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A regulatory cost assessment of ornamental aquaculture farms in Florida

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Abstract

The ornamental aquaculture trade is a diverse sector of aquaculture and faces unique challenges that other commodity groups do not have to contend with. The various production techniques, species, and destination markets make ornamental aquaculture an interesting study in how regulations impact the industry. In Florida, aquaculture is primarily regulated under the Florida Department of Agriculture and Consumer Services, unique from other states. Regulatory costs and the value of lost production on ornamental farms in Florida were estimated to be $5.2 and $23.2 million, respectively. Results from an industry-wide census have shown that there is a high regulatory burden on ornamental farmers for some regulatory categories. These include issues of legal control of fish-eating predators, the restriction of drugs and chemicals, which would be beneficial to production, and the prohibition for farmers to raise species that have been restricted for culture at the national and state level. Larger farms were also able to limit the impact from regulations better than smaller farms by spreading their regulatory costs and value of lost production across greater sales. Although the values of lost production

Significance statement: This study provides the costs and value of lost production due to regulations for the ornamental aquaculture industry in Florida. The results of this study will help to streamline the regulatory framework for ornamental aquaculture farmers in Florida and help to grow the industry as a whole.

were high for ornamental producers, direct regulatory costs were low compared with other aquaculture commodities demonstrating that the industry in Florida may prove a regulatory model for other sectors.

KEYWORDS
aquaculture economics, aquaculture regulations, Florida, ornamental fish, regulatory costs

1 | INTRODUCTION

Regulations are primarily established with the intent to protect the general public and environment from negative externalities, which may otherwise cause harm in the absence of monitoring, oversight, or restrictions. Additionally, governmental and economic stability, a sound rule of law, low levels of corruption, and effective government services such as subsidies and extension programs are vital for successful industry (Hishamunda et al., 2012). Aquaculture is a nascent agricultural industry whose regulations are in constant flux and vary greatly because of factors such as the commodity produced, the culture methodology employed, and geography. A study by Genschick (2011) found that a lack of governmental influence on the *Pangasius* industry in Vietnam led to a decline in environmental sustainability and threatened the longevity of the industry as a whole. Economists have argued that in the absence of regulations, there exists little incentive for businesses to safeguard the health of people and the environment (Stigler, 1971). However, it must also be acknowledged that the enforcement of and compliance with such regulations comes at a cost to businesses, governmental agencies, and ultimately consumers (Engle, van Senten, & Fornshell, 2019). Commodity-specific data regarding the economic burden of regulatory compliance is limited and presents an opportunity for a novel line of inquiry.

In the United States and abroad, there has been a growing movement to assess the current regulatory framework and quantify its impact on industry. In 2012, President Obama issued an executive order to "identify and reduce regulatory burdens," which was anticipated to "eliminate billions of dollars in regulatory costs and tens of millions of hours in annual paperwork burdens" (Executive Order No. 13610, 2012). There has been an effort to assess the regulatory burden in other agriculture industries (Antle, 2000; Hurley & Noel, 2006; Kaplan, Johannson, & Peters, 2004; Metcalfe et al., 2002), which has shown various regulatory burdens that negatively impacted other agricultural sectors. Aquaculture provides an excellent case study for regulatory evaluation because of its relative novelty, compared with other agriculture sectors, and the degree to which it is regulated at the local, state, and federal levels. Abroad, there have been efforts in the European Union to evaluate the regulatory structure of various aquaculture industries and identify areas where these frameworks can be improved (Asche & Roll, 2013; Chu, Anderson, Asche, & Tudur, 2010). A study conducted by Abate, Nielsen, and Tveterås (2016) evaluated 97 countries around the world and compared the development of their aquaculture industry with the stringency of their environmental regulations. They found a strong negative correlation between regulations and industry growth, suggesting a need to streamline regulatory pathways and improve efficiency. Thus, incentive existed to assess the domestic regulatory framework and identify opportunities for improvement, which may facilitate industry growth and prevent a potential shift in production to regions with less stringent regulatory climates. American aquaculture is currently faced with a similar dilemma as the stringency of domestic regulations has impacted industry productivity and stagnated potential future growth (Duff, Getchis, & Hoagland, 2003; Engle, 2016; Engle & Stone, 2013; Thunberg, Adams, & Cichra, 1994). Additionally, confusion in aquaculture regulatory roles because of agency competitiveness has led to a decline in productivity across the industry (Abate, Nielsen, & Neilsen, 2018).

Although there have been initial studies that assessed the cost of regulations on a macro scale (Abate et al., 2016; Wirth & Luzar, 2001), there generally has been a lack of research that has assessed regulations at the individual farm level to understand industry trends. These data are important to developing robust policy and regulatory frameworks as they are the most accurate representation of the true burdens faced by aquaculture producers. Efforts have already been made to assess the regulatory costs and corresponding value of lost production in the baitfish/sportfish and salmonid industries in the United States. Results of the baitfish/sportfish study found that 38% of the farms surveyed had the costs of regulations exceed the profits of the year measured (van Senten & Engle, 2017). Additionally, regulatory costs on average were 25% of total farm costs ($148,544/farm), with 99% of those costs resulting from manpower and farm changes to remain in compliance and sales that were lost because of the regulatory environment (van Senten & Engle, 2017). Additional analysis further showed that farms with an increased regulatory burden had less technical efficiency, as farmers were required to spend more time and resources on regulatory compliance than on optimizing production (van Senten, Dey, & Engle, 2018). The most impactful regulatory category for sportfish/baitfish farms came from navigating interstate shipping regulations, which often differed from one state to another and required substantial effort with respect to labor and veterinary testing for compliance (van Senten & Engle, 2017). Results from the salmonid study demonstrated that on-farm costs averaged $150,506/farm, with regulatory costs representing 12% of total production and marketing costs (Engle et al., 2019). The regulatory category that had the highest on-farm costs for salmonid producers were environmental regulations, specifically pertaining to required effluent discharge permits, testing, and reporting (Engle et al., 2019). Farm-level data collected by Asche and Roll (2013) found similar technical and allocative efficiency declines on salmon farms in Norway that experienced unusually high regulatory burdens. The farm-level regulatory cost burden on West Coast shellfish farms was found to be $15.6 million annually in addition to $110 million annually in lost sales revenue and $169.9 million in lost opportunities (van Senten, Engle, Hudson, & Conte, 2020). These results demonstrate the high costs associated with regulations for three aquaculture commodity sectors in the United States and provide an impetus to assess other commodity groups including ornamental fish production.

