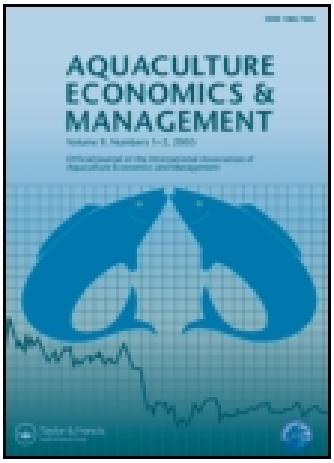

Aquaculture Economics & Management
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uaqm20

COMPETITIVENESS OF U.S. AQUACULTURE WITHIN THE CURRENT U.S. REGULATORY FRAMEWORK

Carole R. Engle [a] & Nathan M. Stone [a]
[a] Aquaculture/Fisheries Center , University of Arkansas at Pine Bluff , Pine Bluff , Arkansas , USA
Published online: 19 Aug 2013.

To cite this article: Carole R. Engle & Nathan M. Stone (2013) COMPETITIVENESS OF U.S. AQUACULTURE WITHIN THE CURRENT U.S. REGULATORY FRAMEWORK, Aquaculture Economics & Management, 17:3, 251-280, DOI: 10.1080/13657305.2013.812158

To link to this article: http://dx.doi.org/10.1080/13657305.2013.812158

Aquaculture Economics & Management, 17:251–280, 2013

ISSN: 1365-7305 print/1551-8663 online
DOI: 10.1080/13657305.2013.812158

Taylor & Francis
Taylor & Francis Group

COUNTRY/SUBJECT REPORT

COMPETITIVENESS OF U.S. AQUACULTURE WITHIN THE CURRENT U.S. REGULATORY FRAMEWORK

Carole R. Engle and Nathan M. Stone
Aquaculture/Fisheries Center, University of Arkansas at Pine Bluff, Pine Bluff, Arkansas, USA

□ *Increased attention has been paid in recent years to both positive and negative effects of increasing numbers of regulations on businesses in the United States. The decline in U.S. aquaculture has been attributed in part to increasing volumes of imports and high feed prices. However, there is increasing concern that the U.S. regulatory environment, as compared to that of international competitors, may also have contributed to this decline. More than 1,300 laws apply to U.S. aquaculture and even though the majority has been issued by individual states and apply only to specific types of aquaculture businesses in that state, the cumulative regulatory burden has increased over time. Major compliance categories include: 1) environmental management; 2) food safety; 3) legal and labor standards; 4) interstate transport of aquatic products; 5) fish health; and 6) culture of commercially harvested species. A substantial portion of the regulatory burden is the managerial and labor time spent on compliance in addition to the direct cost increases. The streamlined one-stop process adopted in Norway appears to have allowed growth of aquaculture within a comprehensive regulatory framework, yet the lack of such a streamlined approach in the United States appears to have contributed to the decline of existing industries and to serve as a deterrent to investment in newly emerging technologies. Favorable regulatory environments in countries that export to the U.S. contrast sharply with the increasingly inefficient, cumbersome and/or restrictive U.S. environment. Such disparities have created competitive disadvantages for U.S. producers. Attention is needed by policy makers to search for streamlining mechanisms and by the scientific community to address the growing competitive disadvantage to U.S. aquaculture to respond to increased global demand for farmed seafood.*

Keywords aquaculture regulations, competitiveness, U.S. aquaculture, U.S. regulations

INTRODUCTION

Concerns over the effects of state and federal regulations on the economic viability of U.S. aquaculture have been documented for many years (National Research Council, 1978). However, in more recent years,

Address correspondence to Carole R. Engle, Aquaculture/Fisheries Center, Mail Slot 4912, University of Arkansas at Pine Bluff, 1200 N. University Drive, Pine Bluff, AR 71601, USA. E-mail: cengle8523@gmail.com

increasing attention has been paid to the effects of an increasingly strict regulatory environment on the broader U.S. economy (Gray, 1987). Crews (2011) reported that the number of new final rules issued by the federal government in 2010 increased to 3,573 as compared to 3,503 new final rules issued in 2009. An estimated 9.80 billion hours were spent in 2010 by the public, who responded to federal register notices requesting information on proposed new regulations (Office of Management and Budget, 2012). In 2011, the U.S. government published 165,000 pages of federal regulations for businesses in the U.S. with the greatest year-to-year increase in regulations (55%) in the Department of Agriculture.

Crain and Crain (2010) estimated that federal government regulations cost an estimated $1.75 trillion dollars in 2008, or 14% of U.S. national income. The "hidden taxes" associated with federal regulations were estimated to represent 50.7% of total federal spending, exceeding $1 trillion per year (Crews, 2011). Estimates of increased costs due to new agricultural regulations include: 1) $500 million (assuming that products were 90% safe prior to new regulations) to $5 billion (assuming products were 50% safe prior to new regulations) from new food safety regulations (Antle, 2000); 2) $830 million as a result of new regulations of confined animal feedlot operations by the Environmental Protection Agency (Kaplan et al., 2004); and 3) $2.2 billion in increased operating costs from the total suite of regulations faced by agricultural producers in California (Hurley & Noel, 2006).

The United States is not the only country with growing concerns over the regulatory environment for aquaculture. Burdens associated with the regulatory and legal environment were identified as major constraints to development of aquaculture in the European Union (Directorate-General for Internal Policies, 2009). The European Union acknowledges that its global competitiveness will require "better regulation, including: . . .legislative simplification and reducing the administrative burden . . . ensuring proper stakeholder participation and consultation, as an essential component of better regulation and better governance" (Directorate-General for Internal Policies, 2009, p. 9). Australia developed an Aquaculture Regulatory Reform Task Force to address similar concerns (Harris, 1998). Hughes et al. (2004, p. 1) discussed the "unnecessarily complex array of legislation and agencies that constrain aquaculture development in Australia." New Zealand re-vamped its zoning regulations that were stifling growth of aquaculture and set a goal of increasing aquaculture production (Stewart, 2012).

The objectives of this article are to: 1) briefly review the literature on the effects of regulations on U.S. businesses; 2) describe several types of regulations that affect U.S. aquaculture; and 3) examine effects of the regulatory environment on U.S. aquaculture and its competitiveness. The intent of this article is to bring attention to the fact that the competitiveness of U.S. aquaculture is reduced by the regulatory environment in the U.S. It

is also a call for attention by policymakers to streamline the regulatory system in the U.S. and for scientists to increase research efforts on the efficiency and costs of the U.S. regulatory system.

EFFECTS OF REGULATIONS ON U.S. BUSINESSES

Government regulations are developed over time in response to a society's desire to provide oversight over businesses and to reduce the spillover effects from externalities that cause harm to other citizens. In the U.S., the responsibility for creating federal laws lies with the legislative branch of the federal government, the U.S. Congress. Members of the U.S. Congress do so in response to interests of society as expressed by each member's constituents. These laws then typically require that the relevant agency promulgate regulations within the agency's established authority (Dudley & Brito, 2012). Regulations exist in different forms that affect businesses in a variety of ways (Hale et al., 2011). The growing volume of research on the economic effects of regulations documents both positive and negative effects.

Some degree of government oversight is necessary to create and maintain the rule of law and political and economic stability. Unstable governments and economies can create levels of risk that are greater than what many entrepreneurs consider acceptable (Hishamunda et al., 2012). Other positive effects may occur when regulations provide options for productivity-increasing changes. Porter and Van der Linde (1995) assert that environmental regulations can result in innovations that enhance an industry's competitiveness. Other regulations can create market incentives (Buttel, 2003) or improve marketability of products (Hurley & Noel, 2006). Subsidies have been used to create financial incentives for businesses to adopt certain practices deemed more desirable than others and to minimize negative economic effects. In other cases, regulations have generated cost savings by improving worker safety (Hurley & Noel, 2006). Such innovations can mitigate costs associated with new regulations (Colyer, 2004).

Regulations can have demonstrable positive benefits to society by providing governmental oversight for environmental conservation of public resources. For example, benefits from the Clean Water Act were estimated to be approximately $11 billion per year, although these estimates applied only to a subset of surface waters and pollutants (RTI, 2000a, 2000b). If extended to all waters of the United States and all pollutants, the benefits would exceed the annual costs estimated to have been incurred from the Clean Water Act.

However, there is a much greater volume of research that has documented negative effects of increased regulations. These negative outcomes result from a variety of different types of economic effects on businesses

(Hurley & Noel, 2006). The first and most direct effect is the increased cost of production that occurs as businesses adjust practices to comply with the new regulations. For example, a rule that imposes fees, testing, more expensive inputs or mandates less efficient production practices will result in increased costs of production (Buttel, 2003). Hurley et al. (2006) found that chemical use fees increased by 125% and air quality fees by 940% from 1999 to 2004 in California agriculture. Costs associated with air quality, chemical use, and workers' compensation had all more than doubled from 1999 to 2004.

The largest fee paid by agricultural growers in California was associated with water quality. In an economic analysis of orange farming in Southern San Joaquin Valley, California, regulations were shown to increase the probability of losing money (Noel et al., 2008). In addition to these direct operating cost increases, regulations that require capital investment in new equipment or treatment structures will increase capital and fixed costs. Palmer et al. (1995) demonstrated negative effects on competitiveness of U.S. industry when environmental standards were tightened. Thus, the analysis of regulations should include costs and benefits that delineate comprehensively the negative effects on U.S. industries as well as the beneficial outcomes to society in the form of clean water, clean air and safe food.

Nearly all new regulations create a time burden for managers. Managers must spend time attending workshops and meetings to understand the new rules, determine whether new regulations are applicable to their businesses, determine what changes will be necessary and decide what options are best. The costs of managerial time spent on new regulations can be either cash or non-cash costs (Hurley & Noel, 2006). If additional personnel must be hired, the cost becomes a cash cost, but if existing managers take on these tasks, a non-cash, opportunity cost is incurred (Hurley & Noel, 2006). Compliance with regulations requires workers to spend more time on paperwork for record-keeping (Coppock, 1996), reporting, and training. This time spent by both employees and management is time that could have been spent on other activities for the company (Hale et al., 2011) and imposes opportunity costs in the form of lost marketing or production opportunities.

