growing MARINE BAITFISH

A guide to Florida's common marine baitfish and their potential for aquaculture

Sea Grant Florida

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A guide to Florida's common marine baitfish and their potential for aquaculture

CORTNEY L. OHS

R. LEROY CRESWELL

MATTHEW A. DIMAGGIO

University of Florida/IFAS
Indian River Research and Education Center
2199 South Rock Road
Fort Pierce, Florida 34945

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ABOUT

Florida's recreational fishery has a $7.5 billion annual economic impact—the highest in the United States. In 2006 Florida's recreational saltwater fishery alone had an economic impact of $5.2 billion and was responsible for 51,500 jobs.

Despite Florida's status as a premier fishing location, only two of the 257 baitfish farms recorded in the 2005 USDA Census of Aquaculture were located in Florida. Since 2005 about 10 new marine baitfish farms have been added, but this disparity clearly illustrates the potential for expansion and diversification of aquaculture within Florida to include marine baitfish production.

Today almost all marine baitfishes sold in stores are wild caught using nets and traps, making availability of most species seasonal despite a year-round demand. Marine baitfish produced by aquaculture could provide anglers with a consistent supply of sought-after species in desired sizes regardless of season, as well as potentially alleviate collection pressure on targeted wild populations.

Successful production and marketing of marine baitfish will require a business plan that includes production of multiple crops through controlled spawning during the off-cycle. A year-round supply would allow marketing of cultured baitfish when the wild supply is limited so that a premium price can be attained.

Substantial research to evaluate the aquaculture potential of many species of marine baitfish suggests that some species have high aquaculture potential while others, for a variety of reasons, are less promising. You can learn more by reading the research and extension publications referenced at the end of this document, and by visiting the University of Florida/IFAS Indian River Research and Education Center's aquaculture website:

http://irrec.ifas.ufl.edu/aquaculture/index.html

CROAKER

hardhead, chut, king billies, grumblers, grunter, corvina, crocus, rocodina, madzuki

Louisiana Seafood Exchange

Micropogonias undulatus (Family Sciaenidae, drums)

Croaker are medium-sized, slightly elongate, moderately compressed, and silvery in color with a pinkish cast. The back and upper sides are grayish with black spots forming irregular, oblique lines above the lateral line. The dorsal fin has small black dots and a black edge; other fins are pale to yellowish. The chin has three to five pairs of barbels along the inner edge of the lower jaw. Atlantic croaker "croak" by vibrating their swim bladders with special muscles as part of their spawning ritual and when handled.

Range: The Atlantic croaker occurs in the northern and eastern parts of the Gulf of Mexico, along the Atlantic coast of the United States from south Massachusetts to Florida, in the Greater Antilles, and along the South American Atlantic coast from Surinam to Argentina. Its US fishing grounds extend from the Rio Grande to Tampa Bay in the Gulf of Mexico and from northern Florida to Cape Hatteras on the Atlantic coast. In Florida, Atlantic croaker are seldom found south of Tampa Bay in the Gulf of Mexico or the Indian River Lagoon on the Atlantic coast.

Habitat: Croaker are found over mud and sandy bottoms in coastal waters to about 3,300 feet (1,000 m) deep and in estuaries where their nursery and feeding grounds are located. Croaker can thrive in fresh water or sea water and in a wide range of temperatures 48–90°F (9–32°C); they are most abundant in waters over 75°F (24°C). Post-larval and juvenile Atlantic croaker occupy estuarine nursery areas where they feed on benthic plankton and invertebrates, such as grass shrimp and worms.

Size: Average 8 inches (20 cm), maximum 14 inches (36 cm)

Bait use: Small croaker (2–3 inches, 5–7.5 cm) are used for flounder and spotted sea trout, with medium sizes (4–6 inches, 10–15 cm) appealing to redfish, snook, and piscivorous gamefish. Larger specimens (7–8 inches, 17.5–20 cm) are used offshore for grouper and snapper.

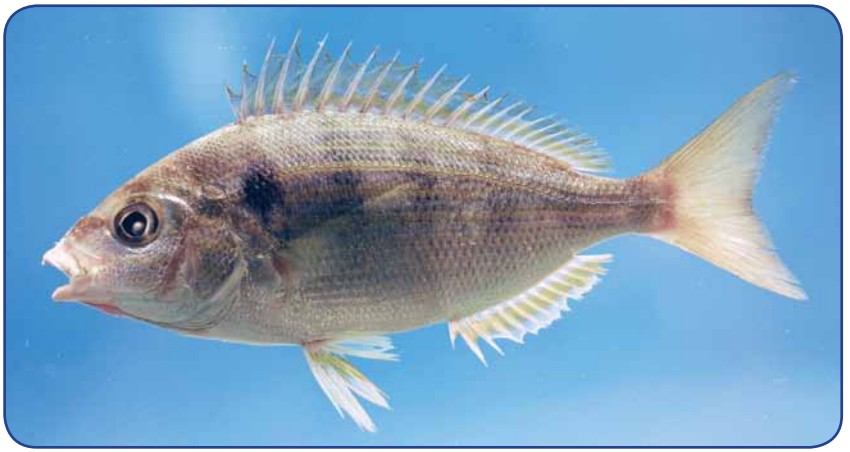
Aquaculture potential: Although the reproductive biology and spawning of wild-caught fish is well-documented, aquaculture methods for croaker are only partially known. Spawning occurs offshore in late summer, although they have been induced to spawn with hormones; females release 40,000–110,000 eggs. Larval rearing regimes similar to red drum have been used with relatively good success. Newly hatched larvae can be cultured in tanks with phytoplankton and fed rotifers (*Brachionus* spp.) 3 to 12 days post hatch. Brine shrimp (*Artemia* sp.) can be added during days 10 to 12, as well as micro-particulate diets (250 µm particle size). Juveniles consume high protein (45%) formulated diets and exhibit rapid growth and survival. Wild juveniles grow rapidly, reaching 6–8 inches (15–20 cm) in the first year. Wild caught juveniles reared in cages in heated effluent (86°F, 30°C) and fed 45% protein formulated feed grew 0.6 inches (1.5 cm)/month. At that growth rate, a 1-inch (2.5 cm) croaker would reach 4 inches (10 cm) total length in 5 months.

