Florida Aquaculture Plan

October 2019

Prioritized recommendations for applied research and economic development by the Aquaculture Review Council for the purposes of creating new technologies, improved farm productivity, increased farm income and employment and other economic and environmental benefits to the state of Florida.

Dear Floridians:

On behalf of the Aquaculture Review Council, it is my distinct pleasure and honor to present a revised and updated *Florida Aquaculture Plan* as required by the Florida Aquaculture Policy Act. The *Plan* consists of aquaculture research and development recommendations, as required by statute (597.003(1)(b) Florida Statutes), that are provided to guide public investment into answering these challenges.

Florida aquaculture is an extraordinarily diverse agribusiness. Our state's unique climate, robust infrastructure, streamlined regulations and positive business environment position Florida to become the national leader in this burgeoning agriculture sector. We culture approximately 1,500 species or varieties of fish, plants, mollusks, crustaceans, corals and aquatic reptiles for food and non-food markets that include seafood (fish and shellfish), freshwater and marine aquarium hobbyists, high fashion leather, water gardening, bait, biological control, or as "seed" for national and international aquaculturists to culture.

Societal, political and economic trends have accelerated global trade, fuel and feed cost volatility, information exchange and technology sharing. These factors require unceasing innovation by Florida farmers to remain competitive. Florida's aquaculturists are constantly adapting to change by investigating new species to culture, new markets and new sustainable production systems. This year's *Plan* includes an overview of Florida aquaculture, with statistics on various commodities from the U.S. Department of Agriculture (USDA) and the Florida Agricultural Statistics Service. While these are the most comprehensive and reliable data available, we know that they vastly underestimate the economic value of our aquaculture products (as is evident from the low survey response rate), and are not reflective of the strong growth, investment and innovation in Florida aquaculture over the past decade.

We are very appreciative of the state of Florida's history of investing public funds to support applied research, extension and education to benefit aquaculture farmers, product distributors and equipment manufacturers and suppliers. Public investment is critical to our continued success and ability to respond to unexpected technical and economic change. Support from legislators is also critical to the continued success of Florida's aquaculturists. With changing global trade dynamics, business practices, regulatory complexity and political pressures, the success of Florida's aquaculture farms will require legislative champions. We hope that the *Florida Aquaculture Plan* can serve as a tool to inform legislators of the challenges, complexities and opportunities for innovation and growth in Florida's most diverse agricultural industry.

Sincerely,

Marty Tanner, Chair
Aquaculture Review Council

Overview of Florida Aquaculture

AQUACULTURE IS AGRICULTURE

Florida's aquaculture industry produces the greatest variety of aquatic species of any state in the nation. Moreover, aquaculture is Florida's most diverse agribusiness. The state's subtropical climate, extensive marine and freshwater resources, cargo shipping infrastructure and extensive coastline has made the state's aquaculture industry uniquely diverse. There are approximately **1,000 certified aquaculture farms in Florida**, located in every region of the state (Figure 1), which produce an estimated **1,500 varieties** of fish, plants, mollusks, crustaceans, turtles and alligators. Farm gate sales of Florida aquaculture products totaled approximately **$75 million** in 2005, **$69 million** in 2012[1] and **$72 million** in 2017[2] (Figure 2).