However, the overall effect on an industry extends beyond the farm-level costs. With the increased importance of international trade and agreements, the effects of increased costs relative to those of trading partners can have substantial effects on competitiveness of U.S. industry. In fact, such relative cost differentials with domestic and imported competing products may be as important as the absolute increase in costs. For example, Metcalfe et al. (2002) found that increased costs from environmental regulation of the U.S. pork industry might not have a substantial effect if their major EU competitors develop even more stringent regulations. Such effects would also

work in the opposite direction. If the major competitor is a developing country with a poorly developed regulatory and enforcement infrastructure, even small increases in cost of a domestic industry might substantially reduce its competitiveness by increasing the relative cost differential.

Innovation can be stifled through increased regulation (Hale et al., 2011). This stifling effect has been attributed to several factors. First, the time spent on compliance and conforming with regulations can reduce the amount of time available for innovations that might improve efficiency and reduce risks. Second, regulations often are unclear. It can be difficult for a business to identify whether the regulation applies to their company and then to determine which compliance options are feasible. Finally, the uncertainty involved with many new regulations can undermine the ability of businesses to manage risk (Hale et al., 2011).

Effects on productivity occur in a similar way (Christiansen & Haveman, 1981; Hazilla & Kopp, 1990). Command-and-control types of regulations impose production practices that are not always the most efficient and may even be outdated (Hale et al., 2011). Such regulations reduce productivity and competitiveness. Some regulations have unintended consequences. For example, Esseks et al. (1998) found that devaluation of land that resulted from regulations affected farm balance sheets and credit capacity.

Finally, there are effects from the cumulative suite of regulations. Hurley and Noel (2006) point out the paucity of research on the cumulative effects of the "basket of regulations" faced by farmers and called for examination of the total effect of all relevant regulations on individual growers and their industries. Further evidence of the effects of the proliferation of new regulations is the recent set of Executive Orders from the White House that address the need for regulatory reform, specifically three executive orders that focus on "Improving Regulation and Regulatory Review" (Federal Register, 2011a), "Regulation and Independent Regulatory Agencies" (Federal Register, 2011b), and "Identifying and Reducing Regulatory Burdens" (Federal Register, 2012). Hale et al. (2011, p. 29) argued that processes for retiring old regulations are not often used:

> One reason for the proliferation of regulations is that effective mechanisms for reviewing and streamlining them are used infrequently. Such review can be forced by having 'sunset provisions' limiting regulations' lifespans unless agencies renew them, or review can be compelled by congress. Agencies may also decide to review their own regulations periodically, as is currently being done by Environmental Protection Agency.

However, the problem may be more that there is no one systematic and efficient process to re-examine and eliminate regulations over time. Hale et al. (2011) further argued that regulations that are focused on outcomes

and designed to allow companies the flexibility to work through the most effective solutions for their company will be more effective than those that mandate specific processes.

Several studies have shown disproportionately greater negative effects on small businesses than on larger firms (Crain & Crain, 2010). These include 36% higher costs on smaller businesses than on large firms (Crain & Hopkins, 2001) and were estimated to be $10,585 per employee. Similar effects were found in agriculture (Carter et al., 2002). In addition to higher costs, middle-income producers paid higher percentages of income to comply with regulations than did larger producers, although the majority of the costs of regulation were paid by high-income producers (Hurley & Noel, 2006). Regulations also create barriers to entry for smaller firms and lead to increasing concentration of larger firms (Jones & Graf, 2001).

AGENCIES, REGULATIONS, AND COSTS THAT AFFECT U.S. AQUACULTURE

In the United States, regulations are embedded in the fabric of U.S. society and affect aquaculture production and marketing in a variety of ways (Aspen Systems Corporation [ASC], 1981; Bye, 1990; Rubino & Wilson, 1993; Ewart et al., 1995; Brennan, 1999; Duff et al., 2003; NOAA, 2010). Aquaculture in the United States has developed during an era of a well-established regulatory environment for businesses. U.S. aquaculture growers face a broad and complex suite of regulations from both federal (Table 1) and state agencies as well as local jurisdictions. These can be categorized as: 1) environmental; 2) food safety; 3) legal and labor standards; 4) interstate transport of aquatic products, 5) fish health, 6) culture of commercially harvested species as well as the increased record-keeping and compliance burden of regulations (Table 2). The inherent overlap, redundancy and duplication of regulations and the corresponding enforcement authorities are evident in Table 2.

Federal environmental regulations that affect U.S. aquaculture were promulgated through laws passed by the U.S. Congress to enhance environmental management and sustainability. U.S. regulations related to environmental management in U.S. aquaculture have tended to be of the command-and-control type rather than using market-based approaches. Command-and-control approaches (such as EPA's effluent standards that mandate, by specific Congressional directives in the Clean Water Act, specific technologies) for some aquaculture segments tend to increase costs without necessarily achieving the desired environmental benefits (Engle & Wossink, 2008).

Food safety in the United States is regulated primarily by the Food and Drug Administration (FDA) with the exception of beef and poultry

TABLE 1 Major Federal Statutes and Regulations that Affect U.S. Aquaculture

Title of statute or regulation	Code
Statute	
Animal Health Protection Act	7 U.S.C. § 8301-8321
Coastal Zone Management Act, 1990 and 1996 Amendments	16 U.S.C. § 1451-1466
Columbia River Basin Fishery Development Program	16 U.S.C. § 835-835 m
Commercial Fisheries Research and Development Act	16 U.S.C. §§ 742, 779
Endangered Species Act	16 U.S.C. §§ 1531–1544
Federal Insecticide Fungicide and Rodenticide Act (FIFRA)	7 U.S.C. §§ 136–136y
Federal Water Pollution Control Act (aka, Clean Water Act)	33 U.S.C. §§ 1251–1387
Fish and Wildlife Coordination Act	16 U.S.C. § 661–667d
Federal Food, Drug, and Cosmetic Act	21 U.S.C. §§ 301–397
Interjurisdictional Fisheries Act	16 U.S.C. §§ 742c, 779, 4001
Lacey Act	18 U.S.C. §§ 41–48
Lacey Act Amendments	16 U.S.C. § 3371–3378
Magnuson-Stevens Fishery Conservation and Management Act	16 U.S.C. § 1801–1891d
Marine Mammal Protection Act	16 U.S.C. §§ 1361–1423 h
Marine Protection, Research, and Sanctuaries Act of 1972	16 U.S.C. §§ 1431–1445
National Aquaculture Act of 1980	16 U.S.C. §§ 2801–2810
National Environmental Policy Act of 1969	42 U.S.C. §§ 4321–4370f
Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990	16 U.S.C. § 4701–4751
Outer Continental Shelf Lands Act	16 U.S. § 1456–1466 43 U.S.C. § 1331–1356
National Aquaculture Improvement Act	
Rivers and Harbors Act of 1899	33 U.S.C. § 403
Regulations	
Coastal Zone Management Act	15 C.F.R. §§923.1–923.135
Federal Food, Drug, and Cosmetic Act	21 C.F.R. Parts 1–99
Federal Insecticide Fungicide and Rodenticide Act (FIFRA)	40 C.F.R. parts 150–180
Federal Water Pollution Control Act (aka Clean Water Act)	40 C.F.R. Parts 104–424
Lacey Act	50 C.F.R. §§ 14.1–14.225
Endangered Species Act	50 C.R.R. §§ 1531–1544
Marine Protection, Research, and Sanctuaries Act of 1972	50 C.F.R. §§ 18.1–18.129
National Marine Fisheries Service (Shellfish)	50 C.F.R. Part 260
Magnuson-Stevens Fishery Conservation and Management Act	50 C.F.R. Part 300
Animals and Animal Products	C.F.R., Title 9
Marine Mammals Protection Act	16 U.S.C. § 1361

Source: National Agricultural Law Center (2012).

products that are regulated by the USDA Food Safety and Inspection Service (USDA-FSIS). U.S. aquaculture growers face higher costs due to the absence of adequate veterinary products and due to the competitive disadvantage of apparent widespread use of antibiotics in developing countries (Love et al., 2011). The lack of equivalent food safety standards for product imported from developing countries with those in the United States has constituted an ongoing policy debate in the United States. Partially in response, FDA has employed comparability of food safety systems in New Zealand and Canada that apply to regulations and has increased

TABLE 2 U.S. Federal and State Regulations that Restrict U.S. Aquaculture Production and Increase Costs

Issue/Concern/Standard	Regulatory Agencies
Environmental Sustainability	
Effluent management • Water quality regulations that enforce the Clean Water Act	• Environmental Protection Agency (EPA) • State Departments of Environmental Quality
Water Use • Ground/surface water appropriation • Tidal wetlands • Non-tidal wetlands • Submerged land leases • Water column leases • Well construction • Pond construction • Waterway construction • Water quality certification	
Biodiversity protection from Aquatic Nuisance Species • Regulates interstate shipment of live fish • Regulates imports of live fish	• U.S. Fish & Wildlife Service (USFWS) • U.S. Environmental Protection Agency (EPA) • State Natural Heritage Commission
Migratory birds and predators • Regulates migratory birds • Regulates predators	• U.S. Fish & Wildlife Service (USFWS) • State Departments of Natural Resources • Animal and Plant Health Inspection Service (APHIS) Wildlife Services
Endangered species • Regulates siting of facilities	• EPA • National Oceanic and Atmospheric Administration (NOAA)
Control of escapes & exotic species • Regulates possession of species • Prohibits stocking fish into wild • Controls importation and interstate transport of non-native animals and plants	• U.S. Fish & Wildlife Service • State Departments of Natural Resources/ Game and Fish Agencies
Wetlands conservation • Regulates wetlands and permitting	• Natural Resources conservation Service (NRCS) • U.S. Army Corps of Engineers
Storage & disposal of farm supplies • Regulates agricultural chemicals, fuel/oil, their storage, and solid waste disposal	• State departments of agriculture • State departments of environmental quality l/oil and solid waste disposal
Food Safety	
Drug and chemical management • Regulation of manufacture and distribution of food additives and drugs for animals, including fish. • Regulation of animal feed products, to ensure safe feeds. • Regulation of pesticides and their application on farms.	• Food and Drug Administration; Center for Veterinary Medicine • State Departments of Health • State Departments of Agriculture
Food safety: microbial sanitation • Mandatory safety program for all fish and fishery products. • Inspection of fish processing establishments, including the condition	• Department of Commerce • NOAA Hazard Analysis of Critical Control Points (HACCP) program to ensure that plant meets Food and Drug Administration (FDA) requirements.