Suggested reading

Creswell, R.L., C.L. Ohs, and C. L. Miller. 2010. Candidate Species for Aquaculture: Croaker, *Micropogonias undulatus*. University of Florida, www.edis.ifas.ufl.edu/fa148.

PINFISH

sailor's choice, chofer, pisswink, sargo



NOAA

Lagodon rhomboides (Family Sparidae, porgies)

Pinfish are compressed and oval, olive colored above, bluish-silver along the sides with thin yellow stripes running longitudinally. A dark shoulder spot occurs near the anterior origin of the lateral line. Six broad diffuse vertical dark bars occur along each side of the body, and these are most prominent in younger individuals and in individuals experiencing stress. The anal fin and the forked caudal fin are both yellowish with broad light blue margins.

(pinfish cont.)

Range: Pinfish inhabit the eastern coast of the United States from New England south to Florida (most abundant south of Virginia), Bermuda, the northern Gulf of Mexico, the northern coast of Cuba, and the Yucatán Peninsula. They are absent from the Bahamas and Antilles.

Habitat: Pinfish are found throughout estuaries and nearshore waters, typically in vegetated benthic habitats such as seagrass beds. The species is also commonly encountered on bare sand or rock reefs, mangrove habitats, and off of inlet jetties. Juveniles inhabit vegetated shallow estuaries and mangroves. Adults inhabit vegetated deeper channels, jetties, and offshore reefs. Pinfish tolerate water temperatures ranging from 50–95°F (10–35°C) and salinities 0–75 g/L.

Size: Average 3–5 inches (8–10 cm), maximum 12 inches (30 cm)

Bait use: Popular bait for offshore bottom fishing. Pinfish ranging from 1.5–6.0 inches (3.75–15 cm) are frequently used by both inshore and offshore anglers to target a wide range of game fish. Arguably the most popular live bait in the southeastern US.

Aquaculture potential: Pinfish are a resilient, easy-to-maintain, fast-growing fish that tolerate a wide range of environmental conditions, and as such show great potential as a new aquaculture species with the purpose of being sold as marine baitfish. They tolerate high densities, reproduce in tanks, grow rapidly, and have established high-demand markets. Hormone injections are effective for ovulation and volitional spawning in pinfish; up to 90,000 eggs per female have been collected. Fertilized pinfish eggs have a single oil globule, a spherical yolk, and are buoyant in seawater. Eggs range in diameter from 0.90–1.05 mm. Pinfish larvae should be cultured at approximately 77°F (25°C) and fed rotifers, *Branchionus* sp., at first feeding (3 days post hatch) because they are small enough to be consumed. Rotifers should be fed to larvae at a density of 5–15 rotifers/mL from 3 to 21 days post hatch. Early juveniles have fully formed fins and range in size from 0.47–0.55 inches (12.0–13.9 mm). Pinfish grow rapidly and can reach a marketable size of 1.97–4.9 inches (5.0–12.5 cm) midway through their first year. Pinfish can grow 0.35–0.39 g/day with a mean survival of 94 to 99% over an 82 day growth period. Average food conversion ratio ranges from 1.7 to 1.9. Further studies in recirculating aquaculture systems, inland ponds, and low-salinity culture methods are needed to define the most appropriate culture techniques and protocols.

Suggested reading

Ohs, C.L., M.A. DiMaggio, and S.W. Grabe. 2011. Species Profile: Pinfish, *Lagodon rhomboides*. Southern Regional Aquaculture Center Publication Number 7210. 6 pp.

Ohs, C.L., S.W. Grabe, and M.A. DiMaggio. 2010. Candidate Species for Aquaculture: Pinfish, *Lagodon rhomboides*. University of Florida, www.edis.ifas.ufl.edu/fa168.

KILLIFISH

mudminnow, bull minnow, marsh minnows, tiger minnows, mummichogs, gudgeons, cacahoe (Louisiana)

Craig Gothreaux

Fundulus grandis (Gulf killifish), *F. heteroclitus* (mummichog), *F. seminolis* (Seminole killifish), *and F. similis* (Longnose killifish)
(Family Fundulidae, killifishes)

Killifish are stout-bodied, about one-fourth as deep as long. Their body is thickest just posterior of the pectoral fins. Both back and belly are rounded, and the top of the head is flat between the eyes and the snout. The mouth is at the tip of the snout and is so small that it does not gape back to the eye. The most striking feature of *Fundulus* is their very deep caudal peduncle and rounded caudal fin. Killifishes vary in shade from very pale to dark, according to the color of their surroundings. Out of breeding season the males are dark greenish or steel blue above, while the belly is white, pale yellow, or orange. The dorsal, anal, and caudal fins are dark green or dusky with pale mottling. The females are typically paler than the males and are more uniform in color.

Range: *F. grandis*—Florida to Vera Cruz, Mexico; *F. heteroclitus*—Gulf of St. Lawrence to NE Florida; *F. seminolis*—throughout Florida, mostly inland areas.

Habitat: *Fundulus* spp. are recognized as hardy fish that tolerate a wide range of water temperatures and salinities. Found in shoals along sheltered shores where the tide flows over seagrass, tidal creeks that cut through salt marshes, on the shores of harbors, and in the brackish water at the mouths of streams and estuaries, particularly in little muddy pools, creeks, and ditches. As a group, they are very tolerant of low dissolved oxygen. Killifish are omnivorous, feeding on vegetation, plankton, and small crustaceans and mollusks, and occasionally eggs and small fish.

Size: Average 3 inches (8 cm), maximum 8 inches (20 cm)

Bait use: These hardy fish are one of the most popular bait species for both marine and freshwater fishing. They are particularly popular as flounder bait.

Aquaculture potential: Considerable information is available on the technical aspects of *Fundulus* sp. culture. In addition, few perceived regulatory concerns or environmental impacts should limit continued development. However, economic issues appear to be a major impediment to commercial expansion. *Fundulus* species are oviparous; fecundity is relatively low at 100 to 300 eggs per day over a 3 to 5 day spawning period for *F. heteroclitus*, depending on fish size, and lower with other *Fundulus* species. The timing and duration of the spawning seasons for the different species will vary based upon geographic location and water temperature parameters. Multiple spawns can be expected over the course of a spawning season. Eggs are attached to solid substrates for the incubation period of 7 to 21 days depending upon water temperature and salinity. A need exists for research on *Fundulus* culture in ponds and recirculating water systems, and egg incubation techniques.

