions is difficult. For example, domesticated stocks are different than their native cousins. They have a less variable genetic structure; reduced genetic variability has been documented in trout and salmon studies (Weston 1991). Through repeated releases there could be impacts on wild populations as wild fish may have evolved genetic traits that make them uniquely suited to particular habitats. Examples of parasites and pathogens associated with aquatic species introductions, including oyster and crayfish (in Europe) aquaculture, are referenced in the next chapter on aquatic animal health.

There are some examples of public and private aquaculture based introductions that are considered beneficial by some measures. The Pacific Oyster was introduced along the coast of Washington after the native Olympia oyster was nearly lost to over fishing and habitat loss. Pacific oyster seed was returned to Japan in 1992 due to problems with the native Pacific Oyster population. Nearly 85% of the salmon in Puget Sound come from hatchery sources. Walleye, a prized sport fish in Washington State, and striped bass, a sport fish in California are both introduced. Pacific Salmon from the Sacramento River were sent to Australia and New Zealand over 150 years ago and now comprise sport, commercial, and aquaculture salmon.

In one case, a species introduction via aquaculture has been proposed in part to rehabilitate an aquatic environment: culture of the Pacific oyster, *Crassostrea gigas*, in the Chesapeake Bay. Natural diseases have eliminated the native oyster, *C. virginica*, from many parts of the Bay. There were one hundred times as many oysters a century ago, capable of filtering the Bay water every three days -- it now takes up to a year (Newell 1989). The oyster reefs also supported a diverse biological community that includes commercially important finfish and crabs.

Introduction of the Pacific oyster is supported by some, opposed by others (see Abrahms 1992; Krantz 1992). The Pacific oyster could compete and supplant the native species or introduce exotic pathogens. Mann et al. (1991) have proposed tests, procedures, and evaluation criteria to be included in a decision-making process to consider introduction of the Pacific oyster.

REGULATIONS

State Regulations

State regulations in the United States concerning conditions under which nonindigenous, hybrid, or domesticated species may be cultured or released vary widely (see Palmer 1991; U.S FWS 1993 for state approaches):

- In nearly all states it is illegal to introduce or release any non-native species without authorization from the state conservation or natural resources agency.

- The definition of introduced, exotic, or nonindigenous species varies by state. Definitions include "not native or established in the state," "outside its native range," and "any species not included on a list of native or established species."

- Typically, state natural resource departments either have a list of allowable ("clean list") or prohibited ("dirty list") species and/or may make decisions on a case by case, species by species basis.

- Some states may allow culture of certain species under certain conditions: closed system only (e.g. Maryland and Louisiana for most new nonindigenous species), containment measures (e.g., Texas and South Carolina for Pacific shrimp species and in Florida for nonindigenous fish), disease-free status of fingerlings or post-larvae, inspection of facilities and design (e.g., Texas for tilapia operations), and quarantine requirements in Hawaii (Brock 1992).

The wide variation in state regulations poses issues of interstate coordination, especially when states share waterways and watersheds. State governments may make decisions about stocking nonindigenous or hatchery reared aquatic animals independently of other states, even if the states share watersheds.

The varying definitions also pose legal issues. Is a sturgeon obtained in California and moved to Georgia an exotic species under Georgia or federal law? The Georgia Department of Natural Resources defines exotic as not native to the state and seized over 1,000 sturgeon at a Georgia aquaculture farm. However, a county judge in Georgia ruled that an exotic species is one imported from other countries and ordered state officials to return the fish (see Water Farming Journal, January 1992).

Federal Regulations

Federal regulation of the importation and introduction of nonindigenous aquatic species includes a few species-specific regulations, the enforcement of certain state laws, and federal import documentation requirements. The Lacey Act prohibits (1) the commerce in unlawfully taken wildlife and (2) the importation of injurious species of wildlife into the United States including a few fish species (e.g. salmon, salmon eggs). Thus, the FWS checks that those engaged in international commerce of live stocks follow state, tribal, federal, and foreign laws concerning imports. Noncompliance may involve a criminal penalty. Also the USDA and the FWS require documentation of source for imports into the United States from abroad.

Executive Order No. 11987 on "Exotic Organisms" ordered federal agencies in 1977 to restrict the introduction of exotic species into natural ecosystems of the United States to

Shrimp Culture Regulations

The primary shrimp species cultivated in the Americas, *Penaeus vannamei*, is indigenous to the Pacific coast of Central and South America. To date, *P. vannamei* has yielded better results than several Atlantic and other Pacific specie and is cultivated outside of its native range in the Caribbean, Mexico, and the United States. South Carolina and Texas, for example, allow the culture of nonindigenous crustaceans if they are certified disease-free and contained within the culture area. Prompted by several accidental releases of *P. vannamei* in South Carolina and Texas, the shrimp industry and government agencies have worked together on several fronts to reduce the likelihood of any effect on wild native shrimp:

- In South Carolina, the state's shrimp growers association worked with state agencies to establish containment regulations based on those in use for several years by shrimp farming companies.
- The South Carolina Wildlife and Marine Resources Department and several private companies are conducting research trials with *P. setiferus*, a species native to the state and possible alternative to *P. vannamei* for the state's shrimp farming industry. Results to date with *P. setiferus* have been encouraging.
- Disease-free broodstock for *P. vannamei* were developed and are maintained by a consortium of the Oceanic Institute in Hawaii, the Waddell Mariculture Center in S.C., and universities in Texas, Mississippi, and Arizona with federal and state funding.

the extent permitted by law, to encourage state and local governments and private citizens to restrict such introductions, and to limit the use of federal funds or authorities to export native species into ecosystems outside of the United States. Regulations were proposed for the implementation of EO 11987 but never finalized (U.S. FWS 1993). The 1990 Aquatic Nuisance Prevention and Control Act (Public Law 101-646) charged an Aquatic Species Task Force of the FWS and the NMFS to identify and evaluate approaches for reducing the risk of adverse consequences associated with intentional introductions of aquatic organisms and to submit a report of their findings to Congress. The law was enacted largely in response to concern about the introduction of zebra mussels. The Task Force addressed the use of nonindigenous species in the aquarium industry, public and private aquaculture, and public fisheries management and recommended (U.S. FWS 1993):

- increased attention to the enforcement of existing federal authorities;
- establishment of a federal import permitting system to provide a review of proposed introductions of nonindigenous aquatic species;
- coordination of the United States implementation of the ICES protocol by the appropriate federal agencies;
- interjurisdictional nonindigenous species consultations;
- state enactment of legislation to address nonindigenous species; and
- development of codes of good business practice by private industry.