In the United States, ornamental fish are raised in 45 states around the country, with Florida leading the nation with respect to number of farms and value of product sold (United States Department of Agriculture, 2018). Other states that boast a substantial ornamental aquaculture industry include Hawaii, Texas, and Ohio. Production is typically centered in regions with a warm climate and access to large logistical hubs such as an international airport. The ornamental aquaculture industry in Florida is very diverse, with hundreds of species currently in production, with many new species being added to the market annually. The seven major families of fishes that are cultured include cyprinidae, cichlidae, poeciliidae, melanotaeniidae, characidae, callichthyidae, and loricariidae (Hill & Yanong, 2002). Currently, approximately 90% of the industry in Florida is comprised of freshwater producers, whereas only about 10% of farms are dedicated to marine ornamental production (USDA-NASS, 2019). Although some wholesalers sell a variety of fresh and saltwater fish, farmers in the Florida ornamental industry generally specialize in raising either freshwater or saltwater species at their facilities. This diversity is also reflected in the agencies that regulate the industry. There are five federal agencies, three state agencies, and various local municipalities that have some type of permit or other regulatory requirement that ornamental farmers must abide by in order to operate in Florida. At the federal level, the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) issues export health certificates to farmers for fish being transported to other states or outside of the United States to countries that require testing for specific species. The United States Fish and Wildlife Service (USFWS) issues bird depredation permits to farmers to remove birds that are deemed a nuisance to their operation. The Food and Drug Administration (FDA) regulates the production of transgenic ornamental fish, which have increased in popularity in the industry. Drugs and chemicals for use on farms are also regulated by the FDA along with the Drug Enforcement Agency (DEA) and the Environmental Protection Agency (EPA).

In the state of Florida, the primary point of contact for regulatory matters is the Florida Department of Agriculture and Consumer Services (FDACS) Division of Aquaculture. Farmers must be licensed through this agency to do business in Florida by participating in the Best Management Practices program (BMP). The Florida Department of

Environmental Protection (DEP) manages five water management districts around the state to regulate the amount of water being pumped from the Floridan Aquifer, which is a vital source of freshwater for many farmers. The Florida Fish and Wildlife Conservation Commission also maintains a list of prohibited species for sale, culture, and/or transport within the state as well as regulate the process of wild collection for broodstock.

Ornamental aquaculture in Florida is similar to other aquaculture sectors with regard to the number of agencies and types of regulations that impact the industry. However, the diversity of species cultured, and the unique production methods utilized by farmers, make it an interesting study in how regulations may impact this unique commodity. The objective of this study was to quantify the regulatory costs and associated value of lost production across the ornamental aquaculture industry in Florida and compare those costs to total annual farm and industry total sales and total costs. Additionally, regulatory costs were compared across different farm sizes, production methods, products cultured, and primary markets. Although regulations have also provided benefits to aquaculture farms as well as to society, it is beyond the scope of this study to quantify those benefits. Ultimately this study aimed to identify areas of high regulatory burden in hopes of advancing the industry by facilitating a more efficient regulatory framework.

2 | METHODS

2.1 | Survey development and methodology

A survey tool was developed to measure the economic effects of regulations on ornamental farms in Florida. In order to obtain an accurate list of producers, the Florida Department of Agriculture and Consumer Services (FDACS) Division of Aquaculture provided a list of all registered aquaculture producers in the state of Florida. The list was then revised to include only producers who cultured ornamental fish for commercial production. Producers who exclusively sold invertebrates or corals were excluded from this study. Of the initial 126 producers identified, 52 farms were determined to be terminating operations, out of business, or were otherwise unable to be contacted. Farms were initially contacted via phone, email, and communication through extension agents to determine their status.

The survey instrument was initially adapted from previous sportfish/baitfish and salmonid studies (Engle et al., 2019; van Senten & Engle, 2017), which assessed regulatory impacts in those industries. Questions were modified and sections were added and removed as appropriate in order to better address the specific needs of the ornamental industry in Florida. The survey began by asking participants to provide general farm information such as types of facilities, species produced, annual sales, and culture techniques that were used. The remaining survey questions asked respondents to list the local, state, and federal regulations that they had to abide by to operate an ornamental farm in Florida. These included any permits, licenses, or special filings that needed to be submitted in order to operate a farm. Manpower costs such as filing reports, completing permit applications, and maintaining vital infrastructure to remain in compliance were recorded. These costs included time spent on each activity as well as the wage or salary for that employee. Additionally, production lost because of regulations, lost access to markets, and other lost business opportunities associated with regulatory compliance were also captured. Capturing management changes that were motivated by the regulatory environment was also a key component of the survey administered to respondents. These effects were measured as either increased farm costs or lost production in terms of sales. These questions were included in all seven primary regulatory categories, which were individually addressed in the survey. The primary regulatory categories examined were: (1) losses because of fish-eating predators and predator control; (2) costs to comply with FDACS Best Management Practices program;(3) regulations concerning access to water and losses associated with restrictions; (4) lost production opportunities because of restricted species; (5) additional costs and lost production because of the restrictions on drugs and chemicals; (6) interstate shipping and fish health costs; and (7) a miscellaneous regulation category that included costs from building permits, insurance, and business licenses. The last section of the questionnaire asked participants for all farm costs on an annual basis. The

data collected from farmers were from the 2018 calendar year as the study began in 2019 and a full year of data were required.

Reliability in survey research measures the consistency of responses to questions asked. Experience with other similar studies showed that examining the list of most problematic regulations and problems with the regulatory costs reported provided a measure of reliability of key questions on the survey. In addition, separate questions were asked of the total farm costs in 2018 and then also the detailed line-item expenditures that were subsequently summed for comparison with the response on total farm costs. The validity of the study was examined through a variety of means. The survey instrument was reviewed by industry experts and then pre-tested with several established farmers to ensure that questions that were asked were relevant to the ornamental industry and would elicit appropriate responses. Survey participants were confirmed to be farmers in the ornamental aquaculture trade who were in some type of managerial position at their business. Moreover, the cost data that were collected were obtained directly from farm records and accounting software in order to ensure the most accurate data were collected.

Prior to beginning the survey, participants were informed about the project, including how and what kind of data would be collected, and how that information would be used to benefit the industry. Information was disseminated through site visits by extension faculty, the Florida Tropical Fish Farms Association, and a workshop held by researchers to explain the goals of the study and respond to questions. Farmers were then contacted via telephone or email to gauge their interest in contributing to the study and to schedule a time to complete the questionnaire. The survey was administered via in-person interviews on individual farms or over the phone. Time to complete each observation ranged from 30 to 90 min.

The confidentiality of the data was an important component of the study, which cannot be overlooked. The data that were provided for this research was highly sensitive business data pertaining to business costs and sales. All researchers on this project who had access to the data were required to sign a confidentiality agreement, which was presented to farmers before the surveys were conducted. Data were coded to remove any type of identifiable information, and individual farm data were averaged, summed, or otherwise manipulated with other farm data to remove the possibility of back-tracing data to any one farm. Data were used only for the explicit purposes of this study and not shared with other third parties. Identifiable information or data will be destroyed when the findings of this study are published.