Suggested reading

Adams, C. and A. Lazur. 2001. Economic considerations for the prospective mudminnow culturist in Florida. University of Florida, www.edis.ifas.ufl.edu/fa309.

Anderson, J.A. and C.C. Green. 2013. Cacahoe minnow production manual. http://www.lsuagcenter.com/en/crops_livestock/aquaculture/baitfish/minnows/Cocahoe-Minnow-Production-.htm.

DiMaggio, M.A., C.L. Ohs, S.W. Grabe, B.D. Petty, and A.L. Rhyne. 2010. Osmoregulatory evaluation of the Seminole killifish after gradual seawater acclimation. North American Journal of Aquaculture. 72(1):124-131.

PIGFISH

piggy perch, grunt

Florida Sea Grant

Orthopristis chrysoptera (Family Haemulidae, grunts)

Pigfish have long anal fins, matching the soft dorsal fin in shape and in size. The head is sloped and pointed, the snout almost pig-like, and the lips thin. A background color of bluish-gray is marked with brassy spots in indistinct lines that are horizontal below the lateral line but extend obliquely upward and backward above the lateral line. These oblique markings are also found on the cheeks. The head is covered with bronze spots, and the fins are yellowish bronze with dusky margins. The name pigfish was probably derived from the chattering noises they make when caught. Like other members of the grunt family, a pigfish makes a grunting sound by rubbing the teeth in their throat together. Pigfish also use these pharyngeal teeth to grind up shellfish and small bits of other food.

Range: Pigfish inhabit the Atlantic coast of the United States from New York to the northern Bahamas and Bermuda, but are less common north of Virginia. They are also found in the Gulf of Mexico from Florida to the Yucatán peninsula.

Habitat: Juveniles typically inhabit shallow waters near shore and are often found near vegetation. Adults occur more frequently on deeper flats over soft bottom habitats such as channel edges, sandy and sparsely vegetated areas, and mid-shelf reefs. Pigfish are abundant in more saline coastal waters and around offshore reefs. They tend to avoid salinity levels under 15 g/L. Similarly, pigfish are found in the wild at water temperatures from 56.7–96.8°F (13.7–36.0°C) but prefer 75.0–80.0°F (23.9–26.7°C), avoiding low temperatures by migrating to deeper water during winter months.

Size: Average 8 inches (20 cm), maximum 15 inches (38 cm)

Bait use: An excellent inshore bait and favorite of sea trout anglers. Most inshore game fish will readily take a pigfish. Larger specimens may be used for offshore species. Average bait size is 2–6 inches (5–15 cm).

(pigfish cont.)

Aquaculture potential: Pigfish have many attributes that make them a good candidate for aquaculture. They are hardy, withstand handling, are euryhaline, tolerate high densities, reproduce in tanks, grow rapidly, and are popular baitfish. Captive pigfish have naturally spawned up to 400,000 eggs per female using a 12:12 light cycle year round, which suggests that spawning is not triggered by photoperiod; spawning occurs at 68–93°F (20–34°C). Hormone injections have been used to induce spawning. Hatching begins within 30 hours of spawning, and larvae will subsist on yolk sac protein and lipid reserves for 2 days post hatch. A feeding regime of rotifers and copepods can be implemented during the hatchery phase and fed twice daily at a density of 5 to 15 individuals/mL. Instar I *Artemia* sp. should be introduced to larvae approximately 15 days post hatch and at a density of 0.5 to 1.3 *Artemia*/mL, increased to 1.0 to 1.3 *Artemia*/mL until approximately 50 days. Weaning from *Artemia* sp. to an artificial diet should begin about 35 days post hatch, and be completed by 55 days post hatch. By 1 inch (2.5 cm), pigfish have scales, all spines and fins are well-developed, and the overall appearance is that of an adult. During the first year of life, the growth of wild juvenile pigfish ranges from 0.28–0.37 inches/month from June through October to 0.12 inch/month from October to April. In one study, juveniles grew 1.1–1.2 inches (2.8–3.0 cm)/month and gained 14.4–15.9 g/month. At this rate a 1-inch juvenile would take approximately 4 months to reach market size. Further research is needed to define optimal diet, stocking density, lighting, salinity, and temperature. Pigfish are resilient, easy to maintain, and grow fast. There is considerable market demand as bait. These characteristics justify further research to improve the hatchery stage of culture, to identify optimal growout conditions, to establish optimal nutrition, and to analyze the production economics of each stage of culture.

Suggested reading

Cassiano, E.J., C.L. Ohs, and J.E. Hill. 2009. Candidate Species for Aquaculture: Pigfish *Orthopristis chrysoptera*. University of Florida, www.edis.ifas.ufl.edu/fa160.

Howe, J.C. 2001. Diet composition of juvenile pigfish, *Orthopristis chrysoptera* (Perciformes: Haemulidae), from the northern Gulf of Mexico. Gulf of Mexico Science 19(1):55–60.

Ohs, C. L., M.A. DiMaggio, and S.W. Grabe. 2011. Species Profile: Pigfish, *Orthopristis chrysoptera*. Southern Regional Aquaculture Center Publication Number 7209. 5 pp.

STRIPED MULLET

finger mullet, flathead mullet

Patrick O'Neill, Geological Survey of Alabama

Mugil cephalus (striped or black mullet), *M. curema* (silver or white mullet), *M. gyrans* (fantail mullet) (Family Mugilidae, mullets)

Mullet have a cylindrical body shape and are bluish-gray or green dorsally, shading to silver on sides with distinct horizontal black barrings, with a white ventral side. Fins are lightly scaled at base and unscaled above. There are six species of mullet in Florida. In addition to striped mullet (*M. cephalus*), white mullet (*M. curema)* and the fantail mullet (*M. gyrans)* are both white, and the fantail mullet has a black blotch at base of pectoral fin, which is lacking in the black mullet. They are frequent leapers and feed on algae, detritus, and other tiny marine forms.

Range: *Mugil cephalus* occurs worldwide from approximately 42°N to 42°S. In the western Atlantic Ocean it ranges from Cape Cod to Brazil, including the Gulf of Mexico, Caribbean, and West Indies.