BEST MANAGEMENT PRACTICES

Strategies for nonindigenous species management and control include the development of industry codes of conduct and decision-making tools. These measures include:

- disease screening and quarantine;

- pond stocking of offspring one or more generations removed from the nonindigenous parent stock;
- containment safeguards to prevent escape;
- studies to document effects of an introduction including study of the species in its native habitat (known diseases, pests and predators, food habits, biotic potential), interactions with new environment and species that might be affected (competition, predation, genetic, behavioral, pathological), and benefit cost analysis; and
- post-importation monitoring.

Several more comprehensive protocols and codes of practice have been proposed to reduce the risks of introducing nonindigenous species or nonnative pathogens. Guidelines have been adopted or recommended by the International Council for the Exploration of the Seas (ICES), the American Fisheries Society (AFS), and the North Atlantic Salmon Conservation Organization (NASCO) (ICES 1979; Kohler and Courtenay 1986; Sindermann 1986; NASCO 1989; Kapuscinski and Hallerman 1990). A premise of these protocols is that use of a nonindigenous species includes risks for the aquaculturist and public resource manager and that some sort of calculus of positive and negative effects will aid in decision making. Although the ICES code (see Figure 2) is "somewhat idealistic, with provisions that are difficult to impose without some effect on aquaculture, it does provide...an international uniform policy concerning introduction of marine species" (Sindermann 1986). Sindermann (1986) recommends that "any proposed introduction of a non-indigenous species should be done according to the spirit of the ICES Code of Practice" and that the code form the basis of federal policy in the United States (Sindermann 1992). Unresolved issues in implementing the protocols include determining who decides, what criteria and measurement techniques to use, how to resolve disagreements between experts about potential impacts, and who pays for the potentially high costs of the studies. ICES type studies are likely to be prohibitively expensive for an individual aquaculturist or company to undertake.

RECOMMENDATIONS

1. General

To paraphrase Sindermann (1986), the best strategy is the development of awareness among state and federal agencies, aquaculturists, and the public that the importation of nonindigenous species in quantity, without adequate controls, can have unintended effects on native stocks and ecosystems (and perhaps on other aquaculture operations), and that it is in the best economic interest of all constituencies to have effective management mechanisms in place. Such a system must have the flexibility to accommodate new opportunities; be reasonable, fair, and consistent; not create unreasonable costs and bureaucratic structure; but have enough rigidity to resist political manipulation.

2. Research

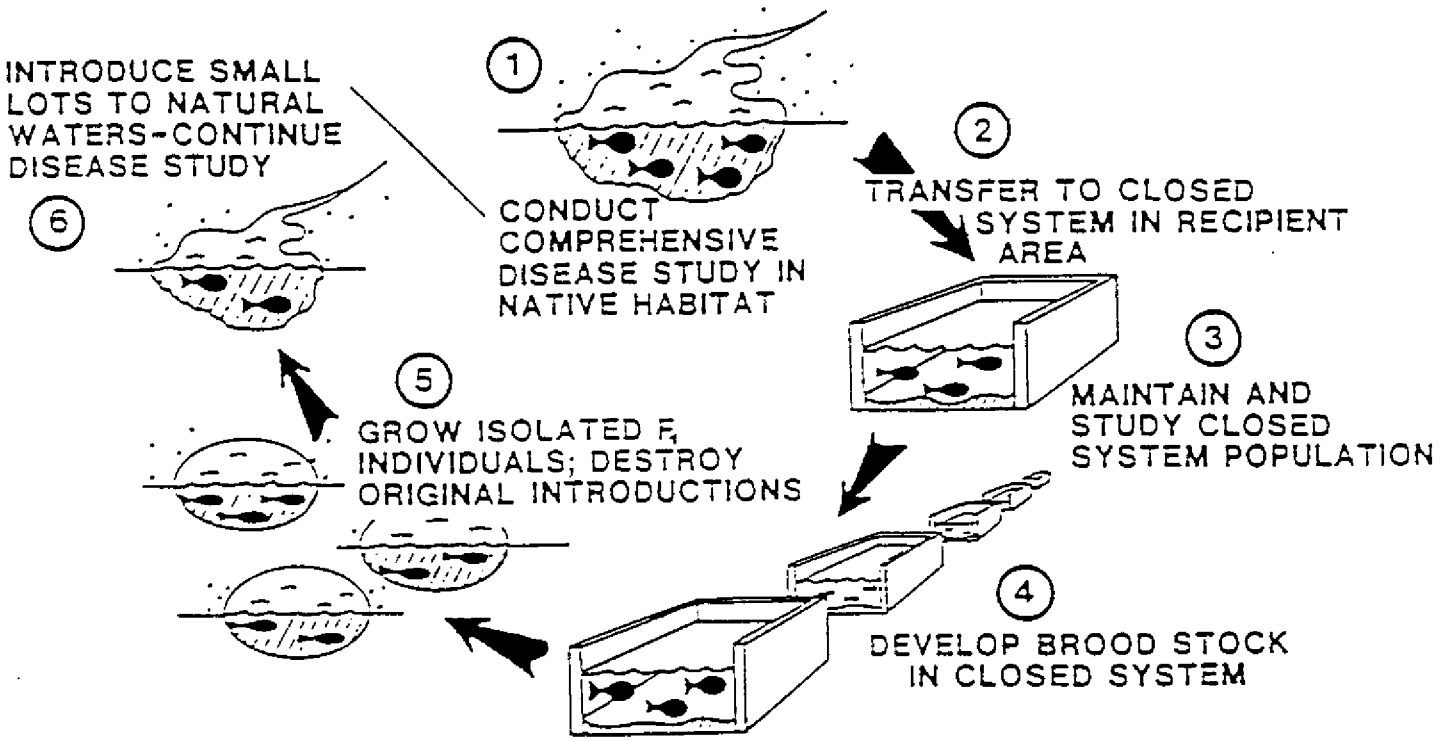
Evaluation of potential nonindigenous species for aquaculture should be addressed by cooperative efforts between private industry, government agencies, and universities. The research objectives and methods could follow "the spirit" of the ICES or other guidelines. Cooperative research, for example, has been used to develop "specific pathogen free" shrimp for the aquaculture industry.

