Integration of Aquaculture into U.S. Ocean Policy

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Introduction: The United States Aquaculture Society (USAS) is a chapter of the World Aquaculture Society (WAS). WAS is an international, not-for-profit organization of nearly 2,300 members from 91 countries and is associated with other aquaculture associations, such as the Caribbean Aquaculture Society, the Asian Fisheries Society, the Aquaculture Association of Canada, the Korean Aquaculture Society, the European Aquaculture Society, and the Aquaculture Association of South Africa. The vision of the WAS (strategic plan 2000) is to "contribute to the progressive and sustainable development of aquaculture throughout the world" "through its commitment to excellence in science, technology, education, and information exchange".

As a chapter of WAS, the USAS follows a similar vision within the United States of America. The mission of the USAS is "to provide a national forum for the exchange of timely information within the U.S. aquaculture community through workshops, meetings, educational programs, and publications". The USAS has a total of 700 members working in academia, government agencies and industry.

The USAS recommends that the Commission recognize the following:

1. Fish (e.g., seafood-both freshwater and marine) is a vital source of food (high quality protein) for people and has substantial social and economic value. And, that aquaculture is a major source for fish and other aquatic organisms.

    - This was recognized at the Earth Summit in Rio de Janeiro in 1992 under Articles 17-18 of Agenda 21, which provide for the development and management of fisheries and aquaculture in the context of the oceans and the freshwater environment (http://www.un.org/esa/sustdev/agenda21text.htm).

    - Fish is man's most important single source of high-quality protein and provides ~16% of the animal protein consumed by the world's population (FAO 1997). This is particularly true where livestock is relatively scarce; however, in North America and Europe, it accounts for <10% of animal protein (FAO 2000).

    - The value of fish traded internationally was estimated at US$ 51 billion per annum (FAO 2000) and over 36 million people were employed directly through fishing and aquaculture. Consumption of food fish has increased from 40 to 86 million metric tons from 1970 to 1998, mainly due to growth in human populations in Asia, Africa and South America, rather than changes in per capita consumption (FAO 2000). FAO (2001) reported that "world production of fish, shellfish and other aquatic animals increased from 117 million metric tons in 1998 to 125 million metric tons in 1999. Aquaculture increased by 2 million metric tons to reach 32.9 million metric tons in 1999". Tidwell and Allan (2001) recognized the importance of these data as illustrating that "a consistent source of fish is essential for the nutritional and financial health of a large segment of the world's population".

- According to the FAO Annual Report: The State of Food and Agriculture 2001 (FAO 2001), while the United States is the world's fourth major exporting country it is the second biggest importer of fish and fishery products, accounting for 16 percent of the total in 1999. According to United States Department of Agriculture, in 2000 roughly 45% of U.S. seafood consumption came from imports and 20% of total seafood consumption was due to shrimp (Harvey 2002). Harvey further states that the "value of farm-raised shrimp, Atlantic salmon, and tilapia imported to the United States ($2.7 billion) was about $400 million greater than the value of the broiler, other chicken, and turkey products exported". He cites the U.S. poultry industry as the world's largest exporter, valued at $2.3 billion in 2001. Overall, in 2000, the U.S. imported more than $10 billion ($1 billion more than 1999) in seafood and exported $3 billion, leaving a **trade deficit of $7 billion**. Imports come from over 60 countries.

- According to a report published by the National Fisheries Institute (http://www.nfi.org/news/story.php?storyid=2002/4/22/13), Americans will eat one billion more pounds of seafood (or just over 11 billion pounds) in the year 2025. This assumes that per-capita seafood consumption remains level at 15.6 pounds and population growth is steady. The statement comes from industry consultant Howard Johnson (H.M. Johnson & Associates).

- According to data from the 1998 Census of Aquaculture conducted by the U.S. Department of Agriculture, National Agricultural Statistics Service (NASS 1999), the value of aquaculture products sold in the U.S. grew from $45 million in 1974 to over $978 million in 1998. Food fish dominated sales at nearly $692 million followed by ornamental fish ($69 million) and baitfish ($37 million). Catfish dominates sales and in 2001 farm sales to processors totaled 597 million pounds and total sales were estimated at $443.4 million (Harvey 2002).

  The U.S. aquaculture industry includes food fish, bait fish, shellfish, ornamental fish and others species like seaweed and alligators (Cicin-Sain *et al.* 2001). While the total production in 1997 was 768 million pounds, the major marine species (salmon, oysters, clams, mussels and shrimp) accounted for less than 10 percent. U.S. aquaculture was only 2% of worldwide aquaculture.

