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MARINE FINFISH AQUACULTURE IN VIRGINIA

SPECIES PROFILES:

Summer Flounder (*Paralichthys dentatus*)
Black Sea Bass (*Centropristis striata*)
Tautog (*Tautoga onitis*)
Northern Puffer (*Sphoeroides maculatus*)
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The commercial culture of marine finfish is virtually absent in the Commonwealth of Virginia. Although the pioneering research for striped bass-white bass hybridization was conducted in Virginia (Kerby 1972), the culture of hybrid striped bass is conducted primarily in freshwater in open ponds and closed recirculating systems. Currently there are limited research programs and demonstration projects to explore the potential for marine finfish culture for the commercial production of seafood. The use of cultured animals for wild stock enhancement has been conducted for striped bass in the past and currently there is an active stock enhancement program for shad. The use of hatchery reared marine finfish for the purpose of wild stock enhancement is becoming an increasingly popular concept for a wide variety of species. Considerable research is needed, especially for non-anadromous species, to further develop the practicality of the concept.

The desire to explore the commercial practicality of marine finfish culture has been fueled by the world-wide successes of salmon aquaculture. By the year 2000, it is projected that salmon aquaculture will produce 950,000 MT. Aquacultured salmon has become a significant factor in the production of wild and cultured seafood products. Considerable interest has developed in the culture of a wide variety of marine finfish including cod, halibut, flounder, sturgeon, red drum, dolphin fish and tuna to mention some of the candidates. In some cases, the successful commercial culture of some of these species is fast becoming a reality. There are several important factors that
interplay in the choice of species for culture. These include brood stock and fingerling availability, market acceptability, favorable economic conditions, hatchery and grow-out technology and favorable climate. If grow-out strategies include pen-culture or flow-through systems, climate and cultured species have to be compatible. In the use of closed recirculating systems to produce the completed product, the necessity for a climate-species match is diminished.

Virginia is located at a particularly difficult latitude for marine aquaculture; in the summer the climate is too warm for most temperate species and in the winter too cold for most tropical or subtropical species. The exclusive use of open water or flow-through grow-out systems may be particularly difficult. Most practical options include the exclusive use of closed recirculation systems or the combination with open water pen culture or flow-through systems. Nonetheless, the choice of species for culture will be an important consideration.

There is considerable regional interest in the summer flounder (*Paralichthys dentatus*); active research programs are underway in North Carolina, Rhode Island, New Hampshire and Maine (Waters 1996). There was at least one commercial hatchery that produced fingerling summer flounder in 1996. The choice of summer flounder as a candidate for commercial scale aquaculture is being influenced by several factors including market acceptability, fast growth, brood stock availability and declines in wild stock availability. In addition, several funding agencies, including NOAA Sea
Grant, are now providing support for research and demonstration projects.

Other species that hold potential for culture in Virginia include black sea bass 
(*Centropristis striata*), tautog (*Tautoga onitis*), northern puffer (*Sphoeroides maculatus*)
and cobia (*Rachycentron canadum*). Each of these species possess their own
particular set of characteristics that offer varying degrees of suitability for culture;
common to each is the paucity of research and practical information for culture.

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**SPECIES PROFILE: Summer Flounder (*Paralichthys dentatus*)**

The summer flounder, *Paralichthys dentatus*, is found between Nova Scotia and
the southeastern coast of Florida, chiefly in estuarine and shelf waters. It is most
abundant from Cape Cod, Massachusetts to Cape Hatteras, North Carolina, and
genetically distinct populations exist north and south of Cape Hatteras (Grimes et al.,
1989).
In the South Atlantic Bight, spawning times and habitats of summer flounder are poorly documented. Seasonal migration patterns of adult fish have been deduced, however, based on collections of newly hatched larvae, commercial catch data, and generalized coastal and shelf trawling surveys. During cooler months, summer flounder migrate offshore. They spawn near the bottom of shelf waters (30 m - 200 m deep) in late fall, winter, or early spring. Spawning in the mid-Atlantic region continues into February and March in some years and probably begins north of the Chesapeake Bay and progresses southward in a cycle that ends in the South Atlantic Bight (Smith 1973). Adult summer flounder move back inshore to estuaries or coastal waters in the winter and spring (Wilk et al., 1980).