2.2 | Data analysis

Definitions for "regulatory costs" and "value of lost production" adhere to those previously defined by Engle et al. (2019). Regulatory costs are costs associated with regulatory compliance such as manpower, permits, infrastructure, and other management changes. The value of lost production calculated for this study was based primarily on farmer estimation of the lost production because of regulations. Although a minority of farmers recorded data for production losses, many did not and had to base their losses on market knowledge and their expert understanding of their businesses and the ornamental sector. For each observation, the total regulatory cost was calculated by first determining the regulatory cost for each of the seven respective regulatory categories. Those costs were broken into several indirect and direct cost categories including total capital investment costs as well as annualized fixed costs and annual variable costs. Annual fixed and variable costs were calculated as a percentage of total annual costs to determine their relative importance. The percent of total annual costs that were fixed versus variable was calculated for each regulatory category as well. Additionally, any lost production or business opportunities were calculated across the regulatory categories and tabulated separately from the other costs. These regulatory costs and value of lost production because of regulations were then compared with the farm's gross sales from 2018 as well as their total costs from that year and then presented as a percentage. Regulatory cost or value of lost production because of regulations per $1,000 of sales was determined as an additional measure of any scalable impacts from regulations.

All metrics were then averaged for each regulatory category to determine industry-wide impacts. Additionally, total annual regulatory costs and value of lost production because of regulations were compared with the industry's gross sales and costs to determine a percentage impact. Regulatory costs and value of lost production because of regulations were then summed across the seven regulatory categories to determine total regulatory effects industry-wide. The total industry costs from regulations and the value of production losses because of regulations were adjusted for survey coverage to estimate the total state-wide values.

2.3 | Regulatory costs by groupings

Observations were aggregated by categories of farms with similar business practices and characteristics to determine if there were higher or lower regulatory impacts based on the type of producer. These comparisons included farms that primarily cultured fish indoors in aquarium/tank facilities versus outdoors in earthen ponds, and comparisons between farms that targeted different market channels. Those market channels included international destinations, direct to wholesale producers, or farms that sold direct to retail or final consumers. Farms were initially sorted by size as determined by their gross sales from 2018. These size categories were based on transition points identified from graphs of respondent gross sales. Following consultation with industry experts, the following size categories were defined: (1) "small" farms with sales less than $100,000 per year; (2) "medium" farms with sales between $101,000 to $500,000 per year; (3) "large" farms with sales between $500,000 and $2,000,000 per year; and (4) "extra-large" farms with sales greater than $2,000,000 per year (Figure 1). Previous studies had grouped farms according to size by the volume of fish sold annually. However, this categorization was not possible in the Florida ornamental industry because of the variability in the definition of a "product" and the corresponding farm records that are based on sales revenue, not weight, of the wide variety of animals and plants sold in the ornamental trade.

2.4 | Coverage and response rates

The overall response rate for this study was 41%, with a coverage rate of 82% (Table 1). Coverage was calculated by dividing the gross sales for each observation recorded by the total industry sales. The value of the ornamental industry in Florida was estimated based on the expertise of industry leaders who have decades of experience working in

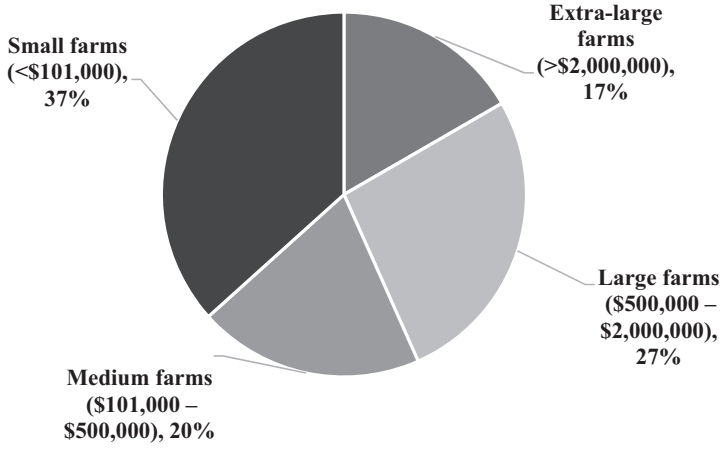

FIGURE 1 Breakdown of ornamental fish farms in Florida based on gross sales from 2018

and around the ornamental aquaculture industry. This study was conducted as a census of the ornamental industry, but ultimately all farms were not able to be surveyed. Non-response bias is a concern in all surveys. In this study, the very high coverage rate of 82% shows that the data represent 82% of ornamental fish production in Florida. Previous regulatory studies have all shown more severe regulatory cost burdens on small-scale farmers. In this study, the data represent four different size categories, including small-scale ornamental fish producers. Additionally, the data include the range of farm types recognized by industry experts, such as marine producers, indoor farmers, and start-up farm businesses.

3 | RESULTS

3.1 | Top issues on ornamental farms

Farmers were asked to rank the top issues faced in conducting their business and operating their farms. The issues that were presented to them were problems controlling disease outbreaks, access to affordable and/or quality labor, accessing new or current markets for their products, high costs or difficulty navigating regulations, competition from foreign imports, pressure to sell land for urbanization and development, and an open-ended response where other issues could be reported. Results were categorized by the percent of respondents who ranked the issue as the most or second-most impactful issue. Import pressure was reported as a top-two issue for 32% of respondents, labor was the second-most frequent top-two issue as ranked by 27% of respondents, and regulations and diseases were reported as being a top-two issue by 13% of respondents (Figure 2). Respondents were also asked to list and rank the most burdensome regulations, which affect their ornamental aquaculture operation. Responses were then coded into respective regulatory categories and the top two choices from each participant were counted. Interstate shipping was a top-two regulatory problem for 37% of respondents, access to water was an issue for 33%, and regulations pertaining to drugs and chemicals for 27% of all respondents (Table 2).

3.2 | Ornamental markets

The ornamental aquaculture industry sells to a variety of markets, with the size of the operation generally influencing the targeted markets. Small farms typically sold exclusively to wholesalers, medium-sized farms sold direct to retailers or consumers, and large farms were represented as wholesalers and international shippers. In the state of Florida, 87% of farmers shipped their fish within the state in some capacity, with 50% of those farmers selling only to in-state customers. Forty percent of farmers indicated that they ship outside of the state and on average a farm would sell to 19 states in 1 year. International shippers comprise 33% of the industry with popular destinations including Canada, Mexico, the Caribbean, and the European Union.