2. The development of aquaculture in the U.S. is in the national interest and requires a national policy. Development of marine aquaculture requires the integration of aquaculture into an overall coastal and ocean policy that respects the rights of states and local communities.

- The huge U.S. seafood import volume very negatively affects U.S. food security, both in the area of feeding ourselves if imports are cut off and in the potential for bio-terrorism or food safety issues such as toxins and chemicals in imported foodstuffs. Dependence on overseas production can lead to dependence on others guaranteeing food safety and quality or requires increased monitoring by U.S. authorities.

- The National Aquaculture Act of 1980 (Public Law 96-362, 16 U.S.C. 2801, et seq.) recognizes the importance of aquaculture and established a national aquaculture development plan. It declared it to be "in the national interest" to have a national policy "to encourage the development of aquaculture in the United States". The National Aquaculture Act designates the U.S. Department of Agriculture as the lead agency and established an interagency aquaculture-coordinating group, the Joint Subcommittee on Aquaculture of the Federal Coordinating Council on Science, Engineering, and Technology within the Office of Science and Technology Policy. The 2002 Farm Bill (Farm Security and Rural Investment Act of 2002), which was signed on May 13, 2002, reauthorized the National Aquaculture Act as amended (16 U.S.C. 2809) through 2007.

3. As with all human activities, aquaculture has social, economic, political and environmental impacts. These impacts (both positive and negative) should be considered within the context of other activities, particularly alternative methods of supplying the increasing demand for seafood and other fishery products. Cooperation is needed at national, regional and international levels among sociopolitical and academic institutions and the fisheries and aquaculture sectors to achieve sustainable aquatic production, environment protection, and socioeconomic development.

- Seafood is a vital food source and provides income to large segments of the population. While marine capture fisheries have historically accounted for more than 80% of the world's fish supply, it is not keeping pace with the demand for seafood. Total landings from marine fisheries increased approximately five fold between 1950 and 1990, but increased only 9% between 1990 and 1997. During this same period fish consumption increased 31% (FAO 1999). About 47 to 50 percent of stocks are fully exploited, another 15 to 18 percent are overexploited, and 9 to 10 percent have been depleted or are recovering from depletion (FAO 2000). MacLennan (1995 [cited in Tidwell and Allan 2001]) describes 70% of stocks as in need of urgent management.

  Fish remains the only important food source that is still primarily harvested from the wild rather than farmed (Tidwell and Allan 2001), but sustainable harvests cannot continue to increase as fast as consumer demand. The U.S. must choose between being a consumer (i.e., importer) or a producer (i.e., exporter) of seafood, and aquaculture should play a major role in defining the options available. As U.S. farmers have reduced the amount of farmland required to produce food by intensifying production and increasing efficiency, so must U.S. aquaculturists.

- Mace (1997) contends that overcapacity in capture fisheries is the single most important factor threatening the long-term viability of exploited fish stocks and the fishing industries that depend on them. Effort needs to be reduced in most of our fisheries. In the USA, estimates of overcapacity vary from 0 to 75% depending on the fishery (Sissenwine and Swartz, 1992 [cited in Mace, 1997]).

- As with capture fisheries, aquaculture has environmental impacts, some of which are deleterious. The challenge for scientists and policy makers is to identify these impacts, and wherever possible, develop economically viable technical solutions. Goldburg *et al.* (2001) in their review for the Pew Ocean Commission cite five potentially negative aspects of aquaculture. These include 1) biological pollution (i.e., damage to native populations through competition, interbreeding, or spread of disease and parasites), 2) fish for fish feeds (i.e., use of fish meal in prepared diets), 3) organic pollution and eutrophication (i.e., nutrient loading associated with fish waste and uneaten feed), 4) chemical pollution (i.e., use of antibiotics, pesticides and herbicides), and 5) habitat modification. These issues are each addressed separately below.

1) Biological pollution: Within this category are potential problems associated with introduced, and even native, species on native fauna and flora, as well as the issue of trangenics or genetically modified organisms (GMOs). Several species are cited as examples of introduced species or native U.S. species being grown outside of their natural ranges. In addition, they include spread of diseases and parasites within this category.

It is important to understand how diverse aquaculture is and how important it is to not overly simplify and generalize. Over-simplification, especially in a policy-making process involving aquaculture, could have unintended and dramatic negative consequences on many rural, economically depressed communities in the U.S. For example, the majority of commercial aquaculture production in the U.S. is based on the production of native species grown within their natural range. The largest (by far) aquaculture sector in the U.S., catfish, raises Ictalurus punctatus in the Mississippi Delta, where this species is endemic. The baitfish industry developed in Arkansas because of the golden shiners found there. The history of the growth of both these industries is that, as declining local fisheries for these species were not able to meet the demand, entrepreneurs experimented with ways of culturing the same species to meet this traditional demand.