The summer flounder appears to become sexually mature by the age of two. Adult females, on the average, are 60 mm longer (in total length) than males at first attainment of sexual maturity in the Mid-Atlantic Bight. The number of maturing ova in summer flounder is highly correlated with weight and length. Fish in the mid-Atlantic region between 366 and 680 mm total length have an estimated 0.46 to 4.19 million ova (Morse 1981). Eggs are pelagic, with a mean diameter of mature unfertilized eggs of 0.98 mm. The egg volume is approximately 95% yolk. Incubation time in the laboratory is approximately 9 days at 5° C and 2-3 days at 21° C (Johns et al., 1981).

Larvae measure approximately 3.0 mm at hatching and grow to about 3.6 mm by the time yolk-sac absorption is complete. Growth until the absorption of the yolk sac is
complete is not temperature dependent; it has been observed that a length of 3.6 mm is reached within six days of hatching at both 11° C and 21° C (Johns et al., 1981). No data on larval feeding habits is available.

Young summer flounder are >6 mm long when they first are transported to estuarine nursery areas by currents. Postlarval flounder are generally found at salinities above 12 ppt; however, juveniles are prevalent at higher salinities. Yearlings move to the ocean in summer, but underyearlings remain in the estuaries. In the mid-Atlantic region, growth rate of age I+ summer flounder decreases from north to south, and growth rate and growth efficiency are greatest at salinities >10 ppt. Growth of young-of-the-year stops toward the end of their first year in fall and does not resume again until spring when the fish are yearlings (Grimes 1989). Adults commonly reach a length of 35 inches and a weight of 18 pounds in the mid-Atlantic area (Smith 1987).

It is thought that zooplankton and small crustaceans are eaten by larval and postlarval summer flounder, but supporting data is lacking. The diet of juveniles consists of mysid shrimp and small fish, and adults feed on fish and mysid and decapod crustaceans (Grimes 1989).

The summer flounder is an important commercial and recreational species along the Atlantic seaboard of the United States and is the major recreationally caught flounder of the mid-Atlantic inshore waters. There are three major commercial fisheries:
the inshore summer fishery; the offshore winter fishery; and a fall and winter trawl
fishery inside the 20-fathom (36-m) contour that developed on the Virginia and North
Carolina coast in the 1960s (Grimes 1989). In 1980, a downward trend in east coast
landings (metric tons) began. By 1990, the recreational catch hit a record low, and the
commercial catch dropped to its lowest level in 15 years. Landings have improved
slightly in recent years but remain far below the average for past years. Indications are
that summer flounder stocks along the entire Atlantic coast are still experiencing over­
fishing (Holton 1995).

The flatfishes were among the first marine fishes to be experimentally cultured.
Some of the most commercially important fish of north temperate waters fall into this
group. In addition to their economic value, other characteristics have made summer
flounder desirable for culture. They inhabit chiefly shallow waters, are generally hardy,
and, unlike most of the marine commercial fishes, are somewhat sedentary (Bardach et
al., 1972). They have also been found to grow well stocked at very high densities (50-
60 kg/m²) and are euryhaline, tolerating a salinity range of 12-35 ppt (Duffy 1996).

The majority of the research that has been conducted on flounder culture in the
United States has taken place at the University of Rhode Island (URI) and the
University of New Hampshire (UNH). For the past six years, URI research efforts have
been focused on spawning the flounder, while UNH has experimented with grow-out in
closed recirculating systems (Duffy 1996). The first commercial hatchery producing
summer flounder fingerlings commenced operation in New Hampshire with a spawn last November. Since the United States is far behind Europe and Asia in the establishment of a marine fish culture industry, strategies for approaching flounder culture research were based on techniques used for producing turbot in Spain and Japanese flounder (*P. olivaceus*) (Bengtson 1996). The Japanese boast 20 years of experience in flounder culture (Ikenoue and Kafuku, 1992). Adjustments to those techniques are being made, however, as the summer flounder learning curve takes shape.