(*Continued*)

TABLE 2 Continued

Issue/Concern/Standard	Regulatory Agencies
of product, the equipment, the manufacturing process, hygienic practices, sanitation, and labeling of product.	
Legal and Labor Standards	
Administrative and Jurisdictional Overlap	
Property rights & regulatory compliance. • Regulates siting of facilities • Regulates ownership of product	• U.S. Corps of Engineers • U.S. Coast Guard • National Marine Fisheries Service • Gulf of Mexico Fisheries Management Council
Leasing, Tenure, and Permitting Policies: Private and Public Rights	
Land use	
Business permits	
Worker safety & employee relations • Occupational Safety and Health Administration	• Occupational Safety and Health Administration (OSHA) • State Departments of Labor • U.S. Immigration and Customs Enforcement (ICE) Agency
Interstate Transport of Product	
The Lacey Act	• U.S. Fish & Wildlife Service • State Departments of Natural Resources/ Game and Fish Agencies
Lack of clear state regulations	
Inconsistent state regulations	
Fish Health	
Interstate transport of fish and inspection	• State Departments of Natural Resources • State Departments of Agriculture • Animal Plant and Health Inspection Service (APHIS) • U.S. Fish & Wildlife Service
Lack of Diagnostic Support	
Management and Response to Disease Outbreaks • Regulates fish diseases • Imposes quarantines	• Animal Plant and Health Inspection Service (APHIS) • U.S. Fish & Wildlife Service (USFWS)
Animal health and drug and chemical use • Restrictive policies on use of pharmaceuticals	
Culture of Commercially Harvested Species	
Market and Processing • Reduce market opportunities • Wholesale Fish Dealers • Retail Sales License • Processing/Food establishments • Fee fishing (pay lakes) licenses • Shellfish depuration	• State Departments of Health
Production Permits • Aquaculture permit • Importation (shipping)	

(*Continued*)

TABLE 2 Continued

Issue/Concern/Standard	Regulatory Agencies
• Species permits • Propagation/possession permits • Collection permits • Stocking permits	
Possession, Ownership and Sale (from Rubino & Wilson, 1993)	
Records and Compliance	
Record-keeping requirements • Purchases • Sales records • Pesticide application records • Bird depredation orders • Aquatic herbicides • NPDES effluent monitoring records	• Environmental Protection Agency • Animal Plant and Health Inspection Service (APHIS) • U.S. Department of Agriculture Farm Services Agency • State Departments of Environmental Quality • State Departments of Agriculture

training in developing countries on compliance to U.S. regulations even though it does not recognize equivalence.

A variety of legal and labor standards apply to aquaculture and include: 1) administrative and jurisdictional overlap; 2) property rights; 3) leasing, tenure, and permitting policies; 4) land use; 5) business permits; and 6) worker safety and employee relations. Of these, property rights are one of the most important issues, particularly for aquaculture in marine and coastal areas. This is because land under the water is generally owned by the state for three miles off the coast[1], but jurisdictional authority is not always clearly defined. Local zoning, shoreline master plans, and local permits are required in many cases.

As an example of the complexity involved, the key permit requirement in state or federal marine waters is the U.S. Army Corps of Engineers permit (authorized under the Rivers and Harbors Act and/or the Clean Water Act). The USACE permit then triggers consultations with the National Marine Fisheries Service, and the U.S. Fish & Wildlife Service related to the Endangered Species Act, Essential Fish Habitat, and the Marine Mammal Protection Act. For large finfish operations, an EPA National Pollutant Discharge Elimination System (NPDES) permit is also required. The USACE permit also triggers a National Environmental Policy Act (NEPA) assessment that includes an Environmental Impact Statement, an Environmental Assessment, and a Coastal Zone Management consistency review.

Aquaculture businesses with markets across the U.S. transport their live and processed products to many states. The lack of clear and consistent state regulations has resulted in delays, increased costs, and impoundment of live fish hauling trucks. Interstate transport of live aquatic products is

governed on the federal level by the U.S. Fish & Wildlife Service (USFWS) through the Lacey Act, and separately by individual state departments of natural resources and game and fish agencies (Table 2). The Lacey Act was passed originally to prevent hunters from selling game animals in other states (Rumley, 2012). However, in recent years, the Lacey Act has been used increasingly for reasons that extend beyond its original purpose (Rubino & Wilson, 1993).

There are two broad ways in which use of the Lacey Act has resulted in negative impacts to aquaculture farms. The first has been its use to prosecute farmers for violating state laws or regulations for not having paperwork completed properly. There is little provision in the Lacey Act for honest mistakes, and the consequences can be severe: up to 5 years in prison and/or a $500,000 fine for a fish farming business. The severity of penalties and absence of guidance on circumstances that trigger federalization of a state wildlife law have had a chilling effect on fish farmers (Rumley, 2012). The second way is to regulate species listed as injurious. In recent years, this provision has been used to ban interstate transport of live black carp (*Mylopharyngodon piceus*) and live bighead carp (*Hypophthalmichthys nobilis*). The total economic impact of the loss of the trade in bighead carp was $135 million/year (Engle & Stone, 2005). There are no national estimates of losses to all aquaculture from the listing of black carp as injurious under the Lacey Act.

Diseases of fish have historically been regulated by individual states with each state setting its own regulations. Authority for fish health and responsibility for fish disease regulations may fall to individuals with little training and time to attend to the issues that arise. It can be very difficult for fish farmers to easily access current state regulations or to identify individuals capable of answering questions related to that state's regulations in a timely manner.

At the federal level, the Animal Plant and Health Protection Service (APHIS) has been designated as the principal authority for fish diseases. However, the outbreak of spring viraemia of carp in North Carolina in 2002 resulted in involvement of the USFWS as well as APHIS, and demonstrated a lack of preparedness for such an event with an aquatic animal. Delays were incurred due to lack of protocols to make necessary decisions related to disinfection, indemnification, and criteria for allowing the farm to resume business. The delays resulted in costs of treatment and disinfection in addition to market share lost due to the lengthy quarantine of the farm.

In recent years, the National Aquatic Animal Health Plan (NAAHLN) and the federal National Aquatic Animal Health Task Force (APHIS, USFWS, NMFS) provide a structure to address disease outbreaks in a coordinated fashion with states and tribes. In 2012, in Washington, Alaska and the tribes, the Task Force coordinated: 1) a report to Congress; 2) research; 3) monitoring; and 4) contingency plans related to Infectious Salmon Anemia (ISA) reports in British Columbia. However, the ongoing impasse

over an appropriate course of action for Viral Hemorrhagic Septicemia (VHS) in the Great Lakes indicates that greater coordination is needed.

Culture of aquatic species that are also gamefish or harvested commercially from the wild become embroiled in a set of regulations that were developed initially to manage wild fisheries. When a private farmer wishes to culture such a species, that grower often faces a set of restrictions that have little applicability to their business (Rubino & Wilson, 1993). Some states still prohibit sales of farm-raised species that are considered gamefish even if raised exclusively on farms. Other states require costly tagging to identify farmed fish and prevent sales of poached or out-of-season fish (Table 2).

Each separate regulation and rule increases the record-keeping and compliance burden of aquaculture businesses. Examples of the types of records that are required for aquaculture growers include: records of purchases of supplies, sales records, volumes of fish transported, records of pesticides and herbicides applied, bird depredation and effluent discharges (Table 2). State Departments of Agriculture require training and record-keeping for use of restricted use pesticides. Given the many different types of regulations enforced by a wide array of different federal and state agencies, the total amount of records kept for compliance has escalated dramatically for U.S. aquaculture growers.

As a result of the complexity and overlap of U.S. regulations, oversight is fragmented with no overall federal framework (DeVoe, 1997). No one state or federal agency is charged specifically with authority over individual industries (Brennan, 1999)[2]. Rather, regulatory authority for all industries is spread across a variety of agencies. For aquaculture, USDA was designated as the lead agency for coordination and dissemination of national aquaculture information by the National Aquaculture Act of 1980. Although not designated as the agency for permitting and regulation of aquaculture, the USDA as chair of the Interagency Working Group on Aquaculture has fostered coordinated interagency actions to approve new animal drugs for aquaculture, develop science-based national effluent guidelines and standards and improve permitting of shellfish aquaculture operations. The National Aquaculture Act of 1980 further called for initiatives to clarify and adapt regulations to be appropriate for aquaculture (Public Law 96-362; Joint Subcommittee on Aquaculture [JSA], 1983), but this provision has not been implemented.

The Joint Subcommittee on Aquaculture (JSA) has reported periodically on permits and regulations that affect U.S. aquaculture. In 2009, the JSA listed regulations in 17 different agencies within the Departments of Agriculture, Commerce, Interior, Health and Human Services, and the Environmental Protection Agency.

However, the majority of regulations that affect aquaculture occur at the state level (JSA, 1983). Most states required between four and ten

permits/licenses for aquaculture, but New York and Texas each had more than 20 (JSA, 1995). Florida consolidated their permits/licenses to less than 20 in 2007. De Voe (1997) referred to more than 50 federal statutes with direct effects, 120 with indirect effects, and a total of 1,200 laws that affected aquaculture operations across all states. This represented a substantial increase over a 1981 report that identified 50 laws with direct effects and 70 with indirect effects (ASC, 1981). Although a given aquaculture business will need to contend only with the laws and regulations that apply in the state where the business is located and that are relevant to their specific business (i.e., laws that affect farms are different from those that affect processors), those farms that ship live fish across state lines will have to contend with laws in each state where they sell fish. Thus, the total regulatory environment has become increasingly complex. McCoy (2000) concluded that "aquaculture may be the most highly regulated industry in America" (cited in Duff et al., 2003, p. 20). Bartley et al. (2007) provide additional support for the degree of regulation in aquaculture.