The history of the trout industry is somewhat different in that the major cultured species, Oncorhynchus mykiss was introduced to the U.S., not for aquaculture purposes, but for recreational fishing.

The culture species that has drawn the majority of criticism in terms of "biological pollution" is that of the Atlantic salmon. Rigorous and conclusive studies of the potential long-term genetic impacts of introducing Atlantic salmon to the west coast have not been done. Currently, only 9 commercial salmon farms exist in the state of Washington. The majority of salmon farms are located in Chile, Norway, Scotland, and other countries. Thus, the issue of "biological pollution" from introduced salmon stocks is far more of an international, not a U.S., issue. It would seem, then, that the greatest and most effective means of addressing this would be in an international forum.

Tidwell and Allan (2001) reviewed the issue of 'biological pollution' and specifically that of Atlantic salmon as raised by Naylor *et al.* (2000). Gross (1998 [cited in Tidwell and Allan 2001]) reviewed and analyzed the potential impacts-both positive and negative. He listed as positive benefits to wild stocks a reduction in pressure on stocks because of a shift in consumer preference from wild to farmed fish. He concluded that the current poor state of the wild salmon fisheries was caused by mismanaged capture fisheries and habitat destruction.

Currently, no GMO aquatic species are approved for commercial production in the U.S. The only production is experimental.

Goldburg *et al.* (2001) give several examples of diseases and parasites, which have been reported to have been spread by aquaculture, including Japanese oyster drill and sea lice. LaPatra (2002) states “the biological significance of aquatic animal pathogens in effluents is unknown. In general, most of these pathogens existed in aquatic populations either prior to or in the absence of aquaculture. Huge gaps exist in our knowledge regarding pathogen distribution in the environment, the environmental fate of pathogens and host susceptibility in aquatic ecosystems.” He furthers states that “federal, state, and tribal pathogen control programs exist and have existed for several years. The goal of these programs is to prevent the introduction of significant fish pathogens into the United States, specific states, regions or facilities. These regulatory control programs have been successful at limiting the introduction of important fish pathogens.”

In many farming operations, disease is a risk that is addressed through prevention of introduction and minimization of stress to the organisms-both plant and animal. Most diseases are ubiquitous and only occur when the organism becomes weak. In wild populations, disease often occurs and is undetected. Diseased or weakened animals are often selected as prey by an array of predators in the wild. In aquaculture facilities, fish are contained and therefore can be counted when moribund or mortality occurs. When diseases or parasites do arise, diseases can be treated and controlled through various methods.

2) Fish meal: This issue is sometimes described as “fish for fish feeds”. The concern is that as aquaculture production increases, so will the demand for fish meal, adding more pressure to existing stocks. Tidwell and Allan (2001) addressed the concern of Naylor *et al.* (2000) that aquaculture is ‘a contributing factor to the collapse of fisheries stocks world-wide’. They were able to demonstrate that while world aquaculture production has been increasing, world landings of pelagic fish used in fish meal production as well as fish meal production itself have remained relatively stable. They explained that market forces have simply reallocated the use of a fixed amount of fish meal. The large majority of fish meal is still used in other livestock feeds and as fertilizers. Since fish convert feed better than terrestrial livestock, this may be a more efficient use of this resource.

Tidwell and Allan (2001) also addressed the issue raised by Naylor *et al.* (2000) that certain aquaculture species, particularly salmon and shrimp, are net consumers of fish (i.e., require as much as 3 kg of fish in their feed to produce 1 kg of farmed fish). Citing Forster (1999), they explained that, based upon classic energy flow values, 10 kg of forage fish are required to produce 1 kg of wild carnivore (e.g., salmon). When by-catch is included, the total becomes 10-15 kg. When considered “*in toto*, aquaculture is a huge net producer, generating 3.5-4.0 kg of food fish for each kg of pelagic fish used in fishmeal production”.

Hardy and Tacon (in press) reviewed the history, trends and outlook for fish meal production and use. They predict that the use of fish meal will remain more or less constant, and that the proportion of fish meal used in feed formulations will decrease. They state that the “increasing efforts to reclaim protein from seafood processing by-product will increase the supply of fish meal by as much as 10%, enough to offset decreases in production associated with natural variation in landings and with cessation of fishing for stocks that have been depleted by over-harvesting."