3. Consistent Standards

Consistency of standards, even uniform standards in some cases, may be warranted because what happens in one state (or country) may affect another in terms of effects on wild and aquaculture stocks. The wide variety of

Figure 2

Proposed Steps to Reduce Dangers of Disease in the Introduction of Non-Indigenous Species



Source: Sindermann 1986, following ICES guidelines

state policies as to which species may be cultured and sold poses problems for aquaculture producers, market developers, and natural resources management personnel. One strategy is to adopt consistent regional approaches based possibly on watersheds.

4. Cooperation

Nonindigenous species regulations should be formulated jointly by regulators, aquaculture producers, and other stakeholders. BMPs already in use (e.g., containment methods) provide models for regulation. Aquaculture producers don't want their stock to escape into the wild and have a strong financial interest in maintaining healthy stock. These concerns are reflected in BMPs. The South Carolina shrimp containment regulations (see box) are an example of industry best management practices (albeit informal) codified into regulation.

5. Fairness

Regulations, if required, should be developed such that they are applicable to aquaculture producers, stock enhancement practices of fish and game agencies, the aquarium industry, and terrestrial plant and animal agriculture.

6. Risk Management

"Risk management" (see U.S. EPA 1990) might be one of the criteria used in government nonindigenous species programs and regulations. Such an approach would compare the positive and negative impacts of various sources of nonindigenous species and apply resources to the greatest potential risks and negative impacts in terms of both economic and environmental costs.

National Research Council (1992) Recommendations on Stock Enhancement

- Evaluate past and present stock enhancement programs with regard to their efficacy, cost-effectiveness, environmental problems, and potential payoffs. Based on the study, develop guidelines for more effective and less potentially damaging future programs.
- Public agencies should ensure that common-property fish stocks are maintained in a healthy condition, that genetic resources are conserved and biological diversity maintained, and that threatened or endangered species are protected.
- Public agencies should promote the participation of the private sector in meeting the nation's needs for fish and shellfish for stock enhancement. The private sector needs to meet specifications required for stock releases into public waters.

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VII. AQUATIC ANIMAL HEALTH

Issues concerning aquatic animal health parallel concerns in agricultural plant, livestock, and poultry production, and to some degree concerns in human public health. Historically, plant, animal, and human pathogens have been disseminated throughout the world by migration or transport of animal and plant products. Regulatory structures to reduce the introduction of exotic animal pathogens or the spread of endemic pathogens have been established and changed to reflect expanding knowledge and technology. The amount of attention given to regulations ranges in intensity from areas where pathogens or disease have been identified, to areas where largely unconfirmed fears of disease have surfaced, to other areas where little or no problems have been recognized.

This chapter defines disease, outlines key regulatory issues, presents examples of aquatic health regulations which help to prevent introductions, examines BMPs which can be employed to help reduce losses due to disease, and provides some general guidelines and recommendations.

ISSUES

Definitions and Environmental Impacts

The definition of disease (dis-ease), normally thought of as "a condition in which bodily health is impaired", is often mis-understood. To what extent do pathogens pose a threat? What level of health is affected? Our ability to answer these questions depends, in part, on available information and our ability to measure the problem. With test results, observations and experience, medicine and biology can determine causes, effects, impacts, and corrective action, but like all science and medicine, knowledge and technology are limited. Specific conditions must be understood to determine appropriate regulations and BMPs.

The terms health and disease cover broad areas and go well beyond the scope of this document. Historically disease was often viewed as synonymous with the presence of a causative agent. Campbell et al. (1979) defines disease as "the sum of the abnormal phenomena displayed by a group of living organisms in association with a specified common characteristic or set of characteristics by which they differ from the norm of their species in such a way a to place them at a biological disadvantage". Ill-health or disease almost always result from a combination of interrelated factors; the presence of a pathogenic agent is only one of those factors. An existing pathogen is no guarantee of disease and the two terms must be considered separately. Disease can result from both biotic and abiotic factors, nutritional and genetic disorders, environmental conditions (toxin and nutrient overloads), physical disorders, pathogens, parasites and pests and most often a combination of the above. The causative agents of disease are usually synergistic, so that conditions that lead to stress provide opportunity for invasion by organisms which may otherwise be benign. Observations suggest that 95% of all disease outbreaks are due to pathogens present in the environment in synergism with other adverse conditions, and possibly 5% of disease is due to highly virulent, infectious agents (Eric May, pers. comm. 1992).

The most serious potential problem for wild and cultured species is the encounter of an exotic pathogen. Biological or mechanical vectors (carriers) may serve as a source for new introductions. Eggs, live fish, and transport water are the most easily tracked and

identified, but fresh and frozen products, ballast water, and research specimens are also involved in the transfer of unwanted organisms.

Exposure to exotic or endemic pathogens can affect both aquatic species living in the wild or in culture conditions, with pathogen transfer occurring in both directions. There are many examples of transfer of disease from native species to those in culture (Williams and Sindermann 1992). Transfer from cultured species to free ranging species is known but poorly documented. This dichotomy is exacerbated by the nature of the media. It is easier to observe and diagnose disease conditions in confined culture operations, while wild species tend to be more dispersed and evidence of disease more difficult to detect. Also, some organisms that are highly pathogenic in a culture setting do not result in disease in the same species living in the wild. In some instances, pathogens can be managed in a culture situation or do not pose a threat to wild populations.

Most diseases can be separated into two general categories. Obligate pathogens are invasive organisms that require a host to survive (viruses, some bacteria, parasites). These are usually treated by quarantine, vaccination, antibiotics, and destruction of the host. Facultative pathogens are those pathogens that cause diseases in organism predisposed by stress (viruses, bacteria, pests). Facultative pathogens can naturally occurring in the water, in the normal flora of the infected organism and are usually treated through water quality management that reduces stress. Weston (1991), and Ganzhorn et al. (1992) reviewed cases of diseases associated with fish introductions, Lightner et al. (1992) and Thompson (1990) provided examples for crustaceans, and Sindermann (1986), Chew (1990), Weston (1991), Farley (1992) and Ganzhorn et al. (1992) provided examples for molluscs. Other forms of disease are caused by genetic, nutritional or environmental disorders.