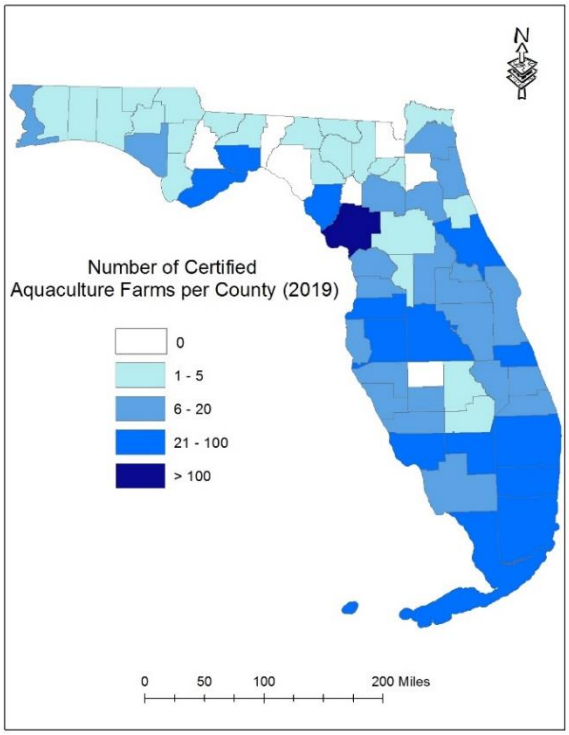

Figure 1. Density of certified aquaculture farms by county (FDACS internal data, 2019).

THE FLORIDA AQUACULTURE PLAN

The **Florida Aquaculture Policy Act** (Chapter 597, Florida Statutes) established that aquaculture is agriculture, consolidated state regulatory responsibilities under the Florida Department of Agriculture and Consumer Services (FDACS), created the **Aquaculture Review Council** (ARC) as an industry advisory council to FDACS and provided a mechanism to invest public funds into industry-identified research and development priorities. This document, the **Florida Aquaculture Plan**, outlines current research and development priorities as identified by various aquaculture industries throughout the state. The Plan is revised annually by the ARC, with input from various state aquaculture associations and industry members. The priorities outlined in the Plan are subsequently used by the ARC to annually solicit, review and recommend research

[1] Reported from 359 operations with sales in 2005 and 404 operations with sales in 2012. Based on the total number of operations certified with FDACS in those years, the overall survey response rate was 74% in 2005 and 70% in 2012. (Source: USDA, National Agricultural Statistics Service, Florida Field Office. *Aquaculture.* June 2013. NASS.USDA.gov/Statistics_by_State/Florida/Publications/ Aquaculture)

[2] 2017 values reported from 634 farms, calculated based on nine categories for aquaculture in the USDA 2017 Census of Agriculture. (Source: Botta and Court. *Briefing on Florida Aquaculture from the 2017 Census of Agriculture.* August 2019. Presented internally to FDACS)

projects through a public competitive grant funding process. In this way, the Florida Aquaculture Plan supports research which is directly driven by and has immediate use for farmers and aquaculturists throughout the state.

MAJOR AQUACULTURE COMMODITIES

Alligators

Alligators are the primary aquatic reptile aquaculture product in Florida. Beginning in St. Augustine at the turn of the 20th century, alligator aquaculture for hides, meat and tourism began to increase in popularity and profitability and continues to be a robust industry today. In 2005, 12 out of 14 operations reported sales of alligator or alligator products totaling **$4.07 million.** Hides and meat accounted for **$3.6 million** (90%) of sales in 2005. In 2012, sales from live animals at 7 farms totaled **$1.4 million** and sales from eggs, hides and meats at 5 farms totaled **$6.6 million.**

Aquatic plants

Aquatic plants include those grown for water gardens, aquariums, food markets (such as watercress) and wetland restoration. In 2005, 20 operations reported sales of aquatic plants totaling **$17.6 million, $8.4 million** of which (48%) was for ornamental markets from 17 operations. In 2012, sales (excluding those for food markets) totaled **$5.3 million** from 19 operations. Sales from aquatic plants in Florida peaked in 2001 at **$21.3 million** (Table 1), and the industry has been in decline since. Business owners attribute the significant reduction in sales to an overall decline in aquaria hobbyists in the U.S. over the past two decades.