3) Organic pollution and eutrophication: This includes excess nutrients, particularly nitrogen, from uneaten feed, urine and feces as well as other organics, such as mucus and dead fish. Eutrophication can be associated with over-enrichment from organic materials. While Goldburg *et al.* (2001) list eutrophication as a major problem in estuarine and coastal environments, they note that aquaculture's contribution is small and site-specific. As such, siting of aquaculture facilities and operations (as with any human activity) is crucial to the environmental sustainability of the activity. Under no circumstances does 'one size fit all'.

No animal utilizes 100% of its food and all therefore excrete wastes. Any waste that is not utilized or captured within an aquaculture facility and is discharged into the environment is strictly regulated by states and EPA. The Joint Subcommittee on Aquaculture (JSA) formed the Aquaculture Effluents Study Task Force (http://ag.ansc.purdue.edu/aquanic/jsa/effluents/index.html) in September 1999 to assist the Environmental Protection Agency (EPA) in developing regulations on aquaculture effluents. The task force was renamed the Aquaculture Effluents Task Force subsequent to EPA's decision, announced January 21, 2000, to promulgate national effluent standards for aquaculture operations.

The EPA rules (http://www.epa.gov/ost/guide/aquaculture/inforequest.html) are currently being developed and will apply to both freshwater and marine culture systems. Any additional regulatory effort should take into consideration both the federal EPA regulations as well as the state-level regulations. A recent survey showed that state agencies indicated that aquaculture effluents were not a problem except in a few specific cases. In these cases, existing regulations were adequate to address the problems. The U.S. Aquaculture Society has recently published a book (Tomasso 2002) that reviews the scientific knowledge base relevant to the issue of aquaculture effluents in the U.S.

As with any human activity, there are costs and benefits that must be weighed to determine the cost to benefit ratio and ultimately the value of each activity.

4) Chemical pollution: Chemicals typically listed as potential pollutants in aquaculture are antibiotics, parasiticides, pesticides, hormones, anesthetics, various pigments, minerals and vitamins. Concerns include potential effects on human health and on natural ecosystems.

The Global Aquaculture Alliance addressed the issue of antibiotic residues in seafood, particularly the antibiotics chloramphenicol and nitrofurans which are banned in most countries from animal food production due to their toxicity to humans (http://www.gaaliance.org/issu0.html). This article cites a recent study by the U.S. Geological Survey (2002), which analyzed water samples from 139 streams across 30 states and found the presence of antibiotics in 48% of the samples at combined levels of 3.6 ppb. The pervasiveness of the distribution demonstrates that chemical residues can be found in association with many human activities.

U.S. aquaculture currently has limited chemicals available for use on food fish or non-food fish and a variety of programs and regulations in place. Only two antimicrobials are approved and available for use in food fish production in the U.S. Producer quality assurance programs have been developed for major species grown in the U.S. and address practices to avoid residues and protect the environment. FDA's mandatory HACCP program for seafood processors includes raw product received from farms and requires accounting for use of drugs, chemicals and pesticides. Federal registration requirements for pesticides are currently undergoing re-registration based on stricter criteria and include an environmental risk assessment with safe use indicated on product label. Withdrawal periods for slaughter, livestock watering, or water draining may be found on specific products based on food safety and/or environmental risk concerns. The FDA approval process for drugs also includes an environmental assessment. Antibiotic use is dropping due to advances in vaccine development, loss of cost effectiveness and lack of therapeutic value.

5) Habitat modification: Based upon the 1998 Aquaculture Census (NASS 1999), U.S. aquaculture operations covered approximately 321,000 acres of fresh water while marine aquaculture occupied 64,000 acres (less than half a percent of the total state waters). As with any human activity, habitat use will be modified. Therefore, proper site selection is critical and its use should be fully evaluated for the costs/benefits. In many cases, aquaculture production will be less intrusive than wild harvests and other human activities.

The old adage of “if you build it, they will come” is sometimes true for aquaculture. The business of aquaculture requires the re-structuring of the environment to optimize growth and minimize stress on the animal, just as businesses develop an optimal environment for production. Because aquaculture does not work in a sterile environment, the aquaculture species is maintained in a “living” environment where selectivity of the environment determines the other occupants-plant, animal, etc. In other words, another habitat is created in which a new mixture of the old and new takes shape. In an open system, such as the ocean, and closed systems (e.g., ponds), this habitat modification can actually benefit the original occupants and attract new ones. Birds and other fish species tend to benefit from the change in habitat and readily available food source.