Habitat: Adults migrate offshore in the fall in large schools to spawn; juveniles migrate inshore at about 1 inch in size, moving far up tidal creeks. They inhabit estuarine, intertidal, freshwater, and coastal marine habitats, with juvenile fishes most common in impounded areas, around mangroves, and in seagrass beds. They also migrate offshore throughout the late fall and winter into warmer waters.

Size: Average 9 inches (23 cm), maximum 20 inches (51 cm)

Bait use: A ubiquitous inshore bait, it may also be used for large offshore game fish. It can be drifted live or trolled dead, especially for large gamefish such as sailfish and marlin. Currently, wild-harvested mullet used as bait either originate from commercial harvesters or are captured by recreational anglers for their own use.

(striped mullet cont.)

Aquaculture potential: *Mugil cephalus* is one of the most important animal protein sources for people in the Pacific Basin, Southeast Asia, India, the Mediterranean, Eastern Europe, Central America and South America. As such, it has been exploited as a commercial and recreational fishery. Mullet can adapt to a wide range of temperature and salinity conditions and are amenable to aquaculture. Reproduction, larval culture, and juvenile growth are well documented and aquaculture demonstrations have been conducted. However, despite a large number of publications addressing culture methods, the technical aspects of larval culture is the primary impediment for aquaculture. Not much is known about the economic characteristics of mullet aquaculture in the United States.

SPOT

Lafayette, flat croaker, golden croaker, silver gudgeon, goody, chub, roach, jimmy, spot croaker

Nate Tessler

Leiostomus xanthurus (Family Sciaenidae, drums)

Spot are moderately deep-bodied and compressed with an elevated back. Body color is typically bluish-gray dorsally, fading to golden yellow or yellow-tan ventrally. Twelve to fifteen dark streaks run obliquely from the dorsal surface down the sides to about mid-body and tend to fade with age. Fins are typically pale yellow in color. The head is short with a small, inferior mouth. The distinctive dark spot above the pectoral fin is the reason the most common name given to this species is "spot."

Range: Spot are common along the Atlantic coast from Cape Cod south to the Bay of Campeche, Mexico. They are less common in south Florida and the Florida Keys, and north of Cape Cod, Massachusetts.

Habitat: Spot are tolerant of wide variations in water temperature and salinity. The lower lethal temperature is thought to be approximately 39°F (4°C), while the upper lethal temperature is over 95°F (35°C). Spot have been found at salinities of 0 to 60 g/L. Larval spot feed on plankton, while juveniles and adults are predators of small infaunal and epibenthic invertebrates.

Size: Average 7 inches (18 cm), maximum 11 inches (28 cm)

Bait use: Spot are good bait for bottom fishing, particularly grouper. Spot are also a popular inshore bait for striped bass (mid-Atlantic states), snook, and redfish.

Aquaculture potential: Sufficient technical information is known about spot aquaculture. Recent projects have demonstrated viable culture methods using recirculating systems. An individual spot female is capable of producing between 30,000 and 60,000 eggs per spawning season. While it is possible to obtain a "natural" spawn within the broodstock holding tank, the use of a spawning hormones simplifies egg collection. A thorough summary of culture technology of spot can be found in *Production of Spot as Live Bait for Recreational Angling* (Oesterling et al., 2005). Further research is warranted that couples recirculating technology for spawning, larval production, and juvenile culture with extensive pond production methodology. Although the economics of production and marketing need to be more adequately addressed, environmental impacts and regulatory considerations do not appear to be major impediments to the further development of spot aquaculture.

Suggested Reading

Oesterling, M.J., D.G. Sennett, and D.P. Kilduff. 2005. Production of Spot as Live Bait for Recreational Angling. Virginia Sea Grant Marine Advisory No. 78. 17 pp.

BALLYHOO

balao, halfbeak, 'hoo

Florida Sea Grant

Hemiramphus brasiliensis, H. balao (Family Hemiramphidae, halfbeaks)

Although several species of ballyhoo occur in Florida, two are dominant. Ballyhoo, *H. brasiliensis*, has long pectoral fins and the upper lobe of the tail fin is gray. *H. balao*, has a short pectoral fin and their upper lobe is reddish. Typically slender and silvery, ballyhoo are often mistaken for needlefish, but differ by having a shorter upper jaw and a lower jaw that elongates into a flat blade with an orange-red tip. The single dorsal fin is set far back on both species near the deeply forked tail.

Range: Found from Cape Cod to northern Gulf of Mexico and south to Brazil, including Florida, the Bahamas, and the Caribbean.

Habitat: Ballyhoo inhabit warm oceans, and are a primarily a pelagic, surface schooling fish. They are common on reefs, shoals, and large bays. Ballyhoo are omnivorous and feed on algae and other marine plants, plankton, invertebrates such as pteropods and crustaceans, and small fish.

Size: Both species average 10–12 inches (25–30 cm), but commonly reach 15–16 inches (38–40 cm)

Bait use: Typically sold frozen, usually pre-rigged and used for trolling; favorite bait for sailfish, dolphin, and wahoo.

Aquaculture potential: Aquaculture methods for ballyhoo are little known, although successful spawning and larval rearing has been reported. Ballyhoo are egg-layers and often produce comparatively small numbers of large eggs. The eggs of *H. brasiliensis* and *H. balao* are typically attached with several filaments to floating or benthic vegetation, and are 0.059–0.098 inches (1.5–2.5 mm) in diameter. Larvae hatch in 8 to 9 days and are 0.19–0.43 inches (4.8–11 mm) in length. Fecundity ranges from 1,200 to 12,000 eggs/female, depending on size and species. *H. balao* is almost three times more fecund than *H. brasiliensis*.

MOJARRA

striped mojarra, sand perch, goat, sand brim

Florida Sportsman

Eugerres (Diapterus) plumieri (Family Gerreidae, mojarras)

Mojarra are colored dark olive dorsally with tan to silvery sides, often with a metallic sheen. They have conspicuous black stripes along the center of each scale row that end toward the belly. All fins, except the pectorals, are dusky in large adults, and the anal fins are sometimes dark orange. They have a pelvic spine, and the first two anal spines are pale. The dorsal and anal spines are long and stout with three anal spines.

Range: Western Atlantic, south from South Carolina and throughout the Gulf of Mexico. Absent from the Bahamas and West Indies.