TABLE 1 Survey statistics for ornamental aquaculture census in Florida

	Number of farms	Percent
List frame	74	
Refusals	44	
Completed surveys	30	
Response rate		41
Coverage rate		82

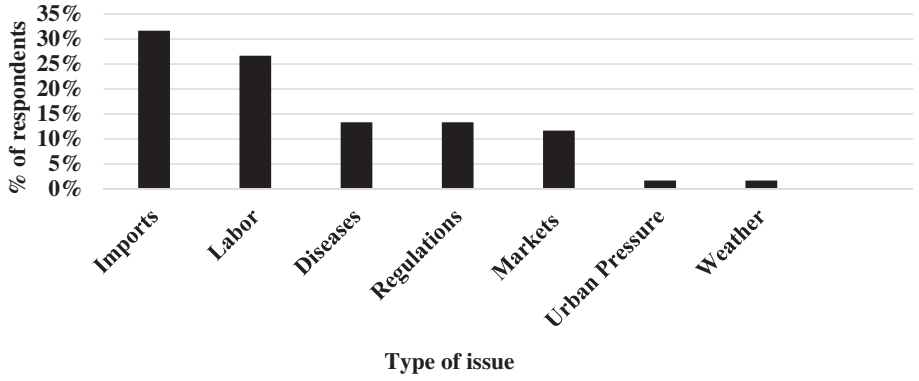

FIGURE 2 Percent of farmers who ranked the following issues as either first or second with respect to the greatest challenges facing the ornamental industry

TABLE 2 Top two regulatory burdens for ornamental aquaculture farmers in Florida

Regulatory category (regulating agency)	% of respondents
Interstate/international shipping (USDA)	37%
Access to water (FDEP)	33%
Drugs/chemicals (FDA/EPA)	27%
Best management practices program compliance (FDACS)	17%
Restricted species (FWC)	17%
Bird control (USDA)	13%
Other	10%
Import competition	3%

Abbreviations: EPA, Environmental Protection Agency; FDA, Food and Drug Administration; FDACS, Florida Department of Agriculture and Consumer Services; FDEP, Florida Department of Environmental Protection; FWC, Florida Fish and Wildlife Conservation Commission; USDA, U.S. Department of Agriculture.

3.3 | Permits and licenses

Participants were asked to report all required permits and licenses to produce ornamental fish in Florida. These permits included those required at the federal, state, county, and local levels. Some of these permits were only required if the farmer was participating in certain activities such as international sales or bird depredation, whereas others were required irrespective of activity. Permits were categorized into seven survey categories based on function and associated impact. On average, farmers possessed three permits or licenses per farm ranging from one to six permits for the surveyed participants. If multiple permits were required for the same activity, they were only counted once in this instance (i.e., international USDA APHIS permits). Cumulative permit applications per farm averaged 10 per year ranging from 1 to 103 renewals annually.

One permit that was common among all of the respondents was the FDACS Aquaculture Certificate, which is renewed on an annual basis following an on-farm inspection performed by the agency. Primary compliance requirements include runoff control devices, escapement control, and environmental stewardship (FDACS, 2016). The DEP requires that farms that have a well greater than 6 in. in diameter apply for a permit and be monitored for their water usage. Farms with wells below this threshold are not required to have a permit or have their water use monitored. The permits are issued and regulated by five water management districts created by the Florida DEP. The USDA

issues export health certificates for certain state and international shipping requirements, which are required on a per-shipment basis and need a veterinarian to certify that the organisms do not pose a disease transmission threat. Additionally, the USFWS issues bird depredation permits to farmers who wish to control the impact of predatory birds on crops of fish housed in exposed earthen ponds. Other miscellaneous permits reported include business licenses, building permits for non-agricultural structures, and Occupational Health and Safety Administration (OSHA) permits.

3.4 | Regulatory costs and the value of lost production because of regulations: Regulatory categories

The costs because of regulations and the values of lost production because of regulations were summed separately across each of the regulatory categories and then divided by the total regulatory costs and lost production values to determine a percent contribution for each category. Regulatory costs totaled $5.2 million and the value of lost production totaled $23.2 million across all regulatory categories after they were adjusted for industry coverage from the study. Regulatory costs (49% of the total) and production losses (44% of the total) because of restricted drugs and chemicals contributed the greatest in both analyses (Figures 3 and 4). Miscellaneous regulations had the second highest value for losses in production because of regulations at 28%, whereas losses in production because of predators had the third-highest contribution at 13% (Figure 3). Regulatory costs for predator control contributed the second-most (34%) and water restrictions had the third-highest contribution at 13% (Figure 4).

Regulatory costs were highest in the restricted drugs and chemicals category ($2.1 million) with an average of $69,559 in total regulatory costs per observation, an increase of $95 in regulatory costs per $1,000 of sales on average per farm, the highest rate of increase among all regulatory categories (Table 3). Additionally, these costs were entirely made up of variable costs and represented 10% of all industry costs (Table 3). Lost production opportunities because of the restriction of these drugs and chemicals were also the highest among the other regulatory categories ($8.5 million), averaging $280,786 per farm or $686 per $1,000 in sales, also the highest rate for all categories (Table 4). These lost opportunities could amount to an additional 19% in additional sales and represented 41% of industry costs (Table 4). The three drugs and chemicals that were most commonly reported by participants were methyltestosterone (MT), Dylox 420 SL®, and Baytex® (Table 5). MT was reported as a desirable drug by 43% of participants and its potential industrial use would increase a farmer's sales by 56% on average or add $4.2 million to

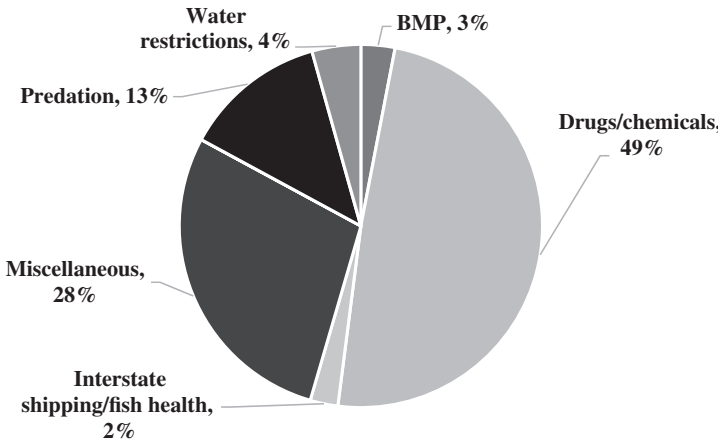

FIGURE 3 Percent of regulatory costs by regulation category

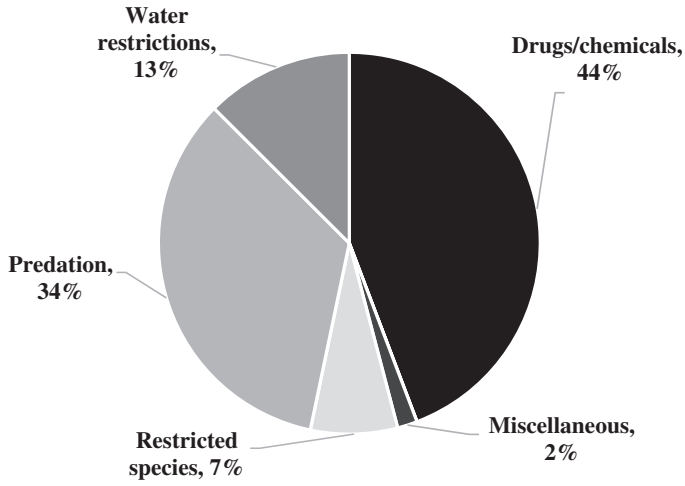

FIGURE 4 Percent of lost production because of regulations by regulatory category