Regulatory Issues

Aquatic animal health issues can be divided into two categories:

1) the management of cultured animals to avoid the health risks associated with confined culture conditions (crowding, transport and handling, water quality problems) and

2) the management and regulation of the transfer of animals and products to prevent the introduction of exotic pathogens, parasites, and pests.

Prevention of exotic pathogen introductions and the spread of pathogens into non-endemic regions is a priority for private and public culturists and resource managers. Fish health regulations have been designed to prevent introduction or eliminate existing pathogens. The existence of a pathogen has been used to mandate eradication and/or restrict stock movement.

Much like public health or terrestrial agriculture, institutional problems exist and there are technical voids which complicate diagnosis and control of aquatic animal disease. Basic uncertainties that affect health care regulations at all levels exist within public and private aquaculture production. Examples include:

- unknown (in some cases) dynamics of pathogen transfer, conditions which favor disease outbreaks, and effects on cultured and wild stocks;

- inadequate funding for research, certification and diagnostic programs, and approval for new therapeutants and vaccines; and

- limited diagnostic and treatment procedures and limited availability and high costs of diagnostics may result in inadequate services.

Some aquaculture producers argue that current and proposed fish health regulations pose significant economic costs and that some of regulations are based on outdated assumptions and theories (see, for example, Northeast Regional Aquaculture Center, Industry Summit, 1992; Summary of Meeting of the Steering Committee of the JSA Task Force on Aquatic Health Management, January 6-7, 1993, which includes statements from East Coast Atlantic salmon and inland trout industry representatives).

REGULATIONS

Measures to prevent the introduction of exotic disease exist in the United States and in many other countries. Most state regulations address the introduction and spread of aquatic diseases through authority placed with state natural resource agencies. Private and public aquaculture producers also control health problems through BMPs as a practical matter to insure viable production.

State and federal aquatic animal health regulations cover fresh and marine waters and a variety of fish and shellfish species and may include elements of the follow list:

- registration of aquatic farms;
- permits and regulations for introduction of fish or products into the state or the country;
- permits regulating transfer of fish and products within the state or the country or from facility to facility;
- certification procedures and requirements for aquatic animal movement;
- regulations for removal of dead, dying or diseased animals and for decontamination procedures where needed;
- quarantine periods and procedures where necessary;
- provisions for "disease free" stocks where needed;
- treatment and handling for animal feed ingredients; and
- notification of reportable disease.

Federal Regulations and Policies

There are several federal regulations and policies which apply to fish health and aquaculture. As noted in the previous chapter, the federal government is involved in enforcing state laws, federal documentation requirements, and some species specific regulations concerning the importation of aquatic species. The Lacey Act (Title 50 Code of Federal Regulations) prohibits the importation of injurious species of wildlife into the United States including salmon and salmon eggs. For example, the Lacey Act requires that live or dead fish or eggs from the genus Salmonidae be accompanied by a certificate stating that they are free of the protozoan *Myxosoma cerebralis* and the virus causing viral hemorrhagic septicemia.

The FWS established regional and state fish health laboratories in the 1950's to protect wild stocks from disease. In the 1960s, the FWS instituted a fish health program directed at regulating the importation of salmon eggs.

There are some attempts to reduce the risk of pathogen introductions associated with imports that require disease inspections to be conducted by qualified specialists. Shipments of live fish between the United States and Canada, for example, are inspected by inspectors certified by the FWS or the Department of Fisheries and Oceans of Canada (Ganzhorn et al. 1992). The Task Force on Aquatic Animal Management under the aegis of the federal Joint Subcommittee on Aquaculture (JSA) was established in 1991 to develop a nationwide aquatic animal health strategy to address

regulatory issues, research needs, and the industry's need for diagnostic services. The Task Force includes industry, state, university, diagnostic services, FWS, and USDA representatives. Key elements of a national strategy have been identified (Joint Subcommittee on Aquaculture 1992). These include protection of fishery resources and aquaculture industries from foreign and domestic pathogens; development of model state regulations, cooperative, necessary authorities, and required resources for implementation; coordination and full use of professional aquatic animal health personnel, facilities, and technical resources; and identification of research and development priorities.

State Regulations

There are many state specific regulations depending on conditions, species of fish and specific culture practices. State regulations include many of the measures to prevent the spread of disease listed above and the measures included in nonindigenous species regulations (previous chapter). Some state examples:

- Washington and Alaska have strict regulations over salmon imports for aquaculture and have rigid certification and quarantine requirements for eggs.

- In Hawaii, the introduction of non-native aquatic organisms is treated like other agricultural products. Quarantine is required and permits are handled by the Plant Quarantine Branch of the Hawaiian Department of Agriculture with oversight by several associated committees. The state uses an ICES-type protocol to prevent the introduction of IHHN and other viral pathogens that might come in with nonnative shrimp species (Brock 1992).

- In South Carolina, shrimp imported for aquaculture are required to be certified disease-free by disease "specialists".

- Disease regulations for aquatic animals have been developed by the Washington State Departments of Agriculture and Fisheries (WDF), and are administered through joint agreement. The WDF also reviews each aquaculture permit under the WDF Hydraulics Permit process, permit designed to protect the salmon resources and associated habitats of the State (J. Pitts, personal communication).

- California's Department of Fish and Game (DFG) has responsibility for maintenance of fish health in the state. To encourage the acceptance of DFG's program by the aquaculture industry, an Aquaculture Disease Committee was established. The program provides disease certification (for a fee) at the request of farmers. DFG also maintains a cooperative relationship with the California Department of Food and Agriculture which manages inspection stations at the state's borders. Permits issued by DFG are required before live organisms can be brought into California.

- Shellfish producers in many states are regulated through state water quality programs designed to certify the status of the water where shellfish are grown.