Habitat: Mojarra are found near shore along sandy bottoms. They are also common in brackish waters, mostly over mud bottoms in mangrove-lined creeks and lagoons, often entering a considerable distance into fresh waters. They feed on aquatic insects, shrimp and other small crustaceans, clams, and small fish.

Size: Average 10 inches (25 cm), maximum 12 inches (30 cm)

Bait use: Mojarra are good bait for snook, tarpon, snapper, and grouper; however, their soft flesh makes them sensitive to handling.

Aquaculture potential: Striped mojarra are not routinely cultured. They have been hormonally induced to spawn. Induced spawning occurs in the summer, with injections of 5–10 IU/g of HCG, at a temperature of 82–86°F (28–30°C) and salinity 30–35 g/L. Fecundity increases from 18,000 to 70,000 eggs per fish with increasing length of the female. Eggs (534–636 µm diameter) float at the surface at salinity 35–36 g/L and are neutrally buoyant at 30 g/L. Hatching occurs within 24 hours after fertilization. Larvae emerge at 0.06 inches (1.45

(mojara cont.)

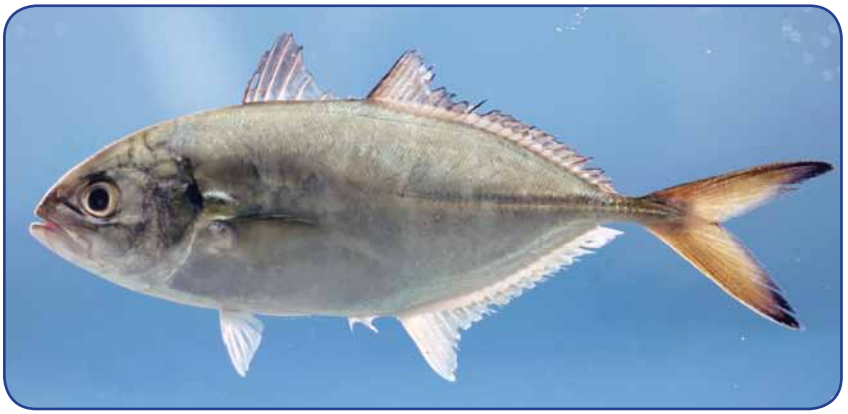
mm) in length and begin feeding 3 days post hatch on rotifers (*Brachionus* sp.). Wild copepods (mainly *Acartia* sp., copepodite stages) have been used as food for days 10 to 20 of larval rearing and brine shrimp nauplii (*Artemia salina)* starting 18 days post hatch. At 30 to 35 days post hatch (length 0.6–1.0 inch, 15–25 mm) they have scales, the shape of the body and pigmentation is similar to adult fishes, and they will accept artificial food. Survival through metamorphosis has been achieved with 50% survival. In spite of their small eggs and larvae, mojarra demonstrate high survival and rapid growth and development up to metamorphosis.

Suggested reading

Avila-Poveda, O.H. and S.L. Lamouroux-López. 2007. Saline acclimation of striped mojarra *Eugerres plumieri* (Cuvier 1830) and optimal dosage of carp pituitary extract (CPE) to induce spawning. Reviews in Fish Biology and Fisheries 17(1):11-19.

BLUE RUNNER

yellow jack or yellow mackerel, hardtail jack, runner



NOAA

Caranx crysos (Family Carangidae, jacks, scads and pompanos)

Blue runners are light olive to bluish green above and silvery gray to golden below the midline. They frequently have a black spot on the operculum and are readily distinguished from crevalle jack (*C. hippos*) by the lack of a black blotch on the pectoral fin. The tip of the caudal fin (tail) is blackish.

Range: Blue runners inhabit the Atlantic coast from Nova Scotia to Florida, Gulf of Mexico, Caribbean and Central America to Brazil. Also found in the eastern Atlantic from Angola to Britain and the Mediterranean.

Habitat: Mature adults 9–10 inches (23–25 cm) are often near shore in schools and spawn offshore from January through August. The fry form schools associated with floating objects. Adults feed on fish, shrimp, and squid.

Juveniles are found offshore and sometimes on sand bars and in the surf along beaches. They are also occasionally found in shallow lagoons, around mangroves, sea grasses and patch reefs. Blue runners are known to congregate near artificial reefs, fish aggregating devices, and other structures.

Size: Average 12 inches (30 cm), maximum 22 inches (56 cm)

Bait use: These fast swimming fish are used to troll for large gamefish and are used extensively as live bait for king mackerel and billfishes. Wahoo, amberjack, and grouper are caught with this bait.

Aquaculture potential: Aquaculture technology is established for several species of carangids (jacks and pompano). Females become reproductively mature at an average length of 12 inches (30 cm). The peak of the spawning season in the Gulf of Mexico occurs from June to August, with a secondary peak during October in northwest Florida. Fecundity ranges from 41,000 to 1.5 million eggs/female, and the pelagic eggs, less than 1 mm in diameter, hatch in approximately 24 hours. The blue runner's larval stage has been extensively described, with distinguishing features including a slightly shallower body and a heavier pigmented head and body than other larval *Caranx*.

ROUND SCAD

cigar fish, cigar minnow, hardtail

Jabatan Sabah

Decapterus punctatus (Family Carangidae, jacks, scads and pompanos)

The round scad is a cigar-shaped fish, with greenish coloration dorsally and white ventrally, often with a yellow stripe running from the head to the caudal peduncle. They have small black spots along the front half of the lateral line. These fish have a deeply forked caudal fin and two separate, deeply-notched dorsal fins. This species is one of the few baitfish species that have spines, which in round scad are particularly sharp.

(round scad cont.)

Range: Found only in the Atlantic Ocean from Nova Scotia in the north to Rio de Janeiro in the south, including the Caribbean and Gulf of Mexico. Additionally, in the eastern Atlantic from Morocco to South Africa.

Habitat: Round scad are commonly found in coastal waters from the beach to the Continental Shelf. They are also known to gather near the bottom in large schools. Round scad mostly eat copepods, but have also been known to eat other zooplankton such as pteropods, ostracods, and gastropod larvae.

Size: Average 6–8 inches (15–20 cm), maximum to 12 inches (30 cm)

Bait use: Common offshore bait for bottom fishing and drifting. Less commonly used for pelagic species.