TABLE 3 Regulatory costs by regulatory category on ornamental aquaculture farms in Florida

Regulatory category	Total	Average loss per farm (median)	Average loss per $1,000 of sales (median)	Mean of total sales	Mean of total costs	Fixed costs	Variable costs
Best management practices program	$129,141	$4,305 (1,898)	$50 (5)	<1%	<1%	28%	72%
Restricted drugs and chemicals	$2,086,764	$69,559 (0)	$95 (0)	5%	10%	0%	100%
Interstate shipping and fish health	$105,404	$3,513 (0)	$3 (0)	<1%	<1%	19%	81%
Miscellaneous	$1,209,308	$40,310 (0)	$84 (0)	3%	6%	74%	26%
Predation	$543,190	$18,106 (4,967)	$75 (12)	1%	3%	66%	34%
Water restrictions	$185,308	$6,177 (13)	$9 (<1)	<1%	1%	10%	91%
Industry w/out coverage	$4,259,115	$141,971	$317	9%	21%	31%	69%
Industry with coverage	$5,194,043	$173,135	$387	11%	26%		

Note: Values are in $/year or % of industry sales/costs. The restricted species category had no regulatory costs reported across all observations.

current industry sales. Interest in Dylox® was reported by 40% of participants and legalization of its use would increase an individual's sales by 107% or contribute $2.6 million to industry production. Desired access to Baytex® was reported by 37% of participants and could benefit farmers by increasing sales by 37% on average or add $1.7 million to the industry. (Table 5).

TABLE 4 Value of production losses as a result of regulations on ornamental aquaculture farms in Florida

Regulatory category	Total	Average loss per farm (median)	Average loss per $1,000 of sales (median)	Mean of total sales	Mean of total costs
Restricted drugs and chemicals	$8,423,572	$280,786 (183,325)	$686 (116)	19%	41%
Miscellaneous	$320,000	$10,667 (10,000)	$61 (0)	1%	2%
Restricted species	$1,401,483	$46,716 (120,000)	$410 (0)	3%	7%
Predation	$6,511,930	$217,064 (60,000)	$164 (100)	14%	32%
Water restrictions	$2,385,000	$79,500 (75,000)	$80 (0)	5%	12%
Industry w/out coverage	$19,041,985	$634,732	$1,401	42%	93%
Industry with coverage	$23,221,933	$774,063	$1,709	51%	113%

Note: Values are in $/year or % of industry sales/costs. The Best Management Practice program and the interstate shipping and fish health categories both had no production losses because of regulations reported across all observations.

TABLE 5 Value of lost production as a percent of total sales for restricted drugs and chemicals

Type of drug/chemical (regulating agency)	Farms who would like access	Mean of total sales ($)
Methyltestosterone (DEA)	43%	
Value of lost production		56% ($4,228,077)
Dylox 420 SL (EPA)	40%	
Value of lost production		107% ($2,581,488)
Baytex (EPA)	37%	
Value of lost production		44% ($1,693,028)

Note: The percent mean of total sales is on a per farm basis.
Abbreviations: DEA, Drug Enforcement Agency; EPA, Environmental Protection Agency.

Costs because of miscellaneous regulations were the second highest among the regulatory categories totaling $1.2 million. These costs averaged $40,301 per observation (Table 3). The regulatory costs that contributed the most to the miscellaneous category were costs associated with compliance with the USDA crop insurance program. These regulatory costs included supplies to cover outdoor ponds with greenhouse plastic to provide insulation in the winter and the labor associated with those activities. Additional regulatory costs in this category include OSHA compliance costs and building code and permit compliance for nonagricultural structures. The value of lost production because of regulations was the lowest for the miscellaneous category, which reported production losses at an average of $10,667 per observation only increasing $61 per $1,000 of sales per observation, the lowest rate of increase of all categories (Table 4).

Costs because of predator control were the third-highest regulatory category in terms of average on-farm costs at $18,106 per observation and totaling $543,190 across the industry (Table 3). The more significant impact for this regulatory category was observed in the lost production because of the regulatory environment. These production losses amounted to $217,064 per observation (totaling $6.5 million industry-wide), made up 14% of total industry sales, and on average accounted for 24% of a farmer's total sales (Table 4). Farmers in Florida are exposed to a variety of different predators, which impact their businesses in different ways. Producers were asked to rank the impact of fish-eating predators on their farms as "takes quite a few fish" as the most impactful, "takes some fish" as moderately impactful, and "does not take many fish" as the least impactful option. Birds such as herons, cormorants, and

ospreys were the most common predator reported by participants (70%), with 62% of respondents stating that these species had the greatest impact on their farms (Table 6). The second-most frequently reported predator was turtles, with 50% of farmers reporting issues from turtles and 60% of respondents listing them in the moderate impact category (Table 6). Otters were identified as the third most common predator, with 47% of respondents reporting production losses from them and 57% of those farmers reporting them in the highest impact category (Table 6).

Although there were no regulatory costs associated with restricted species regulations, some participants reported significant values of lost production because of the inability to culture and market potentially profitable fish ($1.4 million in total). These production losses averaged $46,716 per farm (Table 4). Although a minority of respondents indicated interest in the marketability of restricted species, those that did reported a high potential for increased sales based on market knowledge and an estimation of consumer demand. These species included leucistic *Atractosteus spatula* (alligator gar), *Scleropages formosus* (Asian arowana), *Cherax* spp. (ornamental crayfish), and *Cichla ocellaris* (peacock bass) (Table 7).

Water is an essential component requisite to the proper functioning of any aquaculture facility, and in Florida, restrictions pertaining to water access have had a quantifiable impact on ornamental producers, regardless of the species being cultured. Although regulatory costs associated with water access were the second lowest of all categories ($6,177 per farm; $185,308 industry-wide), lost production because of regulatory restrictions was third highest per farm averaging $79,500 and totaling $2.4 million across the industry (Table 3, Table 4). These costs accounted for 12% of total industry costs (Table 4). Regulatory costs associated with water restrictions included implementation of infrastructure such as recirculating aquaculture systems and reclamation facilities, labor associated with operating those facilities, and permit costs for wells.

The final two regulatory categories were regulatory costs and the value of lost production because of the FDACS BMP program and interstate shipping and fish health costs. Both of these categories did not result in reported losses in production because of regulations; however, producers averaged $4,305 per farm ($129,141 in total) and $3,513 in costs per farm because of regulations ($105,404 in total), respectively (Table 3). Regulatory costs

TABLE 6 Top three most impactful predators on ornamental aquaculture farms in Florida

Predator type	% of farms reporting	Takes quite a few fish	Takes some fish	Does not take many fish
Birds	70%			
Percent of respondents		62%	29%	10%
Turtles	50%			
Percent of respondents		27%	60%	13%
Otters	47%			
Percent of respondents		57%	29%	14%

Note: Other predators reported by participants include frogs, raccoons, snakes, crawfish, walking catfish, rodents, and alligators.