The wide state to state variation of fish health regulations and the lack of a uniform national fish health strategy has been cited by the Joint Subcommittee on Aquaculture (JSA) as a factor "resulting in inequitable treatment of the aquaculture industry and sometimes poor relations between private aquaculturists and public resource agencies" (JSA 1992). The American Fisheries Society, National Aquaculture Association, United States Trout Farmers Association, and Catfish Farmers of America have pushed for greater agency

cooperation, a national approach to fish health, and additional funding for health programs for many years. The JSA Task Force on Aquatic Animal Health Management, as noted above, is working on national strategies and programs.

Some aspects of public fish health management have been addressed on a regional basis. Examples of regional approaches include the New England Salmonid Health Guidelines, the work of the Great Lakes Commission, and the Pacific Northwest Fish Health Protection Committee. A variety of collaborative industry-government regional efforts are underway to design aquatic health policies, regulations, and BMPs.

BEST MANAGEMENT PRACTICES

Like livestock or poultry management, recognized strategies have evolved over the years to enhance production and produce a higher quality product. The same principles apply to aquatic animal health and production. BMPs for aquatic health management are essentially those listed in earlier chapters for pond and water quality management, animal husbandry and handling, nutrition, and containment.

The ICES and other codes of practice (see previous chapter) offer recommended practices to reduce disease risks. For these protocols or codes to be effective, however, a significant investment in quarantine and disease diagnostic facilities will be required (Lightner et al. 1992). One of the problems limiting practical implementation of the ICES protocol is that insufficient knowledge is available about the diseases and parasites of importance or about the diagnostic tools for most species (Sindermann 1986).

Disease Free Shrimp Broodstock

Specific pathogen free (SPF) broodstock of *Penaeus vannamei* were developed by a Consortium formed under the U.S. Department of Agriculture. The four primary participants, the Oceanic Institute in Hawaii, the Waddell Mariculture Center in South Carolina, the Gulf Coast Research Lab in Mississippi, and the University of Arizona Veterinary School, received funding from the USDA and cooperated on the development, testing, and verification of SPF *P. vannamei* broodstock. Broodstock are provided to several cooperating hatcheries for commercial production of larvae for the industry. The development of SPF shrimp has helped to quiet some of the concerns of the wild shrimp industries along the South Atlantic and Gulf Coasts, and produced a shrimp that in some areas grows faster and has better survival than the hatchery produced post-larvae available in past years.

RECOMMENDATIONS

1. General

All participants should recognize that promoting aquatic animal health is in the best interest of culturist and resource manager alike. Fair and consistent regulatory policies should be developed to protect wild, stocked, and farmed aquatic animals, while allowing public and private aquaculture to prosper. While effective regulation is essential, antiquated or excessive regulation not aimed at cost-effective aquatic health management will stifle public enhancement and private production. Effective regulations, model state and regional regulations, and cooperative management agreements must be developed through cooperative efforts, with periodic revisions to reflect changing knowledge and information.

2. *Best Management Practices*

Industry associations should encourage establishment of BMPs at the farm and hatchery level. Experience shows that most pathogens express themselves in unfavorable conditions, and goals should be set to encourage preventative medicine. The development of BMP's is a dynamic process with constant upgrading as new research and discoveries emerge in the area of fish health management. Farm, state agency, university, cooperative extension, and health care provider groups should be encouraged to communicate and share ideas and new procedures through workshops, research, and demonstration programs.

3. *Services*

Private and public fish health services, veterinary medical education and practitioner services, as well as nutrition, genetics and engineering expertise and services need to be expanded and adequately funded.

4. *Regional Considerations*

Movement of stocks and transfer of species should be based on regional conditions, knowledge of endemic pathogens and conditions in regional receiving waters. Federal and state agencies should develop regional maps and inventories of pathogen occurrence and update inventories on a regular basis.

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VIII. DRUG AND CHEMICAL USE

This chapter examines the regulation of drugs, therapeutants, chemotherapeutants, parasiticides, disinfectants, chemicals, growth hormones, pigments, and water quality agents as they are used in aquaculture. For regulatory purposes, the claims made for a product determine whether it is a drug as distinguished from a non-drug substance (e.g., pesticide or water treatment chemical). The definition of a drug under federal law is an article intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease in man or other animals; and articles (other than food) intended to affect the structure or any function of the body of man or other animals.

ISSUES

Aquaculture producers aim to produce and maintain healthy fish. Producers are becoming more knowledgeable about the use of BMPs to keep water quality or other production parameters at optimal levels to reduce stress on the cultured organism and the likelihood of disease outbreaks in their operations. Drugs or chemicals are generally used only as a last resort to treat disease, because of their high cost.

But disease can be a problem in aquaculture, especially as the intensity of production per production unit rises. By one estimate, more than 200 million catfish and 10 million trout were recently lost in one year due to disease (Schnick 1992). As noted in the previous chapter on aquatic health management, stress increases susceptibility to disease. A Florida veterinarian specializing in aquaculture estimated that 96 percent of all of the fish disease syndromes he is called upon to treat are directly related to stress (Stoddard 1990).

Drugs and chemicals are used in aquaculture to treat disease outbreaks. For example, a list of therapeutants used in shrimp culture are identified in Williams and Lightner (1988). In some cases, antibiotics may be used as a prophylaxis (National Research Council 1992). Chemicals (naturally occurring and artificially produced) may also have other uses in aquaculture. Pigment added to feeds produces a colored flesh in farmed salmon, for example. Growth hormones that may control the sex, size, and behavior of some aquatic species are being tested. Hatchery tanks and ponds may be disinfected with chlorine. Antifoulants to prevent growth of algae and encrusting invertebrates are used in some marine aquaculture situations.

The use of drugs and chemicals to treat disease or for other purposes in aquaculture raises a number of regulatory issues:

Quality Assurance. Public confidence in the quality of aquaculture products is critical to aquaculture's success. Shellfish advisories, the Consumer Reports (1992) article on seafood contamination at the retail level, and reports by environmental activists on the use of antibiotics in salmon (Whiteley and Johnstone 1989) are some of the examples of real and perceived quality control problems. Americans are likely to remain concerned about food safety (Stoddard 1990; Lane and Bruhn 1992).

Environmental Impacts. Drugs and chemicals used in aquaculture could be inadvertently released into the aquatic environment (directly into the water or through feces) and affect aquatic and marine species and their environments (for example, development of drug-resistant strains of bacteria and accumulation of antibiotics in sediments, fish, and shellfish).