Food fish

Food fish species produced in Florida include tilapia, catfish, sturgeon, striped bass, cobia, flounder and red drum. Sales were reported from 60 farms in 2005, including catfish, tilapia, sturgeon and bass, for a total of **$3.6 million.** Of these, 23 farms reported sales for catfish (**$1.4 million**), 18 for sales of tilapia (**$477,000**) and 19 for sales of bass, carp, sturgeon and other food fish (**$1.7 million**). In 2012, food fish sales were reported from 95 farms for a total of **$4.6 million.** Catfish sales were reported from 17 farms for a total of **$390,000** (a 72% decrease from 2005), 47 farms reported sales of tilapia for a total of **$1.2 million** (a 152% increase from 2005) and 31 farms reported sales of **$2.98 million** for other species including bass, sturgeon, carp, cobia, pompano and red drum.

Ornamentals

The ornamental industry includes marine and freshwater fish, marine and freshwater invertebrates, snails, coral and live rock. Florida ranks first in the nation for ornamental fish production—approximately 45% of the total U.S. ornamental economy—and is the largest sector of Florida's aquaculture industry (Figure 2). Ornamental fish sales in 2005 totaled **$33.2 million** from 133 operations and **$27.3 million** in 2012 from 101 operations

(Table 1). Live rock sales from 6 operations totaled **$341,000** in 2005 and **$373,000** from 12 operations in 2012. Total sales for all ornamental species were **$35.5 million** in 2012.

	Sales Value (US $1,000)				
	1997	**2001**	**2003**	**2005**	**2012**
Alligators	3,189	3,253	2,452	4,070	7,995
Aquatic Plants	13,200	21,320	20,433	17,560	5,327
Clams and Oysters*	13,078	18,264	12,970	10,694	11,889
Live Rock	n.d.	577	661	341	373
Ornamental Fish	57,200	42,424	47,229	33,232	27,269
Other Aquaculture**	13,767	3,078	3,875	7,156	12,920
Total Value	**$100,434**	**$88,916**	**$87,620**	**$73,053**	**$65,773**
Survey Response Rate	**--**	**--**	**55%**	**74%**	**70%**

Table 1. Farm gate sales value (in thousands of dollars) for select Florida aquaculture commodities, 1997-2012. The average survey response rate from all operations in 2003, 2005 and 2012 was 66%. (Source: Florida Agricultural Statistics Service (FASS); USDA Florida Field Office)

Notes: Aquatic plants for food markets (watercress) were not reported in 2012. Survey response rate was calculated from the number of total operations reported by FASS/USDA and the number of total operations certified with FDACS (internal data available starting in 2002).

* Value in 2001 includes clams only; oysters in 2001 were counted as "other aquatics." Clam sales in 2001, 2003 and 2005 were reported to include clam seed.

** Value includes catfish, tilapia and values reported as "other aquaculture." Due to inconsistency in reporting, this value does not include data on other fish, whether used for sport, game, stocking or food.

Shellfish

Hard clams dominate shellfish aquaculture in Florida, and most of the hard clam production occurs in Levy County (Figure 1). In 2012, sales reported by 139 operations totaled **$11.9 million**, with hard clams bringing in **$11.65 million** (98% of total sales). Other shellfish produced in the state include oysters and sunray venus clams. In 2005, sales of clam, clam seed and oysters from 153 operations totaled **$10.7 million** (down from $13 million in 2003), with 142 operations reporting hard clam sales of **$9.8 million** (92% of total sales). Hurricanes in 2004 and 2005 negatively impacted Florida's coastal zone, where clams are cultured, and in addition to large production losses in 2004, 55 clam farmers reported going out of business between 2003 and 2005. Nevertheless, Florida's shellfish industry has seen strong growth. The number of water column and submerged land leases for clam and oyster aquaculture has increased by 360% since 2003 (FDACS internal data, 2019).