Thus, aquaculture is subject to a wide variety of regulations by a large number of state and federal agencies, and local jurisdictions, but with limited coordinating mechanisms and examples for efficient regulatory oversight. This has led to duplication of regulations, redundancy, confusion, increased costs, and restricted growth and development (DeVoe, 1997; Brennan, 1999; Duff et al., 2003; Fletcher, 2004). This is particularly true for interactions between aquaculture and wild fisheries and environmental sensitivities, especially in coastal areas.

EXAMPLES OF REGULATORY FRAMEWORK FOR AQUACULTURE IN OTHER COUNTRIES

A comprehensive review of the regulatory framework for aquaculture in other countries and its related effects is beyond the scope of this article. However, the contrast between the regulatory environments in Norway, Chile and the United States sheds light on the trade-offs between effects of comprehensive regulatory frameworks and one that is much less developed, particularly with respect to fish disease outbreaks.

Norway, like the United States, has a comprehensive regulatory framework for aquaculture. However, Norway has streamlined its regulatory process into a one-stop-shop for aquaculture permits and licenses (Stewart, 2012). Aquaculture has continued to grow in Norway with continued investment in the sector, while U.S. aquaculture has declined. Although Norway is a much smaller country with a more homogeneous population than the United States, its regulatory process may provide a useful contrast to that of the United States.

The principal regulatory tool in Norway is the fish farming license. This license is issued by a single agency, the Ministry of Fisheries (Poseidon Aquatic Resource Management Ltd., 2008). However, the application process for a license includes regulations promulgated from five different acts: 1) environmental emissions; 2) food safety law; 3) aquaculture act; 4) harbor and coastal transportation act; and 5) water resource law. The central legislative authority is the Aquaculture Act that is intended to promote the growth of sustainable aquaculture in Norway.

Applications received by the Ministry of Fisheries are forwarded to relevant agencies at national and local levels, including the Food Safety Authority, the county governor, the National Coastal Administration, the Water Resources and Energy Directorate, and the relevant municipalities which have planning and construction authority. The regulatory system allows flexibility on the part of businesses and emphasizes industry self-regulation. The initial investment cost of the license is substantial, but subsequent regulatory costs appear to be minimal, because many of the regulatory costs have been internalized, through internal audit processes. In the long term, the capital cost of the license per kg decreases over longer time frames. The salmon farming licenses in Norway are indefinitely tradable and are viewed as an important asset by salmon farms. The substantial initial cost has also served as a barrier to entry that has served to regulate industry growth. Although aquaculture farms in Norway have had disease scares, none have been of a scope to reverse the trend of steady growth in aquaculture production in Norway.

Preemptive government regulations can help prevent or at least minimize the effects of fish diseases. Chile provides a sharp contrast to that of Norway and the United States (Stewart, 2012) in this regard. For many years, Chile had a less well-developed regulatory structure for aquaculture than either Norway or the United States. The regulatory body for aquaculture in Chile is the Servicio Nacional de Pesca (Sernapesca), the Directorate of Fisheries. Aquaculture grew rapidly in Chile, emerging as one of the top 10 aquaculture-producing countries in the world. However, un-regulated growth of aquaculture can result in problems that endanger its sustainability. For example, with only 20 staff in 2006, Sernapesca was ill prepared to head off the outbreak of infectious salmon anemia (ISA) in 2007. The rapid expansion in salmon production in Chile (100, 000 metric tons in 1990 to greater than 800, 000 metric tons in 2007) came to a stop.

Asche et al. (2010, p. 410) contrasted the outbreak of infectious salmon anemia in Chile with the experience in Norway, and concluded that "...government has an important role to play in providing regulations and in implementing emergency measures that help coordinate the industry in its preventative efforts." Buschmann et al. (2009) noted that government efforts to regulate the health of the Chilean salmon aquaculture

industry were limited by a lack of financial and technical resources. Since 2007, Sernapesca has been expanded to a staff of more than 170 with an eight-fold increase in its budget. The industry has since worked alongside the government to implement a much more effective regulatory framework that hopefully will prevent similar crises from occurring in the future.

EFFECTS OF THE U.S. REGULATORY FRAMEWORK ON COMPETITIVENESS OF U.S. AQUACULTURE

U.S. aquaculture businesses have created substantial economic activity and employment across the United States. An economic impact analysis estimated that 300,000 full-time jobs were created by aquaculture businesses in 1993 (Joint Subcommittee on Aquaculture, 1993) with an estimated aggregate multiplier of 3.5 (Dicks et al., 1996). Thus, for every dollar of aquaculture production, an additional $3.50 was generated in economic activity. These results were qualified as an underestimation because data were available on only 30 of the more than 50 species known to be raised in the United States.

When industry contraction occurs, the economic effects occur in the opposite direction, but with the same order of magnitude. An increasingly strict regulatory environment that results in increased costs of production and restrictions on production and sales will result in loss of jobs and economic activity. Such losses will be multiplied throughout local and regional economies.

The scientific literature related to effects of the regulatory environment on competitiveness of existing U.S. aquaculture businesses is sparse. However, the literature reviewed in this article suggests several types of effects on existing aquaculture businesses. Duff et al. (2003) attributes the U.S. regulatory environment to the decline of existing U.S. aquaculture and to the lack of growth and expansion of new industries and technologies. A more subtle type of effect is the amount of time that university scientists and industry representatives must spend in discussion with regulators. This reduces time available for productivity-enhancing research and technological developments.

Effects on Global Competitiveness

Many U.S. regulations are designed to force businesses to internalize various types of costs such as those related to environmental effects. Thus, increased regulations in U.S. aquaculture have resulted in increased costs, both direct and indirect, to the businesses regulated (DeVoe, 1997). Increased monitoring, inspections, and record-keeping have required farms to hire additional management-level personnel to remain compliant. In addition to

such direct costs, the additional record-keeping requirements have increased accounting and legal fees, costs of office supplies, and insurance.

Developed countries such as Norway, Canada and New Zealand that export to the United States have comprehensive, well-developed sets of regulations. However, some have a more efficient permit process that allows for access to sites and increasing aquaculture production as compared to the United States. In these countries, regulations are just as stringent as in the United States, but the permitting process is more efficient and entails greater certainty and less risk for the producer.

However similar costs in developing countries that export competing products to the United States remain external to the individual business due to the lack of regulations in many cases and the lack of enforcement in others (Genschick, 2011). Few developing countries have well-developed sets of enforced regulations related to environmental management, food safety, fish health, or labor standards (Hishamunda et al., 2012). Others have comprehensive regulations, but do not enforce them.

For example, Thompson and Ying (2007) identified key challenges to food safety in China as: 1) dominance of food processing sector by small firms; 2) local governments lacking capacity or incentive to establish effective oversight and 3) the lack of governmental structures that contribute to product safety. Government corruption was listed as an additional challenge, particularly at the local level. Similarly, Liu (2010) identified lack of a developed regulatory framework, corruption, environmental degradation, and desire for economic growth as impediments to food safety in China. Vietnam faces similar food safety challenges:

> These include the lack of a comprehensive model for managing antibiotics and chemicals and biological products; low awareness of the food sanitation issues of different stakeholders; and lack of institutional, technical, and financial resources to ensure the sanitation standards (Thanh & Chuong, 2010, p. 1).

Standards required by developed countries "have placed a heavy burden on Vietnamese exporters", and "the cost of compliance has also reduced the competitiveness of Vietnam's seafood industry" (Thanh & Chuong, 2010). As noted by Rico et al. (2012, p. 84), "The aquaculture industry in Asia has grown faster than the associated development of legal instruments regulating the production and importation of aquaculture chemicals."

As a result of the lack of an adequate regulatory framework, there are numerous, ongoing reports of quality problems of imported products, particularly with regard to product safety (US GAO (United States Government Accountability Office), 2011). The Foreign Agricultural Service of the United States Department of Agriculture reported that "overuse of antibiotics has also contributed to disease conditions" (Foreign Agricultural

Service, 2012, p. 5). The same report referred to a survey on aquatic product safety conducted by China's Ministry of Agriculture that reported use of malachite green and overuse of antibiotics.

Love et al. (2011, p. 7232) summarized drug residues in seafood as detected by inspection programs of the European Union, United States, Canada and Japan, for the years 2000 to 2009. They found that "Asian farm-raised shrimp and prawns, catfish (including other fish sold as catfish), crab, tilapia, and eel, and Chilean salmon had higher frequencies of veterinary drug violations than other products. Vietnam had the greatest number of veterinary drug violations among exporting countries." The authors identified 36 different antibiotics that were used in the seven major aquaculture producing countries. The recent [12/28/2012] FDA Import Alert 16-124, "Detention without physical examination of aquaculture seafood products due to unapproved drugs", listed 26 Chinese firms, 19 Vietnamese, 8 Taiwanese, 5 Malaysian, 2 Mexican and 1 firm in Thailand.

The continued reports of product quality from imported products heighten concerns by U.S. consumers over the safety of food. This, combined with negative media campaigns by non-governmental organizations (NGOs; Lee, 2009), have led retail food managers to seek ways to reduce vulnerability to negative publicity and risk (Fulponi, 2006). For example, Greenpeace mounted a campaign entitled "Carting Away the Oceans: How Grocery Stores are Emptying the Seas" to "use public awareness and objective science to reward retailers that were willing to incorporate the principles of sustainable business into their seafood operations" (Greenpeace, 2009, p. 4). Because it can be expensive for a retail firm to comply with NGO demands, voluntary actions such as requiring certifications may avert the "harm threatened" by NGOs (Lyon & Maxwell, 2008). As a result, certification programs for aquaculture have proliferated as retail food managers seek to protect their brands from negative messages in the press. Since most seafood is imported, the certification of low-cost imports has pressured some major processors in the United States to become certified. However, such costs add to those already incurred by domestic growers to comply with U.S. standards, increasing their regulatory costs (Engle, 2010).