Lack of Drugs Approved for Aquaculture. The aquaculture industry and public safety would both be served by timely approval of safe and effective therapeutants for disease control (e.g., reducing losses from disease outbreaks, discontinuing use of potentially "unsafe" compounds). Only a handful of drugs are approved by the federal Food and Drug Administration (FDA) for use in aquaculture to control a few diseases on a few aquatic species. Approval for salmon does not mean it can be used for striped bass. In addition, about a dozen other compounds with some form of federal approval may be used to control some diseases but these allowances are not included on the compound's labels. Most of these chemicals do not have a commercial sponsor for aquaculture applications or the registration has expired.

High Cost of Developing New Approved Drugs. Most of the candidate compounds identified for potential use in aquaculture do not have commercial sponsors who will support drug approvals for aquaculture. Few pharmaceutical and chemical firms have shown interest in extending the registration of their products for use in aquaculture because of the high registration costs in comparison to their return on investment. Companies need a worldwide market of at least $60 million in annual sales per drug per species to make a profit from an aquacultural drug; the total demand for aquaculture chemicals in the United States for all drugs and all species is estimated at $10 million annually (Schnick 1992). The lack of registered drugs for aquaculture is a worldwide problem. The estimated cost to obtain FDA approval for candidate drugs and chemicals that might be used in aquaculture in the United States is $100 million. The minimal cost to meet the data requirements for an unapproved drug is $3.5 million; some approvals could cost $20 million. Most of the research on new aquaculture drugs is being paid for by the federal government, and funds are limited.

Regulation of Imported Seafood Products. All imports must meet the same standards as domestic product. However, because of the huge quantity of imported seafood, it may be difficult to subject imported seafoods to the same level of scrutiny regarding unapproved drugs as domestic aquaculture.

REGULATIONS

Because approval or registration of new animal drugs and chemicals for aquaculture is largely a federal concern, this chapter focuses on federal regulations. In general, EPA "registers" those pesticides, disinfectants, algicides, and water sanitizers with no claim for disease control (under the Insecticide, Fungicide and Rodenticide Act (FIFRA)), FDA "approves" substances used as drugs, feeds, and food additives (under the Food, Drug, and Cosmetics Act), and the USDA Animal and Plant Health Inspection Service (APHIS) "licenses" veterinary biological products under the Virus-Serum-Toxin Act (for a list and description of federal regulation of drugs and chemicals used in aquaculture see Joint Subcommittee on Aquaculture (JSA), Working Group on Quality Assurance in Aquaculture Production 1992).

Most of the recent federal regulatory activity concerning drug and chemical use in aquaculture has been undertaken by the FDA. Much of the information about FDA's programs and policies has been taken from Stefan (1992, 1993a) and a guide to federal regulation of drugs in aquaculture compiled by the JSA, Working Group on Quality Assurance in Aquaculture Production (1992). FDA's responsibility under the federal Food, Drug, and Cosmetics Act includes assuring consumers that foods are pure and wholesome, safe to eat, and produced under sanitary conditions and that drugs and medical devices are safe and effective for their intended uses. Animal drugs, feed and color additives, and veterinary devices are among the products that are subject to federal requirements.

A drug approval is obtained by submitting to FDA data showing, among other things, that

the drug is safe and effective (it will do what it is supposed to do) for its intended use. An animal drug is defined as unsafe unless that drug is approved for specific applications. Safe means that it is safe to the animal, the person administering the drug, persons eating food products derived from the animal, and the environment. In order for someone to legally investigate the safety and effectiveness of an unapproved compound (develop the data for FDA approval), FDA issues an investigational new animal drug (INAD) exemption. Also, FDA (and EPA) have procedures for registration of compounds for "minor use" whereby approvals may be obtained at far less cost than is typical for uses in major agricultural industries. In certain circumstances, FDA allows veterinarians to administer a new animal drug in a manner that is not in accordance with the approved drug labeling ("extra-label use" see JSA Working Group on Quality Assurance in Aquaculture Production 1992; Stoddard 1990).

The situation regarding the use of animal drugs in aquaculture has changed in recent years for several reasons (see Stefan 1992; 1993a). In the past, FDA was lenient in granting INADs for aquaculture because of the lack of approved compounds for aquaculture. However, little data to support formal approvals was developed and FDA could not demonstrate that it was fulfilling its mandate to protect public health. Also, the federal government does not have a drug residue monitoring program for aquaculture similar to that for meat and poultry. For these reasons, FDA has increased its scrutiny of aquaculture drug use, tightened requirements for INADs, and thereby limited producers' abilities to use some compounds. In addition to limiting use of pharmaceutical products, several common and innocuous compounds used in aquaculture such as sodium chloride, calcium chloride, and sodium sulfite meet FDA's definition of "new animal drug" (Stefan 1993). FDA's definition of some of these common substances as "unapproved drugs" has been criticized by the aquaculture community and the American Fisheries Society has recommended that FDA not regulate these substances (Charmichael 1993).

Drugs used for food and non-food fish must be approved by FDA. Data requirements for approvals are different for food animals than for non-food. If a species is a food species, then it will, as a general rule, be considered food at all life stages. This has been and will continue to be a controversial issue, because in aquaculture "life stages" encompasses eggs, free swimming stages, etc., according to Stefan (1993a). FDA's concern is that, to routinely classify particular stages as "nonfood" would arbitrarily eliminate from human food safety evaluation even the most persistent and potentially dangerous compounds used in these stages. A case-by-case evaluation permits FDA to conclude that use of a particular drug in a particular species for a particular life stage is, for example, of low regulatory priority. Or FDA may conclude that, for purposes of a new animal drug application, very little or no human food safety data are required. FDA considers the following nonfood species: three species of baitfish (Golden Shiners, Flathead Minnows, and Goldfish); ornamental or aquarium fish; and endangered species that in the wild may not be harvested (Stefan 1993a).

FDA officials see a dilemma facing the industry and the regulatory agencies: Congress has passed laws which make the use of unapproved compounds illegal, and FDA can and has interpreted federal laws very strictly (even salt and ice can be considered "drugs"). However, very strict interpretation could severely affect the ability of both public and private aquaculture facilities to function or even to continue to operate (Stefan 1993a).