Aquaculture potential: Little is known regarding aquaculture of this species. Research into captive spawning, larval rearing, growout, and nutrition are lacking. Spawning frequency is approximately every 5 days and fecundity is correlated with fish size and has been reported to range from 5,500 to 34,700 eggs/female.

GOGGLE-EYE

bigeye scad, goggle-eye jack, gog (chicharro ojón, pepona, cojinua–Spanish)

Rick Winterbottom

Selar crumenophthalmus (Family Carangidae, jacks, scads and pompanos)

The goggle-eyes have an elongate cylindrical body with a forked tail and large eyes, and like other jacks have scutes forward of the tail. It is ventrally colored silver and steel-blue on the sides and dorsally. The first dorsal fin is dusky on the margins with the rest of the fin clear; the second dorsal fin is dusky over most of fin with the dorsal lobe blackish. The anal fin is clear or slightly dusky along its base, and the caudal fin is dusky with a dark tip on the upper lobe.

Range: Found worldwide in tropical and subtropical marine waters. In the western Atlantic it ranges from Nova Scotia to the Gulf of Mexico, and south through the Caribbean to Brazil.

Habitat: Goggle-eye are found in small to large schools, mainly inshore or in shallow water around inlets, occasionally in bays and river mouths, and at times over shallow reefs, although they have been reported to depths of 560 feet (170 m). They prefer clean, clear insular waters, but occasionally can be found in turbid waters. Goggle-eye are mainly nocturnal, feeding primarily on planktonic or benthic invertebrates, including shrimps and crabs.

Size: Average 9 inches (23 cm), maximum 12 inches (30 cm)

Bait use: Usually caught at night with light tackle. Goggle-eye are a favorite choice for offshore anglers fishing pelagic species, such as billfish, king mackerel, and wahoo.

Aquaculture potential: Goggle-eye is a very promising species for aquaculture and have high market demand and value. Goggle-eye exhibit volitional spawning, averaging 30,000 eggs/female per spawning event (range from 5,000 to 125,000). Fertilized eggs average 670 µm in diameter and have an average hatch rate of 71%. Eggs hatch in less than 18 hours, and the newly hatched larvae are 0.1 inch (2.4 mm) in length. The larvae exhibit rapid development and are able to consume rotifers (*Brachionus plicatilis*) at first feeding 2 days post hatch. Greenwater techniques for larviculture using microalgae (*Isochrysis galbana* and *Nannochlopsis oculata*) at total concentrations of 400,000 cells/mL and rotifers (*Brachionus plicatilis*) at densities of 30 to 50 rotifers/mL resulted in an average length of 1.5 inches (38.8 mm) and average weight of 1.3 g 45 days post hatch at which time the fingerlings were fully weaned. In the same study, growout trials for three months resulted in an average survival rate of 88%, final weight 28.2–30.3 g, and feed conversion ratio 1.17–1.38. These results confirm that goggle-eye aquaculture is technically feasible and suggests that the species is a strong candidate for commercialization.

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ATLANTIC MENHADEN

pogy, mossbunker, bunker, alewife, LY, fatback, shad

Jay Flemming

Brevoortia tyrannus (Family Clupeidae, herrings, shads and sardines)

Menhaden have a deep and compressed body with scutes apparent along their belly. The upper jaw has a distinct median notch with no teeth. Three species of menhaden are common in Florida, but all are similar in size and appearance, and are all used as bait. The Atlantic Menhaden, shown here, is slightly larger than its Gulfside counterparts, the Gulf menhaden, *B. patronus*, and the yellowfin menhaden, *B. smithi*. The latter two can be distinguished by their spots, a lone prominent spot behind the gill cover of the yellowfin, as opposed to a large spot and a series of smaller ones on the Gulf menhaden. The Atlantic variety also has numerous spots. These three species are dark greenish dorsally with and dull silver or brassy sides and yellowish fins.

Range: Found along the Atlantic coast from Nova Scotia to Florida (*B. tyrannus*), two species in the Gulf of Mexico (B. *patronus* and *B. smithi*), and several species southward to Argentina.

Habitat: Found widely in the open waters of Atlantic and Gulf of Mexico, and close to beaches around wrecks and shoals. Adults and juveniles form large schools near the surface during spring through early winter.

Size: Average 8 inches (20 cm), maximum 12 inches (30 cm)

Bait use: Menhaden are commonly used for drifting or still fishing. They are caught by cast net or with small treble hooks and used whole live or as cut bait.

Aquaculture potential: Menhaden once comprised an abundant fishery, thus aquaculture of these species has not been investigated. However, a significant decline in menhaden landings may justify further study.

SCALED SARDINE

pilchard, whitebait

Frank Sargeant

Harengula jaguana (Family Clupeidae, herrings, shads and sardines)

Several species of sardine look similar to the scaled sardine. Scaled sardines are brassy colored dorsally and solid silver on the sides. The dorsal side is blue-black with faint lateral streaks. The ventral side is lighter in color and silvery. A dark 'shoulder' spot just posterior to the gill cover is present, although it may be faint in some individuals.

Range: Scaled sardines are distributed in the western Atlantic, from New Jersey, through the Caribbean to Brazil. *Harengula jaguana* co-occurs with six species of *Harengula* throughout its range, and it is often confused with *H. clupeola* with which it co-occurs over most of its range.

Habitat: These species are wide ranging and are found in shallow water up to 60 feet (18 m) in depth. They are found inshore around grass flats and structures like bridges and offshore around markers, reefs, and wrecks.

Size: Average 4 inches (10 cm), maximum 8 inches (20 cm)

Bait use: Used inshore and offshore as live bait for bottom fishing.

Aquaculture potential: Little is known about the reproductive biology or aquaculture potential for scaled sardines. They are rarely found in bait shops, largely because they are susceptible to handling stress, but are commonly caught in the wild by anglers. Thus, they may be readily accepted by bait retailers. Females spawn at about 5 inches (12.5 cm) during the months of February–October in deep water 50–100 feet (15–30 m). Larvae reach approximately 0.6 inches (15 mm) in 20 days post hatch. Scaled sardines grow rapidly reaching a length of 1.6 inches (4 cm) the first year.