Cost increases of U.S. aquaculture that are not matched with similar cost increases by international competitors clearly decrease the competitiveness of U.S. aquaculture. National certification programs can have distinct standards for producers that may not be the same as those in other countries or in global certification programs. Although the major certification programs have single sets of global standards, these standards do not differentiate among production systems in terms of relative "environmental sustainability." For example, third-party certification standards support production systems that would not be permitted in the United States (e.g., flushing of ponds for *Pangasius* culture).

In essence, because U.S. producers must also comply with strict regulations, this creates a *de facto* difference in standards among products that would be under that same certification program. The problem with certification of intensive culture systems is highlighted in an article by Belton et al. (2011) comparing *Pangasius* culture in Vietnam and Bangladesh. Production intensity is less in Bangladesh and practices are more sustainable. However, the authors indicate that producers in Bangladesh are unlikely to meet certification standards.

In addition to food safety, the rapid growth of aquaculture in Vietnam has resulted in environmental concerns. Anh et al. (2011, p. 375) stated that other Southeast Asian countries have implemented effluent treatment technologies among small producers and noted, "this then raises questions over why the Vietnamese government has apparently struggled to regulate compliance with legislated (and recommended) water quality measures."

Favorable regulatory environments as described above in developing countries that export to the United States contrast sharply with the increasingly restrictive regulatory environment in the United States. Such disparities in regulatory standards have created comparative disadvantages for U.S. aquaculture producers that can be seen in the decline of the most successful U.S. aquaculture industries in recent years.

The effect of such a comparative disadvantage may be greater in U.S. aquaculture because it is composed primarily of family farms or small businesses that are not organized to operate as a united force to achieve desired outcomes through lobbying efforts. According to the last Census of Aquaculture (USDA, 2006) and Small Business Administration definitions, 90% of aquaculture businesses were small businesses. Although many international aquaculture growers are also small family farms, the disparity in standards and regulations, particularly with regard to environmental and food safety concerns, results in a strong comparative advantage for developing countries.

Effects on Competitiveness of Existing Industries

The Catfish Example

Catfish composes the largest proportion of aquaculture production in the United States. For many years, the growth of the U.S. catfish industry led it to be regarded as the most important success story of U.S. aquaculture and it is a major contributor to local and regional economies. Kaliba and Engle (2004) showed that 48% of all employment in Chicot County, Arkansas, was related to the catfish industry in 2001. On a state level, Hanson et al. (2004) found that the catfish industry generated more than 10,000 jobs in Mississippi in 2001.

The U.S. catfish industry has undergone substantial contraction since 2003. Total round weight of catfish processed declined from 300, 684 MT

in 2003 to 151, 883 MT in 2011; total hectares in production in 2011 were less than half those in 2003 (Figure 1). This contraction has resulted in the loss of approximately 9,300 jobs. Dramatic increases in feed prices since 2008 have also increased cost of production for all livestock, including farmed fish. Feed price increases have occurred throughout the world, affecting all types of terrestrial livestock production as well as aquaculture. The increase in grain prices that caused increases in livestock feed prices have also created high opportunity costs that favor converting fish ponds to corn and soybean production in catfish farming areas.

Imported *Pangasius* spp. and *Pangasionodon* from Vietnam continue to be imported into the United States, primarily from Vietnam. Imported catfish-like products (basa/tra/swai) (*Pangasius* spp. and *Pangasianodon*) have been priced much lower in U.S. markets than have domestic fish and have made it difficult for U.S. catfish farmers to pass higher production costs on to the end consumer. Lower prices of fish from Vietnam have been attributed to lower labor costs and greater production efficiencies in Vietnam. However, the major reason for the lower prices is that farmers in Vietnam obtain very high yields. When fixed costs of production are spread across greater volumes of production, the result is lower costs per kg. The higher yields of Pangasiidae in Vietnam are due to the volumes of water flushed through raceway-ponds and cages from the Mekong River.

In the United States, water quality is maintained with electric aeration, not water exchange. Engle and Valderrama (2002) showed that waste treatment costs of pond-raised fish in the United States were estimated to cost $0.42 to $0.44/kg. Thus, treating fish wastes in the pond increased

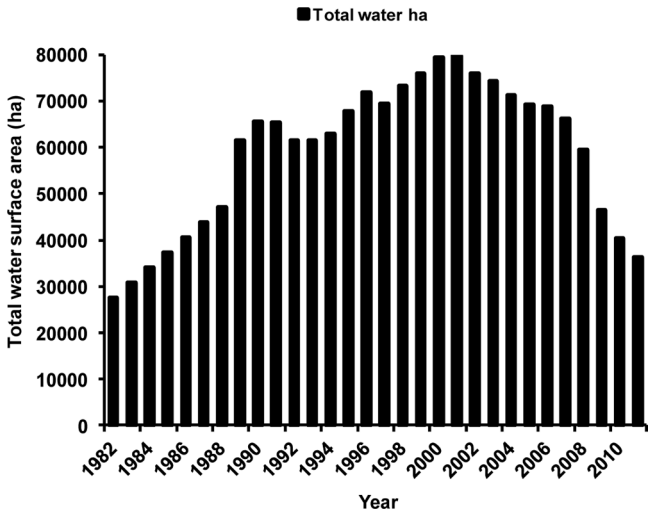

FIGURE 1 U.S. catfish hectareage, 1982–2011.

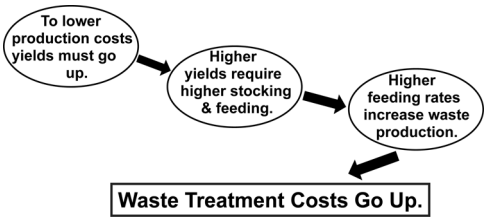

FIGURE 2 Effect of regulatory burden on costs of production of U.S. catfish production.

production costs of catfish in the United States by 28% (Figure 2). Table 3 shows various estimated production costs of basa/tra/swai in Vietnam. When waste treatment and other regulatory costs are added to the reported costs of production, the total cost of producing *Pangasiidae* in Vietnam is nearly doubled and approaches that of U.S. production. In other words, if U.S. catfish farmers were allowed to raise catfish intensively in the Arkansas River and flush wastes downstream to the Gulf of Mexico, similarly high yields would be obtained that would result in lower per-unit costs more competitive with those of imported products. The disparity in environmental regulations and enforcement has provided a strong competitive advantage to Vietnamese growers.

Catfish (*Ictalurus punctatus*) production costs in China were estimated to be $1.94/kg, 26% higher than production costs for U.S. catfish in 2006 (Engle, 2007). The low import price of Chinese catfish in the U.S. market is related to government production subsidies that pay directly for substantial portions of the costs of raising catfish. In the United States, government programs for agriculture provide support during times of low prices or, more recently, to compensate farmers for effects of natural disasters. The U.S. government does not budget to pay directly for normal operating costs, as in China. Thus, the disparity in federal and provincial subsidies in the United States and in China provides a competitive advantage to Chinese growers.

The Trout Example

Trout farmers have been among the most highly regulated segments of aquaculture relative to the discharge of effluents. The EPA effluent regulations are technology-based standards that mandate specific treatment

TABLE 3 Production Costs ($/kg) in Vietnam

Author	Reported cost	Waste treatment costs	W/other regulatory costs	Total costs
Van Binh (2006)	$0.54/kg	$0.43/kg	$0.045	$1.02/kg
Action Aid (2002)	$0.52 to $0.70/kg	$0.43/kg	$0.045	$1.08/kg
Anonymous (2001)	$0.68/kg	$0.43/kg	$0.045	$1.16/kg

processes. These types of command-and-control approaches[3] can lead to production inefficiencies because there is no allowance for farm-level innovation (Engle & Wossink, 2008).

Engle et al. (2005) examined the economic effects of several proposed effluent treatment options for trout farms, including proposed best management practices (BMPs). The BMPs proposed required primarily time of both management and labor, although some also would entail capital investment to construct additional quiescent zones or offline settling ponds, acquisition of land for field application, or additional equipment to remove wastes. The analysis found that the proposed treatment alternatives resulted in negative net returns for medium-sized farms and substantially increased the risk of losing money for large-sized farms (Engle et al., 2005). When full capital costs for new construction were included, the whole-farm models developed were not feasible due to lack of adequate credit reserves and borrowing capacity. If forced to comply, farms would have to take raceways out of production and operate on a less-efficient scale because adjoining land to install treatment facilities was not available.

Trout farmers have indicated that the additional record-keeping related to effluent regulations have required the addition of new manager-level personnel. In addition to the greater management costs, increased record-keeping resulted in greater accounting and legal fees, costs of additional office supplies, insurance, and effluent testing and monitoring. Thus, environmental regulations in the United States have increased costs of domestic trout production relative to countries with less stringent regulations that export to the United States. The effect has been devastating to Idaho small trout industry; the "EPA effectively eliminated 50% of the small trout farms in Idaho. The danger of a $38, 000 a day fine was too great to risk. They quit raising trout. The irony of this was that most of these small farms were using surface water and they were removing more pollutants than they were putting in the water- . . . The result was removing facilities that were cleaning up public waters" (personal communication, Leo Ray, Hagerman, Idaho, October 2012).

The Hybrid Striped Bass Example

Government over-regulation has been highlighted as the greatest challenge to the hybrid striped bass (HSB) industry (Freeze, 2012). Two formal studies that examined costs of effluent treatment options for hybrid striped bass support this assertion. Wui and Engle (2004) found that use of constructed wetlands or settling basins to treat effluents from hybrid striped bass ponds were not feasible, mostly due to the high capital costs involved. Sydorovych and Daniels (2011) found that chemical treatment of effluents also resulted in negative net economic impacts.