TABLE 7 Projected market value of restricted species as a percentage of current total sales

Species type (regulating agency)	Mean of total sales
Leucistic alligator gar, *Atractosteus spatula* (FWC) $n = 7$	89%
Asian arowana, *Scleropages formosus* (USFWS) $n = 5$	44%
Crayfish, *Cherax* spp. (FWC) $n = 2$	184%
Peacock bass, *Cichla ocellaris* (FWC) $n = 2$	17%

Abbreviations: FWC, Florida Fish and Wildlife Conservation Commission; USFWS, U.S. Fish and Wildlife Service.

for BMP compliance included the construction of water control structures such as ditches and retention ponds, the maintenance of those structures, and labor associated with inspections and record keeping. Costs associated with interstate shipping and fish health were primarily related to the logistics, testing, and fees associated with interstate and international shipping, which require specific testing.

3.5 | Regulatory costs and the value of lost production because of regulations: Production strategies, scale, and markets

Farms were segregated into four size categories based on total annual sales for 2018. Costs associated with regulations increased as farm size increased but then dropped for the largest farm size category (Table 8). Extra-large farms had the lowest cost per $1,000 of sales, average percent of total sales, and average percent of total costs among all of the size categories (Table 8). Variable costs made up the majority of the regulatory costs for all size categories except for extra-large farms where 77% of the costs came from fixed costs (Table 8). Lost production because of regulations increased across all size categories as farm size increased, whereas average production losses per $1,000 of sales decreased with increasing farm size (Table 9).

A separate analysis was conducted that grouped farms according to facilities that primarily cultured animals in indoor, controlled environments and those that primarily produce outdoors in open-air ponds. The purpose was to identify differences, if any, between the two types of culture methods. The average cost of regulations per farm was lower for farms that primarily cultured indoors at $3,789 as opposed to $138,181 for outdoor facilities (Table 10). Variable costs also made up the majority of the costs for outdoor farms at 69%, whereas fixed and variable costs were essentially even for farms that grew fish indoors (Table 10). Lost production because of regulatory costs were

TABLE 8 Regulatory costs for four different size categories of ornamental aquaculture farms in Florida

Size category	Total	Average cost per farm (median)	Average cost per $1,000 of sales (median)	Mean of total sales	Mean of total costs	Fixed costs	Variable costs
Small farms	$182,594	$6,086 (11,025)	$340 (335)	38%	37%	16%	84%
Medium farms	$591,012	$19,700 (53,384)	$450 (194)	37%	47%	47%	53%
Large farms	$2,616,388	$87,213 (151,654)	$365 (158)	36%	41%	13%	87%
Extra-large farms	$869,122	$28,971 (56,386)	$29 (15)	2%	7%	77%	23%

Note: Values are in $/year or % of industry sales/costs.

TABLE 9 Value of production losses because of regulations for four different size categories of ornamental aquaculture farms in Florida

Size category	Total	Average loss per farm (median)	Average loss per $1,000 of sales (median)	Mean of total sales	Mean of total costs
Small farms	$1,293,566	$43,119 (33,000)	$27,249 (1,565)	273%	260%
Medium farms	$2,194,954	$73,165 (347,775)	$7,743 (1,060)	136%	175%
Large farms	$4,816,695	$160,557 (244,021)	$5,457 (280)	67%	76%
Extra-large farms	$10,736,770	$357,892 (361,770)	$1,589 (157)	30%	87%

Note: Values are in $/year or % of industry sales/costs.

TABLE 10 Regulatory costs for two different culture strategies on ornamental aquaculture farms in Florida

Culture method	Total	Average cost per farm (median)	Average cost per $1,000 of sales (median)	Mean of total sales	Mean of total costs	Fixed costs	Variable costs
Indoor	$113,673	$3,789 (800)	$ 68 (14)	1%	3%	51%	49%
Outdoor	$4,145,443	$138,181 (37,550)	$ 392 (263)	11%	25%	31%	69%

Note: Values are in $/year or % of industry sales/costs.

TABLE 11 Value of production lost because of regulations for two different culture strategies on ornamental aquaculture farms in Florida

Culture method	Total	Average loss per farm (median)	Average loss per $1,000 of sales (median)	Mean of total sales	Mean of total costs
Indoor	$101,783	$3,393 (0)	$2,803 (0)	1%	3%
Outdoor	$18,940,202	$631,340 (1,017)	$39,235 (254,150)	51%	115%

Note: Values are in $/year or % of industry sales/costs.

TABLE 12 Regulatory costs for three different market types for ornamental aquaculture farms in Florida

Market type	Total	Average cost per farm (median)	Average cost per $1,000 of sales (median)	Mean of total sales	Mean of total costs	Fixed costs	Variable costs
International	$1,774,005	$59,134 (44,984)	$183 (20)	5%	18%	30%	70%
Direct to wholesale	$745,207	$24,840 (37,550)	$280 (263)	16%	16%	68%	32%
Retail/other	$1,739,904	$57,997 (7,614)	$469 (250)	28%	29%	16%	84%

Note: Values are in $/year or % of industry sales/costs.

TABLE 13 Value of lost production because of regulations for three different market types for ornamental aquaculture farms in Florida

Market type	Total	Average loss per farm (median)	Average loss per $1,000 of sales (median)	Mean of total sales	Mean of total costs
International	$8,218,347	$273,945 (80,074)	$7,391 (143)	24%	84%
Direct to wholesale	$2,918,884	$97,296 (254,150)	$16,265 (893)	61%	64%
Retail/other	$7,904,754	$246,992 (114,000)	$15,907 (1,565)	124%	127%

Note: Values are in $/year or % of industry sales/costs.

also much higher for outdoor farms as they averaged $631,340 per farm, whereas indoor farms averaged $3,392 per farm (Table 11). Although an analysis was conducted to distinguish any regulatory differences between freshwater and marine producers, the results proved to be consistent with the indoor versus outdoor results with freshwater producers making up the majority of outdoor farms and marine producers comprising the majority of indoor farms. Thus, the results of that analysis were excluded to avoid presenting redundant results.

Finally, farms were separated into groups based on their target market. Farms that sold to international markets had the highest regulatory costs averaging $59,134 per farm, farms that sold to retail customers had the second

highest average costs at $57,997 per farm, and farms that sold direct to wholesalers had the lowest average costs at $24,840 per farm (Table 12). However, average cost per $1,000 of sales, mean percent of total sales, and mean percent of total costs were highest for international sellers and lowest for retail sellers (Table 12). Variable costs were highest for retail sellers, making up 84% of their total costs and lowest for wholesale sellers at 32% of total costs (Table 12). Average lost production per farm was highest for international producers ($273,945) and nearly as high for retail producers ($263,492) with wholesale sellers with the lowest average production losses because of regulations at $97,296 (Table 13).