ATLANTIC THREADFIN

threadfin herring, greenies, greenback, horse minnow, hairy back, grassy back, shiner, thread, (machuelo–Spanish)

NOAA

Opisthonema oglinum (Family Clupeidae, herrings, shads and sardines)

Threadfin have a rotund body, a deeply curved belly, and a pointed head. Their common name refers to the long ray that trails from the back of their lone dorsal fin like a piece of thread. They are silver with bluish or greenish sides and a dark spot above their gills and another dark spot behind, which is often followed by an entire row of dark spots. Six or seven streaks are present along their sides.

Range: Found from Cape Cod to Florida along the Atlantic coast (infrequent north of North Carolina), Gulf of Mexico and Caribbean and along the Caribbean coast of Central America to Venezuela.

Habitat: Atlantic threadfin are nearshore, pelagic fish that form dense surface schools in tropical and subtropical waters. They feed on plankton, but occasionally consume small fish and crustaceans.

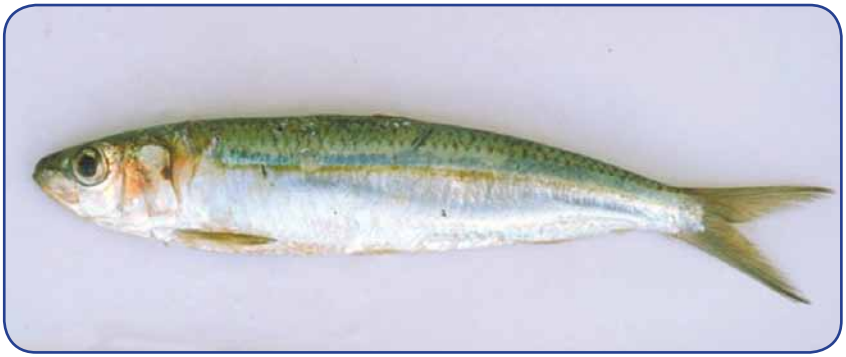
Size: Average 6 inches (15 cm), maximum 12 inches (30 cm)

Bait use: Threadfin are sensitive to over-crowding, and they are usually caught by cast net. They are used live or as cut bait for bottom fishing.

Aquaculture potential: Spawning occurs during the summer months from late March to September. Pelagic eggs are 0.04–0.05 inches (1–1.3 mm) in diameter and hatch after about 62 hours at 75°F (24°C). Little is known about threadfin culture.

SPANISH SARDINE

round sardinella, herring, shiner



Spain Ministry of Agriculture

Sardinella aurita (Family Clupeidae, herrings)

Spanish sardines have a long, torpedo-shaped silvery body and are bluish or greenish dorsally, with silver sides, a roundish ventral side, a deeply forked tail fin, and a single dorsal fin. Both the Spanish sardine and a similar species, the orangespot sardine, *Sardinella brasiliensis*, are more elongated and less flattened than other herrings. Spanish sardines have no markings, whereas orangespots have a gold or light orange streak on the side.

Range: Found from Cape Cod to Argentina including the Bahamas, Antilles, Gulf of Mexico and the Caribbean coast. Also found in the eastern Atlantic and Mediterranean. Widespread throughout Florida with the primary fishery located in Tampa Bay.

Habitat: Spanish sardines form schools in coastal waters from inshore flats to the continental shelf, often around piers and reefs, and prefer clear, saline waters. Juveniles prefer inshore nurseries and feed on phytoplankton. Adults move offshore to spawn and feed on zooplankton.

Size: Average 7 inches (18 cm), maximum 12 inches (30 cm)

Bait Use: Spanish sardines are used both inshore and offshore, drifting or on the bottom.

Aquaculture potential: Little is known about aquaculture of Spanish sardines. Spawning occurs at night. Eggs average 0.04 inches (1.08 mm) in diameter, length-at-hatch is about 0.1 inch (2.5 mm), and growth in the laboratory averages about 0.05 inches (1.2 mm) per day at 79-81°F (26–27°C). Larvae begin actively feeding at 3 days post hatch, and metamorphosis is complete at 0.9 inches (23 mm) total length in about 18 days. Larviculture has been attempted on a laboratory scale only.

TOMTATE

grunt, spot-tail, red mouth, blood mouth

Brian Gratwicke

Haemulon aurolineatum (Family Haemulidae, grunts)

The tomtate is silver-white with a yellow-brown stripe running the length of the body and ending as a black blotch at the base of the caudal fin. This spot is also evident in most juvenile grunts, and may be lost by older fish. The inside of its mouth is bright red.

Range: Found from Cape Hatteras to Brazil, including the Gulf of Mexico, the Central American coast and the Caribbean.

Habitat: Tomtate are widely distributed over sponge-coral habitats, which are scattered over the otherwise smooth plain of the continental shelf from 30–188 feet (9–55 m) depth. Tomtates are seldom found in waters less than 54°F (12°C). They feed on small, bottom-dwelling invertebrates.

Size: One of the smallest grunts averaging 7 inches (18 cm), maximum 12 inches (30 cm)

Bait use: Tomtate are often used as cut bait, or live for bottom fishing.

Aquaculture potential: Little is known about the aquaculture or the reproductive biology of the tomtate. Females may mature when as small as 5.5 inches (14 cm) and males as small as 6.5 inches (16.5 cm), and all fish over the age of 5 are capable of reproducing. Spawning takes place in the spring. Growth rate based on otoliths suggests that they grow rapidly, reaching 5 inches (13 cm) in length in one year. Grunts as a family are generally hardy fish, suggesting that they may be amenable to aquaculture. However, since they are too small to be marketed as a food fish, tomtate have not received attention as candidate species for aquaculture.

SAND PERCH

squirrelfish, sand seabass, sandfish, arenero (Spanish), bolo (Spanish)

NOAA

Diplectrum formosum (Family Serranidae, grouper, seabasses)

Sand perch are pale brown on the dorsal side, fading to white on the ventral side. They have five to seven vertical bars on their body, ranging from yellowish-brown to tan, and may not be prominent. There is also a conspicuous, dark mid-body stripe, ending with a dark spot on the upper half of the caudal peduncle. The sand perch can quickly change the coloration of this stripe and the bar pattern from pale to dark. Bright blue lines run across the head and body, and they also may have orange and blue shading on their sides.

Range: Found in the western Atlantic Ocean from North Carolina through the Gulf of Mexico and Bahamas, south to Uruguay. It is common off the coast of Florida and rare to absent throughout the western Caribbean.