As a result of discussions with aquaculture organizations and producers, the efforts of the JSA Task Force on Quality Assurance in Aquaculture Production, and further work by FDA, FDA's policy and actions on aquaculture drugs now include the following:

1. Under a policy known as "regulatory discretion," FDA has chosen not to object to the use (i.e., has allowed the use without formal approval) of some unapproved compounds used in aquaculture which appear to be sufficiently innocuous and sufficiently supported (as safe) in the scientific literature. A list of these aquaculture drugs with low regulatory priority is in the adjacent box.

2. Use of all other drugs will require approval or an INAD. But because FDA recognized that it would place an unreasonable burden on the industry to abruptly cut off its access to all medications, the agency will grant exemptions for investigational use (FDA's "Compassionate INAD Policy"). FDA has encouraged producer organizations like the National Aquaculture Association, universities, and state and federal resource agencies to sponsor INADs.

3. FDA hopes to be able to continue to emphasize education and voluntary quality assurance programs for producers, with regulatory actions being limited to those brought on a "for cause" basis (Stefan 1993).

4. Criteria that FDA will use to determine regulatory priority for taking enforcement actions include scientific/medical, intended use, approval status of the active ingredient, and misuse potential. Examples of drugs that FDA has identified as high priority for regulatory action include chloramphenicol, nitrofurans, malachite green, fluoroquinolones, quinolones, and central nervous system stimulants and depressants.

5. If a registered pesticide is being used properly (i.e., the labeled conditions in fact exist in the facility at the time the pesticide is used, and the compound is not misused under the requirements of FIFRA), FDA will not object to that proper use even though the pesticide may have a potential, incidental, or concurrent drug use.

6. FDA has begun studies of imported seafoods products and is developing the analytical tools required for analyzing chemical residues in imports of fish and shellfish (Water Farming Journal 1992a). The agency announced that it is prepared to conduct a limited survey of imported shrimp to check for residues of chloramphenicol (Water Farming Journal 1992b).

During the past year, FDA has worked closely with other federal and state agencies and the aquaculture industry to address drug and chemical use issues in aquaculture. A federal Task Force (sometimes called Working Group) on Quality Assurance in Aquaculture Production under the auspices of the JSA has met regularly since 1991 to coordinate efforts to develop educational initiatives, data to support animal drug approvals, and industry quality assurance programs. The Task Force's mission is to increase understanding of and compliance with federal requirements regarding drug and chemical use in aquaculture through education and coordination of related efforts in government, industry, and academia (Joint Subcommittee on Aquaculture 1992). The Task Force's emphasis has included the following:

- Preparation and publication of a document for explaining the roles of federal agencies in regulating animal drugs and feeds, pesticides, herbicides, and vaccines. Efforts are underway to develop a producer guide that will provide information on the legal status of compounds, how to use them safely, and where to obtain assistance.

- Establishment of a central databank of

Low Regulatory Priority Aquaculture Drugs

The following compounds have undergone review by FDA and have been determined to be new animal drugs of low regulatory priority (consult with FDA for allowable uses and concentrations):

Acetic Acid - Dip as a parasiticide for fish

Calcium Chloride - Used to increase water calcium concentration to insure proper egg hardening or to increase water hardness to holding and transporting fish.

Calcium Oxide - Used as an external protozoacide for fingerlings to adult fish.

Carbon Dioxide Gas - For anesthetic purposes in fish.

Garlic (Whole Form) - For control of helminth and sea lice infestations of marine salmonids at all life stages.

Ice - Used to reduce metabolic rate of fish during transport.

Magnesium Sulfate - Used to treat external monogentic trematode infestations and external crustacean infestation in fish at all life stages.

Onion (Whole Form) - Used to treat external crustacean parasites and to deter sea lice from infesting external surface of salmonids.

Potassium Chloride - Used as an aid in osmoregulation; relieves stress and prevents shock.

Povidone Iodine - An egg surface disinfectant during and after water hardening.

Sodium Bicarbonate - As a means of introducing carbon dioxide into the water to anesthetize fish.

Sodium Chloride - Various solutions as an osmoregulatory aid for relief of stress and as a parasiticide.

Sodium Sulfite - Solution to treat eggs in order to improve their hatchability.

drug and chemical information for compounds used in aquaculture.

- Coordination of efforts to obtain FDA approval of needed drugs for aquaculture.
- Assessment of the needs and implications of a voluntary quality assurance program (similar to those of other animal agriculture groups) for the aquaculture industry.

BEST MANAGEMENT PRACTICES

BMPs for disease prevention and control are outlined in the chapter on disease. Additional BMPs for drug and chemical use by aquaculture producers include (taken in part from Schnick 1992 and Culley and Falcon 1992):

- develop and implement a farm quality control program;

- keep accurate production figures and disease losses;
- identify needed drugs and chemicals;
- be knowledgeable about federal and state regulations and industry quality assurance programs concerning the use of these drugs and chemicals;
- participate in an INAD program if the use of unapproved new animal drugs is required.

The aquaculture industry is beginning to establish and implement industry quality assurance programs to insure and identify the quality and safety of its products to the consumer. Such programs could include education about BMPs, assistance to producers on proper drug use, data recording when using an INAD, maintenance of product quality databases, and marketing "quality assurance" or "seal of approval" programs with uniform standards and protocols for assessment of quality assurance. The Catfish Farmers of America adopted a quality assurance program (Water Farming Journal 1993), the U.S. Trout Farmers Association is developing a program, and other producer groups are considering similar programs (Stefan 1993b). The National Aquaculture Association has been working to coordinate development of a generic quality assurance program which can be readily adapted to any type of production operation (Stefan 1993b; J. McCraren, personal communication).

RECOMMENDATIONS

1. Quality Assurance Programs

The aquaculture industry should continue to establish and implement these programs.

2. Funding

Additional public funding will be needed to develop approvals for new aquaculture drugs with the FDA and to implement the INAD process. New sources of funding such as user fees and private funds should also be sought. For example, fish stocked by government agencies for restoration and sport and commercial fishing generate direct expenditures of $34 billion and a total economic value of $88.5 billion annually by one estimate (see Schnick 1992). These industries could contribute to the costs of new drug approvals through user fees. Other ways may be found to entice pharmaceutical companies to register new drugs for aquaculture. Changes in FDA's registration/approval procedures, such as crop grouping in approval of drugs, may be possible in some instances.