Hybrid striped bass growers have been affected negatively by the decision to list black carp, even triploids, as injurious under the Lacey

Act. Black carp are effective biocontrol agents for snails that serve as intermediate hosts of a grub that renders hybrid striped bass foodfish un-marketable. Although the grub poses no harm to humans, its unsightly appearance causes consumers to reject the product. Lack of access to black carp was shown to drive small farms out of business, generate losses of 47% to 59% on medium farms and 33% to 41% on large farms (Wui & Engle, 2007). Total sales lost were estimated to range from $4.7 to $11.96 million/yr with total economic losses (from multiplier effects) of $16.45 to $72.9 million/yr. The combination of these regulations result in increased cost vis-à-vis international competitors and create a competitive advantage for growers in other countries.

More recent water quality regulations promulgated by the state of North Carolina have imposed further economic challenges on the state's hybrid striped bass industry.

> Increased scrutiny by state water quality regulators in recent years has lead to restrictions on effluents from HSB farms in certain areas. Current culture practices are not capable of satisfying the regulatory standards with respect to effluent volume, so new technologies are required to deal with the water leaving farms. Failure to develop these new technologies jeopardizes the continued economic sustainability of this important industry and places the HSB producers in violation of environmental standards. Although this situation is limited to North Carolina, we foresee that the environmental issues that caused it are common to all pond-based aquaculture throughout the entire southeastern U.S. (Daniels, 2012, p. 1).

Effects on Growth and Development of New Industries and Technologies

The set of regulations that apply to aquaculture has been shown to prevent further development of aquaculture in the United States (National Research Council [NRC], 1978; Kennedy & Breisch, 1983; DeVoe & Mount, 1989; Bye, 1990; Rychlak & Peel, 1993; Ewart et al., 1995). Inconsistent regulations faced by aquaculture growers create uncertainties that further reduce the likelihood of investment in aquaculture (Duff et al., 2003). The aquaculture sector will not grow without investment.

Formal analysis of the regulatory framework in various states in the United States showed that states with the greatest amount of aquaculture production were those that had the least stringent regulatory requirements (Wirth & Luzar, 2000). States with more enabling regulatory conditions were more competitive in terms of the growth and development of aquaculture. In more recent years, a few states with stringent and comprehensive regulatory requirements for aquaculture have developed and adopted enabling regulatory frameworks that have resulted in growth of aquaculture.

The growth of marine aquaculture in the United States has been particularly affected by water use conflicts and permitting (McCoy, 1989; Joint Legislative Subcommittee on Aquaculture [JLSA], 1989; Zieman et al., 1990; Hopkins, 1991; National Research Council (NRC), 1992). Relevant challenges have included the emphasis in some areas of tourism, viewscapes, and recreation over working waterfronts and aquaculture production. A striking example is the re-location of shellfish companies from the state of Washington to other countries as a result of a regulatory environment that delayed permits for raft culture of mussels for more than 14 years (NOAA, 2010). Other examples include that of Swecker Salmon Farm and Pacific Seafoods, both from the State of Washington: "We applied for a salmon net pen site in 1987 and spent five years and $500, 000 to get the permits finalized, but the permits were for less production than what we needed to get the operation, so it basically broke my company," according to Dan Swecker (Stewart, 2012, p. 24). Pacific Seafoods similarly has been stymied by permits: "If we could get permits, we would be producing multiple times more salmon in this state . . . and instead of importing it from South America, we would be producing it here," according to John Bielka (Stewart, 2012, p. 24). For Pacific Seafoods' application for a steelhead farm, two permits were required from the county and four were required from the state, in addition to nine plans and studies (Stewart, 2012).

Another example is that of Open Blue Sea Farms (Bianchi, 2009). Brian O'Hanlon successfully attracted investors to finance an offshore cobia farm using emerging underwater pen technology. His production system was designed originally to raise snapper off the coast of Puerto Rico. As production technologies to raise cobia were developed, he began to raise cobia, producing 50 tons in 2008. The Puerto Rico farm required regulatory approval from 20 U.S. agencies but, even though the approvals were obtained, the farm was restricted to no more than 50 tons of production annually. Such restricted production prevented the business from growing to achieve the economies of scale necessary to operate at an efficient level. O'Hanlon subsequently moved his operation to Panama where he obtained a permit for production of 10, 000 tons of cobia a year and provided the opportunity to grow the business to operate at an efficient level.

On a broader level, the development of offshore production of marine species in the United States has been stymied for years due to regulatory barriers in the United States in spite of the dramatic increases in mariculture technologies. Other countries, notably China, Vietnam and Thailand, have taken full advantage of the new technologies, many of which were developed by U.S. scientists. In contrast to freshwater aquaculture, where compliance with existing regulations reduces competitiveness of U.S. producers, the development of marine offshore aquaculture has been stifled by the lack of a clear set of regulations. The lack of a regulatory

framework for offshore aquaculture has been repeatedly cited as the major obstacle to its development (Cicin-Sain et al., 2005; US GAO, 2008; Buck, 2012). Buck (2012, p. i) surveyed a dozen individuals across the marine aquaculture industry, relevant government agencies, universities, and environmental organizations, and concluded "analysis showed that while economic and political factors have a definite influence on the development of offshore aquaculture, the greatest barriers to the growth of the industry in the United States are the lack of a rational and comprehensive federal regulatory framework for offshore aquaculture, and lack of explicit regulatory authority naming NOAA as the lead federal agency."

CONCLUSIONS

Regulations and government oversight are necessary to have the type of orderly, safe and healthy environment desired by U.S. citizens. However, an overly cumbersome and restrictive regulatory environment can stifle and constrain economic activity. The international disparities in standards, regulation, and enforcement put U.S. aquaculture at a comparative disadvantage in an era of increasing globalization.

The stringency of the regulatory environment in the United States has increased in recent years in terms of both the number and complexity of regulations that affect U.S. aquaculture. Especially difficult is the common lack of a lead agency at both federal and state levels to effectively coordinate and streamline regulatory and permitting processes that result in timely decisions and more certainty for investment in new enterprises and expansion of existing operations. The overall cumulative effect has been continued increases in the regulatory costs and risk faced by aquaculture growers in the United States.

Norway, in contrast, has developed a stringent and comprehensive regulatory environment that still fosters growth of commercial aquaculture. Results have demonstrated few major disease outbreaks and an overall strong record of sustainability. The Norwegian system is noteworthy in that it is a one-stop permitting system that allows flexibility in its implementation. Licenses also are tradeable and have become valuable business assets.

Steps towards such a streamlined, one-stop process in the U.S. could include a series of memorandums of understanding or agreements between agencies that reduce overlap and streamline the federal permit review process. For example, the President could issue an executive order requiring federal agencies to have a joint permit application process. States could be encouraged to participate in the one-stop permitting process if a mechanism for this were to be established. The states of Maine and Maryland have taken steps to develop and implement enabling environments for aquaculture (finfish, shellfish and algae in Maine and oyster leases

in Maryland). Maryland has developed a one-stop permit coordination agency that handles state and USACE permits.

A greater emphasis on net actual impacts of aquaculture is needed in the regulatory process, particularly with regard to environmental regulations and their implementation. There is growing evidence that some aquaculture farms contribute to the environment in a positive manner, by returning water "cleaner" than that withdrawn from the environment or shellfish farms with positive environmental impacts. Properly located salmon farms have been shown to have only ephemeral effects on water quality and benthos. A coordinated permitting system might allow for consideration of the net actual effects of aquaculture farms that may result in both improved environmental management and economic sustainability.

There is a strong need for research that assesses and quantifies the inefficiencies and cost effectiveness of requirements that arise from the current maze of regulations and the associated effects on growth and development of U.S. aquaculture. Such research may help to identify ways to reduce the burden and duplication of regulations without sacrificing environmental quality and other benefits to society that result from regulation. Research on the actual environmental impact (both positive and negative effects) of aquaculture is needed so that environmental regulations and their implementation can be developed within the context of actual net impact. Attention is also needed by policy makers to address the disparity in standards, enforcement, and associated effects on the competitive advantage of international competitors as compared with U.S. aquaculture growers.

ACKNOWLEDGMENTS

The authors thank three very thoughtful, careful reviewers for their suggestions and contributions that were very much appreciated.

NOTES

1. Exceptions include the state of Washington, in which submerged areas are privately owned, and states such as Florida, Texas and Puerto Rico where the distance is three nautical leagues instead of three miles.
2. There are some exceptions. In Florida, for example, the Department of Agriculture and Consumer Services has regulatory authority over permitting for inland and coastal aquaculture, but this is rare.
3. Not all environmental regulations have technology requirements and not all are command-and-control approaches.

REFERENCES

Action Aid (2002) *What do the catfish farmers say?* Auburn University, Auburn, Alabama, USA.
Anonymous (2001) Vietnam Trip Report. Auburn University, Auburn, Alabama, USA.

Anh, P.T., S.R. Bush, P.J.A. Mol, & C. Kroeze (2011) The multi-level environmental governance of Vietnamese aquaculture: global certification, national standards, local cooperatives. *Journal of Environmental Policy & Planning*, **13**, 373–397.

Antle, J.M. (2000) No such thing as a free lunch: The cost of food safety regulation in the meat industry. *American Journal of Agricultural Economics*, **82**(2), 310–322.

Asche, F., H. Hansen, R. Tveteras, & S. Tveteras (2010) The salmon disease crisis in Chile. *Marine Resource Economics*, **24**, 405–411.

Aspen Systems Corporation (ASC) (1981) Aquaculture in the United States: Regulatory constraints. Final report. U.S. Fish & Wildlife Service, U.S. Department of the Interior, Rockville, Maryland, USA.

Bartley, D.M., C. Brugère, D. Soto, P. Gerber, & B. Harvey (Eds.) (2007) Comparative assessment of the environmental costs of aquaculture and other food production sectors: Methods for meaningful comparisons. FAO/WFT Expert Workshop. April 24–28, 2006, Vancouver, Canada. *FAO Fisheries Proceedings*. No. 10. FAO, Rome, Italy.