Other commodities

Other aquaculture commodities include turtles, frogs, marine and freshwater shrimp, baitfish (including fathead minnows, shiners and novel marine species such as pinfish, killifish and croakers) and recreational game fish used for stocking (including largemouth bass, sunfish, catfish and crappie). Florida's baitfish industry increased from two farms in 2005 to 12 farms in 2012, reporting **$41,000** in sales in 2012. Sportfish sales were reported from ten farms for a total of **$97,000** in 2012, a sharp decline from **$191,000** reported in 2005. Turtles and turtle products were reported from 28 operations with **$1.2 million** in sales in 2012. Additionally, 13 farms reported shrimp sales of **$7.5 million** in 2012.

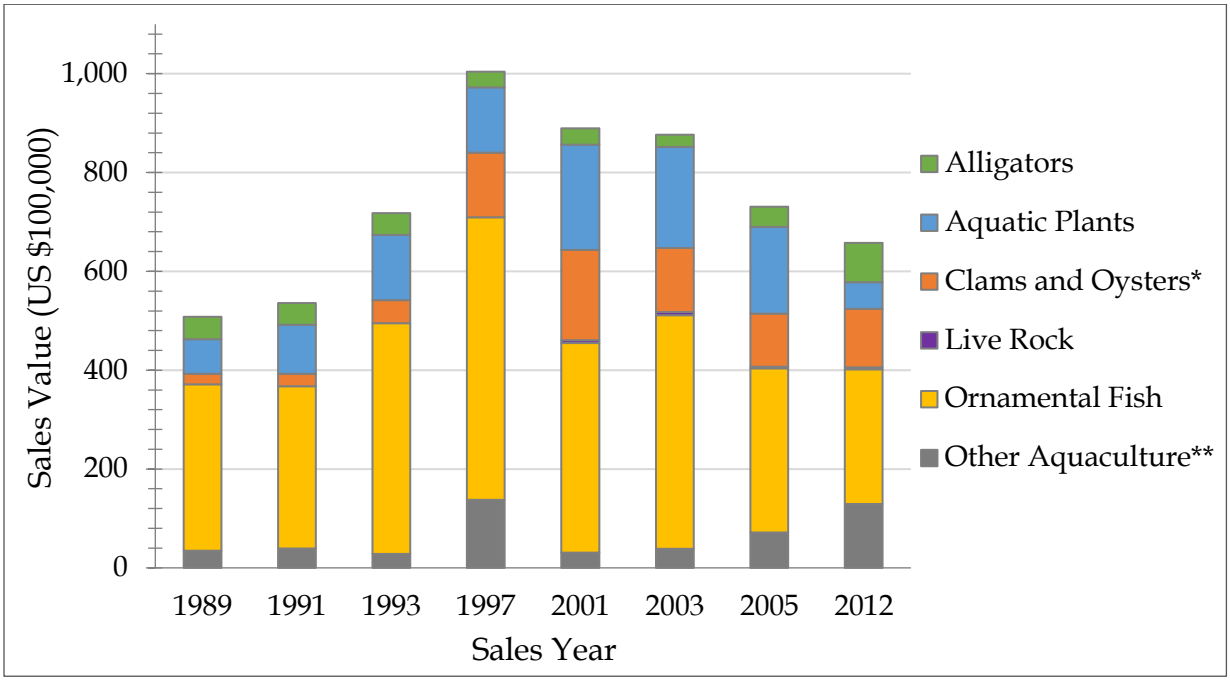

Figure 2. Farm gate sales value (in 100,000 dollars) for select Florida aquaculture commodities, 1989-2012. (Source: Florida Agricultural Statistics Service (FASS); USDA Florida Field Office)

Notes: Aquatic plants for food markets (watercress) were not reported in 2012.

* Value in 2001 includes clams only; oysters in 2001 were counted as "other aquatics." Clam sales in 2001, 2003 and 2005 were reported to include clam seed.

** Value includes catfish, tilapia and values reported as "other aquaculture," although data for tilapia were not reported in 1989. Due to inconsistency in reporting, this value does not include data on other fish, whether used for sport, game, stocking or food.