4 | DISCUSSION

Farmers indicated that competing with imported products was the most challenging issue for their businesses as these products often were cheaper and had a higher production value because of the lack of regulatory compliance in exporting countries. Drugs such as methyltestosterone, which enhance a fish's color, coupled with cheaper labor, lead to domestic producers competing in the global marketplace at a disadvantage. An alternative solution to the deregulation of drugs and chemicals in the United States proposed by many farmers was the prohibition of imported ornamental fish, which came from countries that had fewer regulatory restrictions. The difficulty with enforcing this proposition is evident as screening the millions of fish that enter the United States annually would be highly cost-prohibitive. This conflict is seen in other domestic aquaculture sectors including the catfish/pangasius, salmonid, and shrimp industries (Anderson, Asche, & Garlock, 2019). Although ornamental producers had ranked interstate shipping and fish health regulations as the most burdensome regulation that they face on their farms, the regulatory cost data relegated interstate shipping and fish health category to the lowest impact. This may be because of the fact that producers chose not to engage in international shipping practices simply because they were deterred due to the regulatory compliance. However, none of the respondents were able to accurately quantify this lost production as it was something that they had not actively pursued for their businesses.

In the state of Florida, adjusted on-farm costs because of regulations were $5.2 million across the industry averaging $141,971 per farm. These costs were approximately three times less than the total regulatory costs on salmonid farms and sportfish/baitfish operations as costs for those industries totaled $16.1 and $12 million, respectively (Engle et al., 2019; van Senten & Engle, 2017). The value of production losses because of regulations, restrictions, or compliance, however, were $23.2 million industry-wide with an estimated mean production loss value of $634,733 per farm, nearly five times more than values than in the salmonid industry ($5.3 million/year) (Engle et al., 2019). Environmental regulations and fish health testing contributed significantly to the regulatory costs and value of lost production in the salmonid and sportfish/baitfish industries. Fish health testing costs were especially onerous on farms selling into sportfishing markets either for bait (van Senten & Engle, 2017) or for recreational fishing (Engle et al., 2021). Conversely, in the ornamental industry where farms tend to be smaller in scale and sell products to non-food markets, regulatory burdens have indirect production effects in the areas of restricted drugs and chemicals, predator control, and prohibited species.

Regulatory costs were nearly two-thirds variable costs in the current study, meaning that only about one-third of the costs, which are fixed, can be spread over higher production volumes as a business expands. This is in contrast to salmonid and sportfish/baitfish producers in which the majority of regulatory costs were fixed, meaning that an increase in production would help to spread the regulatory cost over a larger volume of sales (Engle et al., 2019; van Senten & Engle, 2017). Variable costs, such as labor and feed, can thus be controlled with consolidation of production and vertical integration of processes. As variable costs continued to climb for farms, increased demand for fish from large retail chains and the buyout of many farms because of increased real estate value in Florida lead to large, national brands entering the industry. Consolidation is not exclusive to aquaculture and occurs in other sectors of agriculture for similar reasons. Most notably, dairy, egg laying, and hog industries have seen a continued

consolidation over the last three decades as producers aim to streamline costs and vertically integrate production methods (MacDonald, Hoppe, & Newton, 2018).

The value of lost production because of regulations (averaged per farm) generally increased as ornamental farm size increased. The majority of the regulatory burden in ornamental aquaculture impacted the industry's ability to increase production, making accessing more economically efficient methods difficult. If regulatory barriers were lessened, the industry would have the potential to experience a production boom similar to one observed in the salmonid industry in Norway (Asche, Roll, Sandvold, Sorvig, & Zhang, 2013).

Restricted access of specific drugs and chemicals to Florida ornamental aquaculture contributed the most to the value of lost production in the industry. The three commonly reported drugs and chemicals were MT, Dylox 420 SL, and Baytex. Methyltestosterone is used internationally in ornamental aquaculture to create phenotypic males, which demand a higher market price because of their bright coloration and enhanced ornamentation (Ramee, Lipscomb, & DiMaggio, 2020). However, methyltestosterone is currently prohibited for use in the United States under the Anabolic Steroid Act of 2004 and is classified as a controlled substance (Anabolic Steriods Control Act, 2004). The approval process for aquaculture drugs, like MT in the United States, can be laborious and generally proceeds in one of two ways. The first is traditional approval through the United States Food and Drug Administration (FDA); however, this process is typically temporally and fiscally prohibitive. The USFWS has an Investigative New Animal Drug (INAD) program to provide industries the opportunity to apply for investigative use of certain drugs in specific situations (U.S. Fish and Wildlife Service: Fish and Aquatic Conservation, 2021). The drawbacks of this method are that the participants of the study have to constantly collect data to show progress toward eventual full approval, there is a fee involved with participating, and the program must be renewed annually. The final method to facilitate access to drugs for ornamental aquaculture would be indexing for a drug under the Minor Use Minor Species (MUMS) Act of 2004. However, because of interpretation of the statute by regulators, so far only 13 drugs have been approved using this program, when at the start it was anticipated that the industry would now have more than 200 approved drugs using MUMS (Watson, 2019). In the United States, pesticides are regulated under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1910 (Federal Insecticide, Fungicide, and Rodenticide Act, 1910). Beginning in the mid-1990s, the EPA began a review of the usage of older pesticides in the United States specifically targeting organophosphates (Fishel, 2014). At the time, Baytex and Dylox were effective pesticides used in pond culture to clear harmful zooplankton and insects before the addition of larval fish for grow out. As a result of increasing concerns about applicator and public health safety, subsequent decisions were made to remove Baytex and Dylox 80 wettable powder from the market, whereas the liquid form, 420 SL, is still available for turfgrass applications. Currently, there exist five routes for industry to get approval for a pesticide: (1) traditional registration under FIFRA; (2) special local needs registration; (3) emergency exemption; (4) exemption of minimum risk pesticides; and (5) experimental use permits for field testing new products (Fishel, 2014). Options three, four, and five are not available for ornamental producers in Florida as Dylox 420 SL does not meet the requirements to be approved under those standards. Option one is a viable solution; however, pesticide approval at the federal level costs tens of millions of dollars, and the ornamental industry simply is not large enough to fund such an operation. Thus, option two remains the only viable option to approve Dylox 420 SL in Florida under a special local needs registration. Although approval processes are available to producers, these processes are historically time-consuming and can be quite costly to complete. Although these regulations were conceived to protect the environment and public from potentially harmful substances, the current regulatory structure serves as a major impediment to approval of new drugs and chemicals for smaller agricultural industries, like ornamental aquaculture.