Belton, B., M.M. Haque, & D.C. Little (2011) Certifying catfish in Vietnam and Bangladesh: Who will make the grade and will it matter? *Food Policy*, **36**(2), 289–299.

Bianchi, A. (2009) The next seafood frontier: the ocean. Facing a global seaood crisis, one startup's solution is to farm the open seas. *CNN Money*. Retrieved from http://money.cnn.com/2009/04/27/smallbusiness/farming_the_open_oceans.fsb/

Brennan, W.J. (1999) Aquaculture in the Gulf of Maine: A compendium of federal, provincial, and state regulatory controls, policies, and issues. Report to the Gulf of Main Council on the Marine Environment, Aquaculture Committee, Boston, Massachusetts, USA.

Buck, L.E. (2012) U.S. development of offshore aquaculture: Regulatory, economic, and political factors. Master's thesis, University of Washington, Seattle, Washington, USA.

Buschmann, A.H., F. Cabello, K. Young, J. Carvajal, D.A. Varela, & L. Henŕiquez (2009) Salmon aquaculture and coastal ecosystem health in Chile: Analysis of regulations, environmental impacts and bioremediation systems. *Ocean & Coastal Management*, **52**, 243–249.

Buttel, F.H. (2003) Internalizing the societal costs of agricultural production. *Plant Physiology*, **133**, 1656–1665.

Bye, V.J. (1990) Legal, political, and social constraings in aquaculture. In N. DePaux & R. Billiard (Eds.), *Aquaculture Europe '89—Businss Joins Science* (pp. 123–144). Special Publication No. 12, European Aquaculture Society, Bredene, Belgium.

Carter, C.A., J.A. Chalfant, & R. Goodhue (2002) Economic analysis of the January 2001 California Department of Pesticide Regulation Regulations on Strawberry Field Fumigation. A report prepared for the California Department of Food and Agriculture, Department of Agricultural and Resource Economics, University of California, Davis, California, USA, Mimeo, 37 pp.

Christiansen, G.B. & R.H. Haveman (1981) The contribution of environmental regulations to the slowdown in productivity growth. *Journal of Environmental Economics and Management*, **8**(4), 381–390.

Cicin-Sain, B., S.M. Bunsick, J. Corbin, M.R. DeVoe, T. Eichenberg, J. Ewart, ... M. Blaydes (2005) *Recommendations for an Operational Framework for Offshore Aquaculture in U.S. Federal Waters*. Technical Report. Gerard J. Mangone Center for Marine Policy, University of Delaware, Newark, Delaware, USA.

Colyer, D. (2004) Environmental regulations and agricultural competitiveness. *Estey Centre Journal of International Law and Trade Policy, Estey Centre for Law and Economics in International Trade*, **5**(1), 70–86.

Coppock, R. (1996) Research update: Farmers say regulations complicate farming. *California Agriculture*, **50**(5), 5.

Crain, N.V. & W.M. Crain (2010) The impact of regulatory costs on small firms. A report for The Office of Advocacy, U.S. Small Business Administration, Washington, DC, USA.

Crain, W.M. & T.D. Hopkins (2001) The impact of regulatory costs on small firms. RFP No. SBAHQ-00–R-0027. A report for The Office of Advocacy, U.S. Small Business Administration, Washington, DC, USA.

Crews, C.W., Jr. (2011) *Ten Thousand Commandments: An Annual Snapshot of the Federal Regulatory State*. Competitive Enterprise Institute, Washington, DC, USA. 55 pp.

Daniels, H. (2012) Practical control of sex determination in flounder and effluent management from hybrid striped bass ponds. Project No. NCO6819, CRIS report, National Institute of Food and Agriculture, U.S. Department of Agriculture, Washington, DC, USA.

DeVoe, M.R. (1997) Marine aquaculture regulation in the United States: Environmental policy and management issues. UJNR Technical Report No. 24, pp. 1–15 in Interaction in the Environment, 1995. *Proceedings of the Twenty-fourth U.S.-Japan Aquaculture Panel Symposium*, Corpus Christi, Texas, USA.

DeVoe, M.R. & A.S. Mount (1989) An analysis of ten state aquaculture leasing systems: issues and strategies. *Journal of Shellfish Research*, **8**(1), 233–239.

Dicks, M.R., R. McHugh, & B. Webb (1996) *Economy-wide Impacts of U.S. Aquaculture*. Bulletin P-946, Oklahoma Agricultural Experiment Station, Division of Agricultural Sciences and Natural Resources, Oklahoma State University, Norman, Oklahoma, USA.

Directorate-General for Internal Policies (2009) Regulatory and legal constraints for European aquaculture. Policy Department, European Union Parliament, Brussells, Belgium.

Dudley, S.E. & J. Brito (2012) *Regulation: A Primer*. 2nd ed. Mercatus Center, George Mason University, Washington, DC, USA.

Duff, J.A., T.S. Getchis, & P. Hoagland (2003) A review of legal and policy constraints to aquaculture in the US northeast. *Aquaculture White Paper No. 5*, NRAC Publication No. 03–005, Northeast Region Aquaculture Center, North Dartmouth, Massachusetts, USA.

Engle, C.R. (2007) Catfish production in China. *The Catfish Journal*, **47**, May, p. 1.

Engle, C.R. (2010) U.S. government programs that regulate U.S. aquaculture production. Abstract. *Book of Abstracts, Annual Meeting of the World Aquaculture Society*, San Diego, California, USA.

Engle, C.R., S. Pomerleau, G. Fornshell, J.M. Hinshaw, D. Sloan, & S. Thompson (2005) The economic impact of proposed effluent treatment options for production of trout *Oncorhynchus mykiss* in flow-through systems. *Aquaculture Engineering*, **32**, 303–323.

Engle, C.R. & N.M. Stone (2005) The U.S. Asian carp industry: Economic value and importance. *Abstract and Invited Presentation*, Southern Division, American Fisheries Society, Virginia Beach, Virginia, USA.

Engle, C.R. & D. Valderrama (2002) The economics of environmental impacts in the United States. In J.P. Tomasso (Ed.), *Aquaculture and the Environment in the United States* (pp. 240–270). U.S. Aquaculture Society, A Chapter of the World Aquaculture Society, Baton Rouge, Louisiana, USA.

Engle, C.R. & A. Wossink (2008) Economics of aquaculture better management practices. In C.S. Tucker, & J.A. Hargreaves (Eds.), *Environmental Best Management Practices for Aquaculture* (pp. 519–551). Wiley-Blackwell, Ames, Iowa, USA.

Esseks, J., Dixon, S.E. Kraft, & L.M. McSpadden (1998) Owner's attitudes towards regulations of agricultural land: Technical report on a national survey. Report CAE/WP 98–3, American Farmland Trust, Northampton, Massachusetts, USA.

Ewart, J.W., J. Hankins, & D. Bullock (1995) State policies for aquaculture effluents and solid wastes in the northeast region. NRAC Bulletin No. 300. North Dartmouth, Massachusetts, USA.

Federal Register (2011a) Executive Order 13563. Improving regulation and regulatory review. *Federal Register* **76**, 14. Washington, DC, USA.

Federal Register (2011b) Executive Order 13579. Regulation and independent regulatory agencies. *Federal Register*, **76**, 70913. Washington, DC, USA.

Federal Register (2012) Executive Order 13610. Identifying and reducing regulatory burdens. *Federal Register*, **77**, 93. Washington, DC, USA.

Fletcher, K.M. (2004) Law and offshore aquaculture: A true hurdle or a speed bump? In C.J. Bridger (Ed.), *Efforts to Develop a Responsible Offshore Aquaculture Industry in the Gulf of Mexico: A Compendium of Offshore Aquaculture Consortium Research* (pp. 22–33). Mississippi-Alabama Sea Grant Consortium, Ocean Springs, Mississippi, USA. MASGP-04–029. Retrieved from www/nsgl.gso.uri/edu/masgc/masgcb04001/masgcb04001.pdf

Foreign Agricultural Service (2012) China-Peoples Republic of. Fishery Products. Annual GAIN Report No. CH12073, Global Information Network, Foreign Agricultural Service, United States Department of Agriculture, Washington, DC, USA.

Freeze, M. (2012) Better know a hatchery. AFS Fish Culture Section Newsletter. Winter, 2012. Retrieved from //sites.google.com/site/fishculturesection/newsletters-google-docs

Fulponi, L. (2006) Private voluntary standards in the food system: the perspective of major food retailers in OECD countries. *Food Policy*, **31**, 1–13.

Genschick, S. (2011) Pangasius at risk. Governance in farming and processing, and the role of different capital. ZEF Working Paper Series 85, Center for Development Research, University of Bonn, Bonn, Germany.

Gray, W.B. (1987) The cost of regulation: OSHA, EPA and the productivity slowdown. *The American Economic Review*, **77**(5), 998–1006.

Greenpeace (2009) *Carting Away the Oceans: How Grocery Stores are Emptying the Seas*. Greenpeace USA, Washington, DC, USA, 28 pp.

Hale, A., D. Borys, & M. Adams (2011) Regulatory overload: A behavioral analysis of regulatory compliance. Working Paper No. 11–47, Mercatus Center, George Mason University, Washington, DC, USA.

Hanson, T.R., D. Dean, & S.R. Spurlock (2004) Economic impact of the farm-raised catfish industry on the Mississippi State economy. *Journal of Applied Aquaculture*, **15**(1/2), 11–28.

Harris, D. (1998) Aquaculture regulatory reform task force. Discussion paper, Aquaculture Regulatory Reform Task Force, Victoria, Australia.

Hazilla, M. & R.J. Kopp (1990) Social costs of environmental quality regulations: A general equilibrium analysis. *The Journal of Public Economy*, **98**(4), 853–873.