Applied Aquaculture Research and Development Priorities

These applied research and development priorities aim to answer biological or technical challenges that will benefit aquaculturists by:

- Diversifying production
- Proving the practicality of new technologies
- Improving farm productivity and sustainability
- Reducing input costs
- Increasing farm-gate income

A. Species

1. Determine ornamental fish and invertebrate species reproduction and grow-out characteristics of priority species identified by the Florida Tropical Fish Farms Association.
2. Determine production techniques for new bivalve species which have a demonstrated economic need and can be feasibly produced, processed and marketed at a commercial scale.
3. Examine the commercial feasibility of producing and marketing emerging marine and freshwater food fish or crustacean species in pond, raceway or tank systems, including an economic analysis of production costs and potential market returns.
4. Examine the commercial feasibility of producing and marketing live marine and freshwater sportfish or bait species in pond, raceway or tank systems, including an economic analysis of production costs and potential market returns.
5. Develop methods for improving genetics of commercially farmed bivalves which improve production characteristics (e.g., tolerance to high temperature, low dissolved oxygen and salinity variation) in real-world farm conditions.
6. Create a tetraploid oyster broodstock line that can be provided to Florida hatcheries.
7. Determine techniques for optimal growth and propagation of commercially important aquatic plant and moss species.
8. Research on impacts of red tide (*Karenia brevis*) on clams, including effects from exposure to low levels, uptake rates and brevetoxin kinetics in different tissues (adductor muscle, mantle, gonads, etc.).
9. Clam biotoxin depuration studies, including literature review of other methods of toxin neutralization from fields outside of aquaculture.

B. Production Cycle Improvements

1. Evaluate and recommend water conservation practices.
2. Investigate and compare costs of alternative energy sources (e.g., electric, propane, solar) to heat small and large scale grow-out systems.

3. Develop or compare methods to estimate shrimp or fish populations or biomass in ponds.
4. Research to support approval or legalization of methyl testosterone for ornamental fish.
5. Achieve the labeling of a chemical pond treatment to eliminate predacious zooplankton (e.g., Dylox 420L).
6. Increase upland aquaculture farm efficiency by identifying methods and technologies that can reduce production costs.
7. Develop methods to evaluate bivalve shellfish production technologies relative to environmental effects, cost effectiveness and efficiency.
8. Investigate remote technologies for bivalve shellfish growing area surveillance and security.
9. Evaluate the chemical and biological (i.e., phytoplankton species) characteristics of shellfish hatchery production waters which maximize the survival and growth of commercially important bivalve species at early life stages.
10. Scale-up for commercial application of emerging technologies to mitigate off-flavor compounds in food fish recirculating production systems.
11. Investigate Integrated Aquaculture Systems (IAS) and Integrated Multi-Trophic Aquaculture (IMTA) to improve recirculating aquaculture system economics.
12. Develop water quality specific mineral supplement recommendations for low-salinity marine shrimp grow-out.
13. Develop alligator recirculating production system technologies to reduce water and energy consumption/costs.
14. Develop out-of-season spawning protocols to increase year-round oyster seed availability.
15. Provide extension services to oyster hatcheries for tetraploid stock development training, including providing access to specialized laboratory equipment.
16. Provide extension services to new and existing farmers to help them improve productivity, survival, optimal growth rates and marketing strategies.

C. Animal and Plant Health

1. Identify and develop disease diagnostic tools and potential treatment and prevention options, such as vaccines and regular disease surveillance programs.
2. Investigate methods to control microbial communities in aquaculture hatcheries and larval rearing systems.
3. Develop or enhance regular biosecurity training for growers and hatcheries, in both English and Spanish.
4. Develop a protocol to nest, incubate and hatch alligators to increase hatch rates and reduce or eliminate umbilical scarring.
5. Develop a protocol for rearing alligators to increase growth rates and reduce scarring from bites (density levels, frequency of feeding, water level and optimum grow-out house temperature).
6. Develop an environmental health monitoring program for shellfish hatcheries.