4. Aquaculture needs to be integrated into an overall national policy on coastal zone management and the oceans.

- Increasingly, aquaculture products are being produced in other countries to target the large U.S. seafood market. Unhampered by the degree of regulation that the U.S. aquaculture industry faces, these imported substitutes have driven prices down and caused economic damage in many communities in the U.S. Any policy developed with regard to our oceans must address the international aspects of environmental impacts produced in other countries as well as the negative economic impacts of lower-priced imported products on the U.S. economy.

- Integration of aquaculture into coastal management can contribute to improvements in selection, protection and allocation of sites and other resources for existing and future aquaculture development (FAO 1991). This report recognized that coastal zones are characterized by ambiguities of resource ownership and complex interactions among resources, ecosystems and resource users. To address these complexities and provide sustainable development, they suggested a framework of Integrated Coastal Management (ICM). They also recognized the vulnerability of aquaculture to pollution caused by other resource users.

- Cicin-Sain *et al.* (2001) called for appropriate planning and legislation to provide an overall plan for mapping, management, development and conservation within the U.S. Exclusive Economic Zone (EEZ). They also noted that under current law, federal agencies have limited, and often unclear, statutory authority with respect to offshore aquaculture. Key federal agencies currently involved in offshore marine aquaculture are: Army Corps of Engineers (permits for activities on or in U.S. navigable waters), EPA (permits for waste discharge), NOAA (management of U.S. fishery resources in EEZ), and USDA (lead agency for aquaculture). While no other nation appeared to have developed an explicit regulatory policy framework for their EEZs, several countries with considerable experience in offshore aquaculture (Norway, UK-Scotland, Ireland, Canada, Chile, Australia, New Zealand and Japan) were examined. They proposed a potential policy framework and recommended that this marine aquaculture policy be "flexible and responsive to industry changes, with simplified, well-coordinated regulatory processes and technically competent staff". The two major issues cited were 1) a mechanism for granting an aquaculture facility exclusive rights to the use of public open space and 2) environmental sustainability.

- Tidwell and Allan (2001) stated that "the best hope of providing fish to meet future demands will likely be coordinated partnerships of aquaculture, managed wild fisheries, and wise protection and management of coastal zones and ecosystems". These efforts demand a coordinated effort between federal and state agencies and industry.

5. Marine aquaculture faces many challenges and obstacles as a relatively new industry. Many of these require special attention from federal agencies and through additional funding.

- Technological: These include lack of producer experience as well as the need to develop new technologies for sustainability of existing production technology.

- Coastal and Ocean Use Conflicts: These include competing with existing users as well as development along coastal areas.

- Environmental: Aquaculture is often impacted by environmental degradation caused by other users, as well as its own impact.

- Legal and Regulatory: No formal framework exists for leasing and development of private commercial aquaculture activities in public waters (Cicin-Sain *et al.* 2001). State laws and regulations lack uniformity among states and often require numerous permits, licenses and certifications that are difficult to obtain. The regulatory plans of states usually do not satisfactorily balance economic development and environmental protection.

- Financial: Businesses must compete with established ones working in other countries, which may have "substantial subsidies, lax regulations or cheap labor costs" (Cicin-Sain *et al.* 2001). Availability of capital in another problem because of banks' and financial institutions' requirements for loans.

6. The development and sustainability of marine aquaculture requires a sound scientific foundation, human resource capacity building, and open communication both at a national and international level.

- To insure that aquaculture is economically and environmentally sustainable under a variety of conditions and diversity of species grown, research is vitally important. The U.S. government, along with states, should support research and development in fisheries, aquaculture, and the environment to meet the challenges of industry sustainability and globalization, ecosystem protection and rehabilitation, as well as contribute to the welfare of their citizens. Aquaculture industries must also play a role by embracing the world's best practices and developing codes of practice that minimize potential negative impacts of aquaculture.

- Enhanced capabilities in science and technology, resources management, and people empowerment are needed to meet the challenges of fisheries and aquaculture sustainability, environment protection, and globalization

- Much of the development and implementation of a national policy requires a forum for discussion and dissemination of scientific knowledge and technologies appropriate for sustainable development of marine aquaculture. The U.S. Aquaculture Society's mission falls within this domain and provides an appropriate venue for a balanced discussion.

- As is currently being done in developing EPA effluent guidelines under the JSA's Aquaculture Effluents Task Force, the U.S. Aquaculture Society's membership provides a pool of experts from which to draw persons to assist in the formulation of policies, regulations, and bio-safety protocols.

- Any national policy should strengthen human resource development among fisheries and aquaculture professionals in the United States and emphasize gender and ethnic representation in capacity building.

- Any ocean policy should enhance global and regional cooperation and advocacy on fisheries, aquaculture, and environmental issues through better use of existing networks among professional organizations.

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