Hishamunda, N., N. Ridler, P. Bueno, B. Satia, B. Juelmansan, D. Percy, G. Gooley, C. Brugere, & S. Sen (2012) Improving aquaculture governance. What is the status and options? In R.P. Subasinghe, J.S. Arthur, D.M. Bantley, S.S. De Silva, M. Halwart, N. Hishamunda, C.V. Mahan, & P. Sorgellos (Eds.), *Farming the Waters for People and Food* (pp. 233–264). Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand. September 22–25, 2010. FAO, Rome, and Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand.

Hopkins, J.S. (1991) Status and history of marine and freshwater shrimp farming in South Carolina and Florida. In P.A. Sandifer (Ed.), *Shrimp Culture in North America and the Caribbean Advances in World Aquaculture* (vol. 4, pp. 17–35). World Aquaculture Society, Baton Rouge, Louisiana, USA.

Hughes, P., M. Schuele, & A. Weier (2004) Environmental regulatory arrangements and aquaculture production. In *Productivity Commission (2004) Assessing Environmental Regulatory Arrangements for Aquaculture* (pp. 1–16). Proceedings of the Australian Agricultural and Resource Economics Society 2004 Conference (48th), February 11–13, 2004, Melbourne, Australia. Retrieved from www.pc.gov.au

Hurley, S.P. & J. Noel (2006) An estimation of the regulatory cost on California agricultural producers. Annual Meeting of the American Agricultural Economics Association, July, 2006, Long Beach, California, USA.

Hurley, S.P., R. Thompson, C. Dicus, L. Berger, & J.E. Noel (2006) Analysis of the regulatory effects of California specialty crops: an examination of various issues impacting selected forest products, tree, fruit, nut, and vegetable crop industries. California Polytechnic Institute for the Study of Specialty Crops Report. California Polytechnic Institute, San Luis Obispo, California, USA, 232 pp.

Joint Legislative Subcommittee o Aquaculture (JLSA) (1989) *Strategic Plan for Aquaculture Development in South Carolina Volume I: Summary and Recommendation*. South Carolina Sea Grant Consortium, Charleston, South Carolina, USA. 27 pp.

Joint Subcommittee on Aquaculture (JSA) (1983) *National Aquaculture Development Plan*. Joint Subcommittee on Aquaculture of the Federal Coordinating Council on Science, Engineering and Technology, Washington, DC, USA.

Joint Subcommittee on Aquaculture (JSA) (1993) *Aquaculture in the United States: Status, opportunities and recommendations*. Report to Federal Coordinating Council on Science, Engineering, and Technology, Washington, DC, USA.

Joint Subcommittee on Aquaculture (JSA) (1995) *State/Territory Permit and Regulations Impacting the Aquaculture Industry*. Joint Subcommittee on Aquaculture, Washington, DC, USA.

Jones, L. & S. Graf (2001) Canada's regulatory burden: How many regulations? At what cost? *Fraser Forum August*, **3**, 32.

Kaliba, A. & C.R. Engle (2004) The economic impact of the catfish, *Ictalurus punctatus*, industry on Chicot County, Arkansas. *Journal of Applied Aquaculture*, **15**(1/2), 29–60.

Kaplan, J.D., R.C. Johannson, & M. Peters (2004) The manure hits the land: Economics and environmental implications when land application of nutrients is constrained. *American Journal of Agricultural Economics*, **86**(3), 688–700.

Kennedy, V.S. & L.L. Breisch (1983) Sixteen decades of political management of the oyster fishery in Maryland's Chesapeake Bay. *Journal of Environmental Management*, **16**, 153–171.

Lee, D. (2009) Understanding aquaculture certification. *Revista Colombiana de Ciencias Pecuarias* **22**, 3.

Liu, C. (2010) The obstacles of outsourcing imported food safety to China. *Cornell International Law Journal*, **43**, 249–305.

Love, D.C., S. Rodman, R.A. Neff, & K.E. Nachman (2011) Veterinary drug residues in seafood inspected by the European Union, United States, Canada, and Japan from 2000 to 2009. *Environmental Science & Technology*, **45**, 7232–7240.

Lyon, T.P. & J.P. Maxwell (2008) Corporate social responsibility and the environment: A theoretical perspective. *Review of Environmental Economics and Policy*, **1**, 1–22.

McCoy, II, H.D. (1989) Commercial aquaculture zones: A legislative proposal. *Aquaculture*, **6**, 39–46.

McCoy, H.D. (2000) *American and International Aquaculture Law*. West Virginia Supranational Publishing Company, Peterstown, West Virginia, USA.

Metcalfe, M., B. Williams, B. Hueth, R. Van Steenwyk, S. Sunding, A. Swoboda, & D. Zilberman (2002) The economic importance of organophosphates in California agriculture. Retrieved from http://www.cdfa.gov/publications

National Agricultural Law Center (2012) *Major Statutes and Regulations That Affect U.S. Aquaculture*. National Agricultural Law Center, University of Arkansas at Fayetteville, Fayetteville, Arkansas, USA.

NOAA (2010) Summary of NOAA's Aquaculture Listening Session. NOAA, Seattle, Washington, USA. Retrieved from www.nmfs.noaa.gov/aquaculture/docs/aqlistening_wa_final.pdf

Noel, J.E., M. Paggi, & F. Yamazaki (2008) The impact of California regulatory compliance costs on California orange producer profitability. California Institute of Specialty Crops, California Polytechnic State University, San Luis Obispo, California, USA.

National Research Council (NRC) (1978) Aquaculture in the United States: Constraints and opportunities—A report of the committee on Aquaculture of the National Academy of Sciences. *The Commercial Fish Farmer*, **5**(2), 8–11, 44–45.

National Research Council (NRC) (1992) *Marine Aquaculture: Opportunities for Growth*. National Academy Press, Washington, DC, USA.

Office of Management & Budget (2012) *Information Collection Budget of the United States Government*. Office of Management and Budget, Office of Information and Regulatory Affairs, Washington, DC, USA.

Palmer, K., W.E. Oates, & P.R. Portney (1995) Tightening environmental standards: The benefit-cost or the no-cost paradigm? *Journal of Economic Perspectives*, **9**, 119–132.

Porter, M.E. & C. Van der Linde (1995) Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, **9**(4), 97–118.

Poseidon Aquatic Resource Management Ltd. (2008) Report to The Scottish Government: Detailed investigation of a range of issues to assess the cost structure and competitiveness of the salmon growing industry in Scotland. Project Ref: CR/2007/24. Poseidon Aquatic Resource Management Ltd., Edinburgh, Scotland.

Rico, A., K. Satapornvanit, M.M. Haque, J. Min, P.T. Nguyen, T.C. Telfer, & P.J. van den Brink (2012) Use of chemicals and biological products in Asian aquaculture and their potential environmental risks: A critical review. *Reviews in Aquaculture*, **4**, 75–93.

RTI (2000a) A benefits assessment of water pollution control programs since 1972: Part 1. The benefits of point source controls for conventional pollutants in rivers and streams. Research Triangle Institute, Research Triangle Park, North Carolina, USA.

RTI (2000b) A retrospective assessment of the costs of the Clean Water Act: 1972–1997. Research Triangle Institute, Research Triangle Park, North Carolina, USA.

Rubino, M.C. & C.A. Wilson (1993) Issues in aquaculture regulation. A publication of Bluewaters, Inc., pursuant to National Oceanic and Atmospheric Administration. Additional Funding from U.S. Department of Agriculture, Washington, DC.

Rumley, E.R. (2012) Aquaculture and the Lacey Act. SRAC Publication No. 5005, Southern Regional Aquaculture Center, Mississippi State University, Mississippi, USA.

Rychlak, R.J. & E.M. Peel (1993) Swimming past the hook: Navigating legal obstacles in the aquaculture industry. *Environmental Law*, **23**, 837–868.

Stewart, J. (2012) Not made in the United States of America. *Fish Farming International*, **2**(39), 22–27.

Sydorovych, O. & H. Daniels (2011) Economic analysis of alternative effluent treatment options for pond production of hybrid striped bass in Aurora, North Carolina. *Aquaculture Economics & Management*, **15**(1), 46–70.

Thanh, L.H. & P.H. Chuong (2010) Vietnam's aquaculture trade: Food safety and sanitation issues. Case Study #10–12, Food policy for developing countries: The role of government in the global food system. Cornell University, Ithaca, New York, USA.

Thompson, D. & H. Ying (2007) Food safety in China: New strategies. Global Health Governance I(2). Retrieved from http://blogs.shu.edu/ghg/2007/09/01/food-safety-in-china-new-strategies/

United States Department of Agriculture (2006) *Census of Aquaculture (2005)*. National Agricultural Statistics Service, United States Department of Agriculture, Washington, DC, USA.

United States Government Accountability Office (US GAO) (2011) Seafood safety: FDA needs to improve oversight of imported seafood and better leverage limited resources. GAO-11–286, Washington, DC, USA.

United States Government Accountability Office (US GAO) (2008) Offshore marine aquaculture: Multiple administrative and environmental issues need to be addressed in establishing a U.S. regulatory framework. GAO-08–594, Washington, DC, USA.

Van Binh, T. (2006) Before and after the catfish war: Market analysis. CAS Discussion Paper No. 50, Centre for ASEAN Studies, University of Antwerp, Belgium.

Wirth, F.F. & E.J. Luzar (2000) A scale measure of state regulatory climate toward finfish aquaculture. *Journal of the World Aquaculture Society*, **31**(4), 545–557.

Wui, Y.S. & C.R. Engle (2004) A mixed integer programming analysis of effluent treatment options proposed for pond production of hybrid striped bass, *Morone chrysops* x *M. saxatilis*. *Journal of Applied Aquaculture*, **15**(1/2), 121–158.

Wui, Y.-S. & C.R. Engle (2007) The economic impact of restricting use of black carp for snail control on hybrid striped bass farms. *North American Journal of Aquaculture*, **69**, 127–138.

Zieman, D., G. Pruder, & J.-K. Wang (1990) Aquaculture effluent discharge program – year 1 final report. Center for Tropical and Subtropical Aquaculture, Makapuu Point, Hawaii, USA.