Production losses because of fish-eating predators on ornamental aquaculture farms in Florida were the second highest production loss category because of regulations reported by farms ($6.5 million), with the value of production losses averaging $217,064 per farm. By comparison, production losses of catfish because of fish-eating birds were estimated to average $47.2 million annually in addition to expenditures to scare birds from farms of $17.5 million annually (Engle et al., 2020a) and $1.1 million annually on baitfish/sportfish farms in Arkansas alone in addition to expenditures on bird-scaring of $4.4 million per year (Engle et al., 2020b), although results varied from year-to-

year. The USFWS currently administers a program where producers can be issued a permit to trap, remove, or dispose of nuisance migratory birds, which would otherwise be protected under federal law (U.S. Fish and Wildlife Service, 2019b). In order to qualify for the permit, farmers need to document specific production losses because of birds, describe nonlethal methods that have been practiced before resorting to lethal options, and maintain a robust list of all birds taken during the permit period including removal method, species, and relocation or burial site (U.S. Fish and Wildlife Service, 2019b). Other species that impact ornamental farms including the American alligator, and a variety of turtles and birds are protected under the FWC because of their status in the wild and require special permitting to be removed (Florida Fish and Wildlife Conservation Commission, 2018). Throughout the surveying process, producers stated that allocated removal quantities permitted for nuisance pests were often not sufficient. Because of the variable nature of pests on farms and the speed with which damage could be done to a crop, farmers generally viewed the permitting process as cumbersome, as delays in the issuing of permits and the restrictions placed on farmers may lead to significant damages. The USDA APHIS Wildlife Services provides farmers with solutions to dealing with nuisance pests and can remove animals that a private citizen could not without special permissions or permitting. (Animal and Plant Health Inspection Service, 2021). Programs like these are advantageous to ornamental farmers because not only do they help to rectify immediate predator issues, but they also provide a long-term resource for farmers to utilize in addressing future issues.

The restriction of certain species cost ornamental producers $1.4 million in potential sales in 2018. On average, these restrictions contributed to $46,716 in lost production per farm. Alligator gar are protected at the state level under FWC; however, they do not have a federal or state endangered designation (Florida Fish and Wildlife Conservation Commission, 2018). In order to collect alligator gar from the wild, anglers must have special research collection permits issued to them (Florida Fish and Wildlife Conservation Commission, 2021b). The ornamental *Cherax* spp. genus of crayfish is on FWC's prohibited nonnative species list because of their potential to cause ecological and economic harm to Florida's waterways if introduced (Florida Fish and Wildlife Conservation Commission, 2021a). Peacock bass are a protected species in Florida because of their sportfish status, therefore commercial sale of this species is prohibited in order to prevent commercial competition in the sportfishing community. Asian arowana is listed as an Appendix S1 species, the most restrictive category for trade, under the Convention on International Trade in Endangered Species (CITES), which is enforced in the United States via the USFWS (CITES, 2021; U.S. Fish and Wildlife Service, 2019a). With the *Cherax* spp. genus as the exception, the aforementioned species are prohibited from commercial sale because of their status in the wild.

When comparing the regulatory burden between freshwater and saltwater producers, there were notable trends that were identified. Because marine production in Florida is largely conducted indoors, the use of beneficial pesticides, which are currently restricted, and the regulations, which impact predator control, have little to no impact on marine producers. Additionally, significantly fewer marine species would benefit from masculinization with MT, reducing the potential impact of MT accessibility issues. There were no costs associated with crop insurance compliance for marine producers because production was located in climate-controlled facilities. Although the scope of this study focused on measuring the regulatory impact of fish cultured on-site, there are some notable regulations that impact the ability of businesses to import wild-caught marine species. These regulations are primarily enforced by the USFWS through CITES to protect critically endangered species and their habitats. The majority of marine species currently available in the ornamental trade are wild caught (Pouli, Tlusty, Rhyne, & Metian, 2019), and there are research efforts from organizations like Rising Tide Conservation, to increase the amount of aquacultured species available to hobbyists.

The differences in regulatory costs and the value of production losses because of regulations in the Florida ornamental industry compared with the sportfish/baitfish and salmonid industries primarily result from its unique characteristics. Baitfish/sportfish and salmonids sold into recreational fishing markets experience substantial costs associated with state-to-state variability in testing requirements required to obtain approval permits to sell into each individual state (Engle et al., 2021; van Senten, Engle, Hartman, Johnson, & Gustafson, 2018). Additionally, Florida is

unique from many other states in that essentially, farmers are only required to hold an Aquaculture Certificate from FDACS in order to legally sell cultured fish in the state. This single agency model may be indicative of the low direct costs because of regulations compared with the other aquaculture sectors previously studied. Although fundamentally, other permits are required for supplemental activities associated with farming, this single agency clearinghouse limits the interagency competition that has been shown to hinder the growth and operation of aquaculture elsewhere (Abate et al., 2018).

Although this study provided the costs of regulations and the value of production losses because of regulations for ornamental producers in Florida, it is only a snapshot of the industry based on a single year of data. Thus, the regulatory costs and losses in production because of regulations provided do not reflect the cumulative effect of regulations over time and may actually underrepresent the total regulatory burden. Although the total values for lost production and regulatory costs were divided by the coverage rate to account for failing to census the entire industry, certain regulatory categories would almost certainly have higher regulatory costs and losses in production because of regulations if more data were collected. Additionally, because of the scope of the study, we only measured the costs of regulations and not the benefits. We acknowledge the importance that some regulations play in protecting the environment and human health, and further research could prove beneficial as a complement to this study. This investigation was also conducted simultaneously with the COVID-19 pandemic, which may have further impacted response and coverage rates. Although it was initially intended that this survey would be administered exclusively via face-to-face interviews, the study had to be transitioned almost exclusively to telephone contact. Capturing sensitive business data over the phone proved to be difficult at times and it is possible this could have impacted our response rate as some participants may not have felt comfortable sharing the information in this manner. Survey fatigue may have also been a factor as there were many COVID-19 impact studies being conducted in order to calculate losses so relief funds could be accurately distributed.

Aquaculture proves to be an interesting case study into regulatory impacts because of its novelty to the agriculture industry, the diversity of products sold to market, and the rapid global expansion. The scope of this study was to census the ornamental aquaculture industry in Florida and quantify the regulatory costs and associated production losses because of regulations. Quantifying the unintended consequences of regulations was also an important objective of this study. Ornamental aquaculture is the largest aquaculture sector in the state of Florida; however, results from this study indicate that millions of dollars of production potential could be further realized if improvements were made in the regulatory areas such as access to restricted drugs and chemicals, risk-based approaches to listing prohibited species, and more robust and user-friendly measures to control on-farm predation. These production increases would not only translate into profits for local businesses but also provide an economic boost in the form of jobs, infrastructure, and tax revenues. A vibrant and efficient domestic aquaculture industry begins with regulations that promote sustainable growth and understanding the economic impacts of those regulations is a critical step in attaining that goal.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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