Habitat: This warm water, inshore fish inhabits shallow bays and seagrass beds at depths from 3–240 feet (1–80 m). When it is observed offshore, it is commonly associated with wrecks and reefs or occasionally deep channels. The sand perch lives in holes in the sandy bottom or under rocks and is territorial. Sand perch are bottom feeders, consuming crustaceans such as shrimp, crabs, and amphipods, and small fish.

Size: Average 7 inches (18 cm), maximum 12 inches (31 cm)

Bait use: Excellent bait for grouper, snapper, tarpon, cobia, snook, and shark. Used live or cut.

Aquaculture potential: This species has not been cultured previously, and little is known about its larval biology and development. They are synchronously hermaphroditic, which means an individual fish possesses both male and female organs, producing sperm and eggs at the same time. Although mating behavior in sand perch is relatively unknown, it is believed that mating pairs form and result in cross-fertilization. Rather than building nests, they release eggs and sperm into the surrounding water where external fertilization occurs. The eggs and larvae of sand perch have not been described.

BAY ANCHOVY

glass minnow, silverside, bigmouth fry, anchoa de coleta (Spanish)

Miciah McNelius

Anchoa mitchilli (Family Engraulidae, anchovies); may also include *A. hepsetus* (striped anchovy) or *A. cubana* (Cuban anchovy)

Anchovies are small, mostly transparent fish with a tiny subterminal mouth. They are silver gray with a short head and a very short snout and a narrow silvery stripe about as wide as the pupil of the eye which runs along the sides of the body. The dorsal fin is set far back on the body.

Range: Several similar species range from Maine through the Gulf of Mexico to the Yucatán Peninsula and the Bahamas and Caribbean.

Habitat: Bay anchovies inhabit pelagic and coastal waters, but are most common in shallow tidal areas with muddy bottoms and brackish waters. They can tolerate a wide range of salinities and temperatures. Bay anchovies tend to be nocturnal, probably to avoid predators. They are primarily zooplankton feeders with a diet that includes crab megalopae (larvae), copepods, and mysids.

Size: Average 2 inches (5 cm), maximum 5 inches (13 cm)

Bait use: Sold frozen as chum; difficult to use as live bait because they are not very tolerant to handling.

Aquaculture potential: *Anchoa mitchilli* is a pelagic serial spawner during the summer months in the Chesapeake Bay, but likely year-round in Florida. They become sexually mature once they exceed 1.6 inches (4 cm) in length (at 10 months post hatch). Fecundity averages 687 eggs/g female body weight per spawn. Eggs diameter ranges from 0.1 to 0.3 mm. Larval duration in bay anchovies is around 45 days, at which time individuals of approximately 0.9 inches (22.5 mm) complete metamorphosis. Growth rates for young-of-the-year anchovies averages 0.6 inches (15 mm)/month.

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EXAMPLE OF MARINE BAITFISH CULTURE: PINFISH

Pinfish spawn fall/winter offshore with a peak in February and March. They are sexually mature at ~4 inches (~100 mm) total length. Fecundity ranges from 7,000 to 90,000 eggs/female. Ambient temperature and light cycles during spawning season should be ~72°F (22°C), 12L:12D. Photothermal regimes may be altered for off-cycling. Use water with a salinity of 35 g/L. Feed brood fish twice daily to satiation a combination of squid, krill, and a 2.0 mm slow sinking pellet.

Examine for gamete development by abdominal palpation to check for flowing sperm or conduct an ovarian biopsy using a teflon catheter tube (Figure 1).

Figure 1. Ovarian biopsy of a pinfish.

At the time of injection, eggs should be > 500 µm and vitellogenic. Biopsies indicate pinfish exhibit multi-batch, group synchronous reproduction (Figure 2). Human Chorionic Gonadotropin (HCG, Chorulon®) can be used to induce spawning. Eggs are usually collected 48 and 72 hours after injection. A hydrated egg will be about 1 mm in diameter (Figure 3). (*continued on next page)*

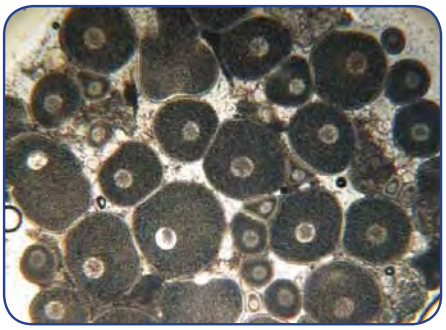
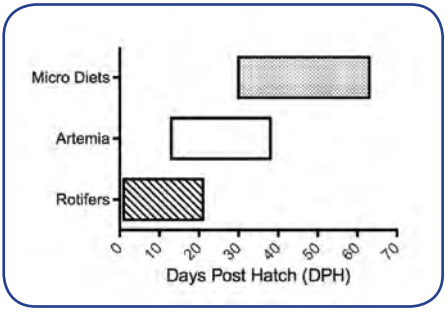


Figure 2. Pinfish exhibit multi-batch, group synchronous reproduction.

Figure 3. A hydrated pinfish egg is 1 mm in diameter.

(example of marine baitfish culture cont.)

The recommended larval feeding schedule is shown in Figure 4. The developmental stages of larval pinfish are shown in Figure 5.



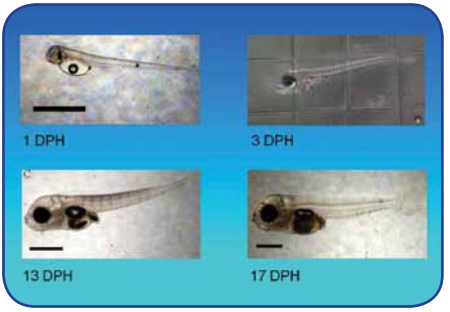


Figure 5. Pinfish at various stages of development.

Juveniles can be cultured to market size of 3 inches in tanks in about 65 days (Figure 6). They should be fed 3-7% of biomass daily divided into two feedings of a 2.0 mm commercial diet. One tested stocking density was 120 fish/m3. Survival was very high at >99%. Culture in salinities as low as 9 g/L has been successful.

Figure 6. Recirculating aquaculture systems used to grow juvenile pinfish to market size.

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Florida Sea Grant
University of Florida || PO Box 110409 || Gainesville, FL, 32611-0409
(352)392-2801 || www. flseagrant.org

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