7. Investigate methods to control aquatic plant predators (i.e., *Physella* spp., *Marisa* spp., Lepidoptera, Amphipoda).
8. Provide pathology extension services to farmers to address and help resolve mortality and disease issues.

D. Nutrition

1. Develop or improve live feed species and production protocols for marine and freshwater aquaculture species.
2. Evaluate alternative feed ingredients and dietary formulations to reduce feed costs and increase growth and reproduction of Florida aquaculture species.
3. Collect, identify, isolate and culture new native marine phytoplankton strains isolated from Florida waters for use in Florida hatcheries (for bivalves, fish, shrimp and other uses).

E. Environment

1. Conduct a science-based risk analysis (assessment and management) of non-native species that informs responsible cultivation and regulatory decisions.
2. Quantify biotic and abiotic resistance to non-native species introduction in disturbed and undisturbed habitat.
3. Assess interactions between coastal aquatic environments and shellfish aquaculture lease sites, focusing on metrics such as carrying capacity, primary productivity and species interactions.
4. Determine upper/lower temperature tolerances of priority ornamental species to inform regulatory decisions.
5. Water quality testing and analysis (including chemical water properties, phytoplankton food sources, bacteria and other pathogens and land-based local chemical inputs) to establish baselines, understand potential mortality impacts and understand the conditions necessary for efficient production of bivalve (hard clams and oysters) larvae (≤ 4mm).
6. Investigate non-plastic alternatives to clam cover netting.

F. Food Safety

1. Develop and obtain U.S. Food and Drug Administration (FDA) approval of an enzyme-linked immunosorbent assay (ELISA) and/or a liquid chromatography-mass spectrometry (LC-MS) test for determination of brevetoxin concentrations in shellfish (oyster or clam) meats.
2. Assess/develop harvest management and/or monitoring tools in compliance with the National Shellfish Sanitation Program (NSSP) harvest/handling requirements to assure product quality of cultured oysters.
3. Develop and provide regular
   HACCP) education for aquaculture processing facilities.

G. Marketing

1. Test Florida aquaculture product branding opportunities (i.e., social media campaign, product source and quality benefits).
2. Develop and test new biodegradable and other non-styrofoam materials for shipping utility.
3. Develop an aquaculture-based model for agricultural tourism, and evaluate potential economic, educational and/or marketing impacts.
4. Identify domestic markets for grade 2 and 3 green, salted alligator skins.
5. Identify designers and/or manufacturers in Florida and the U.S. and educate them on marketing off grade alligator hides.
6. Conduct market research that could lead to expanding FDACS promotional support to develop and provide effective materials and programs that promote increased demand for farm-raised aquaculture products.

H. Economic Analysis

1. Conduct a Florida aquaculture development analysis to: 1) define aquaculture resource needs: water, soils, temperature; 2) describe and map geopolitical regions of the state that welcome aquaculture activities, agriculture zoning, potential municipal partnerships that will accept effluents and farming segments that will accept effluents for crop irrigation; and 3) combine and provide this information as a GIS tool to state and county economic development officials.

I. Education

1. Support school education programs leading to certification(s) of competency in aquaculture.
2. Create an outreach campaign to promote the environmental benefits provided by Florida's aquaculture industry to community stakeholders, consumers and conservation organizations.
3. Develop a continuing education or licensing program for aquaculture workers, producers and processors in Florida.
4. Conduct a Florida aquaculture promotion/public education campaign.
5. Create and conduct an aquarium fish and plant promotional campaign to increase sales and product values.
6. Compile scientific literature and data related to clams and oysters in Florida and archive them in one place that is accessible to farmers, researchers and regulators.

To learn more about Florida aquaculture, visit the Florida Department of Agriculture and Consumer Services website, www.FDACS.gov, or contact the Division of Aquaculture at (850) 617-7600.

For additional information, please contact:

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Cover images, clockwise from top left: Assorted ornamental aquatic plants in aquarium; Tilapia; Angel fish; Alligator