3. Priorities for New Drugs

A list of needed compounds for finfish was compiled by the FWS (Schnick 1992) and for shrimp aquaculture by Williams and Lightner (1988). The JSA Task Force on Quality Assurance is also developing a list of high priority compounds. Stoddard (1990) recommended that more detailed and accurate descriptions be placed on the labels of the therapeutants and chemicals available to aquaculture so that the product has a better chance of being used correctly.

4. Focus of Regulatory Efforts

The federal agencies should concentrate on human safety and use a risk management approach to identify and regulate drugs and chemicals that pose risks to human health. Under such an approach, FDA could exempt from regulation most the common substances listed as low regulatory priority drugs by FDA and use of many drugs and chemicals for broodfish, encourage research on and approvals of label extensions of approved drugs, and devote more resources to checking imported aquaculture products.

5. Industry-Government Coordination

The working relationships among JSA, FDA, EPA, USDA, FWS, the National Association of State Aquaculture Coordinators, and aquaculture producers (private and public) should be continued.

6. Information Exchange, Education

Expanded efforts conducted by industry associations and state and federal agencies directed at producers, consumers, and regulators will help to promote proper use of drugs and chemicals and understanding of quality assurance programs. For example, a producer guide on drug and chemical use in aquaculture is being prepared by the USDA Extension Service (Stefan 1993b).

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APPENDIX: GUIDEBOOK WORKSHOP PARTICIPANTS AND REVIEWERS

The production of this guidebook was a collaborative effort that included the authors, workshop participants and reviewers, and federal and Maryland state agencies that provided funds and facilities.

Many pieces of information for this guidebook already existed. However, the information needed to be brought together, analyzed, and presented in a readable and useful format. Preparation of the guidebook was undertaken by the authors. Information was collected via literature search, telephone calls, and meetings with industry, government, university, consumer, and other interest group representatives. Many of the federal and state offices concerned with aquaculture regulations provided information and reports from their office libraries.

The guidebook authors drew on the fisheries, aquaculture, and environmental communities, and on other interested people in conducting the analysis and preparing the guidebook. The centerpiece of this participatory approach was three workshops, one session each on fisheries industry, environmental effects, and aquaculture industry concerns about aquaculture regulation. Workshop participants from around the country reviewed a draft of the guidebook and discussed aquaculture regulatory issues. Workshop participants included or represented:

- *Aquaculture industry workshop*: aquaculture producers, an industry association, the National Association of State Aquaculture Coordinators, and state government aquaculture offices.
- *Fisheries workshop*: commercial and recreational fishing groups and their representatives, state and federal resource agencies, and university scientists.
- *Environmental impact workshop*: state and federal regulatory agency representatives (state departments of environment, U.S. Environmental Protection Agency, U.S. Food and Drug Administration), the National Sea Grant College Program, university scientists, and environmental group representatives.

A cross-section of staff at federal and state agencies, industry associations, national and regional fisheries associations/councils, and universities reviewed and marked up the penultimate draft of the guidebook. The reviewers and workshop participants served as a peer review and as a guidebook user check on the quality, completeness, and appropriateness of the guidebook. Many of their suggestions were included in the guidebook.

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AQUACULTURE WORKSHOP MAY 20

Sebastian Belle, Connors Aquaculture, Inc., Eastport, ME
Jack Boettcher, Texas General Land Office
David Erickson, Clear Springs Foods, Buhl, ID
Mike Freeze, Keo Fish Farm, Keo, AR
John Manzi, Atlantic Farms, James Island
Joe McCraren, National Aquaculture Association
John Pitts, Washington State Dept of Agriculture
Dennis Walsh, Aquaculture Research Corp. Dennis, MA
Hugh Warren, Catfish Farmers of America
Henry Parker, USDA

FISHERIES WORKSHOP MAY 21

W. Pete Jensen, Maryland Department of Natural Resources
Corky Perret, Louisiana Department of Wildlife and Fisheries
H. Randall Robinette, Mississippi State University
Ron Rogness, National Fisheries Institute
Carl Sindermann, Cooperative Oxford Laboratory, NMFS

Representatives from USFWS and sport fishing associations invited but could not attend.

ALL WORKSHOPS

Brad Powers, Maryland Department of Agriculture
Eric May, Maryland Department of Natural Resources
Malcolm Meaburn, NMFS, Charleston Lab
Michael Rubino, Bluewaters, Inc., Bethesda, MD and Columbia, SC
Charles Wilson, Bluewaters, Inc. and Louisiana State University

OTHER REVIEWERS

John Corbin, Hawaii Dept. of Land and Natural Resources
Thomas Hopkins, Biometrics, Inc., Gaithersburg, MD
Gary Jensen, USDA
James McVey, National Sea Grant College Program
John Nickum, USFWS

THE AUTHORS

MICHAEL C. RUBINO

Dr. Rubino is President of Bluewaters, Inc., a natural resources and aquaculture company with crayfish production facilities near Charleston, South Carolina and an office in Bethesda, Maryland. He is also a partner in Palmetto Aquaculture, a shrimp farming company in South Carolina. He served as Vice Chairman of the State of Maryland's Aquaculture Advisory Committee and has worked on aquaculture and other business ventures in the Caribbean and in other parts of the world. Dr. Rubino has been a consultant to the International Finance Corporation (World Bank) and earlier conducted analyses of environmental regulatory policies for federal and state agencies and private companies. He received a Ph.D. in Natural Resources (Economics) from the University of Michigan.

CHARLES A. WILSON

Dr. Wilson is a partner in Bluewaters, Inc. and the co-founder of Palmetto Aquaculture. As an Associate Professor of Marine Science at Louisiana State University, he has designed and implemented commercial and recreational fisheries programs for many important species, the successful "rigs to reefs" program of converting oil rigs into artificial reefs, and has undertaken many fisheries and shellfish research programs. He has worked on aquaculture and fisheries assignments around the world, published widely in the field, and serves as a reviewer on several academic journals. Dr. Wilson received a Ph.D. in Marine Biology from the University of South Carolina.