Questions related to both stock enhancement and food fish production are numerous, a common denominator being economic feasibility. Additional concerns with stock enhancement are: (1) technical feasibility; and (2) plausibility of a significant biological effect (Bengtson 1994).

Specific research needs for summer flounder that are currently being addressed include pigmentation problems, cannibalism around metamorphasis, weaning to an artificial diet, stocking density, and economics. Production achievements have been encouraging, however. Ten-inch flounder weighing one-half pound were produced in one year at URI in a recirculating system (Bengtson 1994).

**Bibliography**


SPECIES PROFILE: Black Sea Bass (*Centropristis striata*)

The black sea bass, *Centropristis striata*, occurs off the northeastern United States (U.S.) along the entire Atlantic coast. Throughout its range, black sea bass are an important recreational and commercial species. According to the National Marine Fisheries Service, black sea bass are classified as overexploited (NOAA 1995). The U.S. recreational fishery for black sea bass reported landings of 2.1 thousand metric tons in 1993; total commercial landings for the same period were 1.3 thousand metric tons (NOAA 1995). In Virginia, commercial landings for black sea bass in 1992 were reported to be 577,528 pounds, valued at $702,507 dockside (VMRC 1993); this is a significant decline from a high of 1,391,730 pounds in 1984 (VMRC 1985). According to Kirkley (1997), for the past five years, the dockside value of black sea bass was the third highest relative to edible finfish; only summer flounder and seatrout had annual landed values higher than black sea bass.

Black sea bass are opportunistic bottom-feeders that eat crustaceans, fish, mollusks, echinoderms, and plants. It is a dominant species associated with the hard- or live-bottom sponge-coral habitat in the South Atlantic Bight (Mercer, 1989). They occur at water depths as shallow as one meter in estuarine waters to depths of 73 to 195 meters offshore in winter north of Cape Hatteras, North Carolina (Musick and Mercer, 1977).
Black sea bass are protogynous hermaphrodites; most begin life as females and later transform into males (Mercer 1989). Spawning begins in March off North Carolina and occurs progressively later further north. Both sexes reach 50% maturity by age two with the median size at maturity for males and females at 19.0 and 19.1 cm respectively (NOAA 1995). Transformation from female to male generally occurs between ages two and five, with an indication that sexual succession is primarily a post-spawning process (Mercer 1978). Females are rarely found older than eight years (>35 cm), while males may live up to 15 years (60 cm) (NOAA 1995).

Fecundity of black sea bass is significantly related to length, weight, and age. Mercer (1978) and Wenner et al., (1986) provided fecundity relationships for black sea bass in the Middle Atlantic region. Estimates of fecundity ranged from 17,000 in a fish of 108 mm SL (age two) to 1,050,000 in a fish of 438 mm SL (undetermined age).

Little is known of the early life history of black sea bass. Eggs and larvae are pelagic. It is believed that the larvae period is relatively short. Larvae (2-13 mm) have been collected from June to November between Sandy Hook, NJ, and Cape Lookout, NC (Kendall 1972). Larvae longer than 13 mm SL were not collected, presumably because they become demersal or estuarine near that size.

Juvenile black sea bass occur in saline areas of estuaries along the coast from Florida to Massachusetts (Kendall 1977). Within estuaries, juveniles are found around
jetties, piers, wrecks and shell bottom such as oyster reefs.

Black sea bass have been collected year round in North Carolina estuaries at salinities of 1 to 36 ppt and temperatures of 6° to 29° C (Link 1980). In South Carolina estuaries juveniles were found at salinities of 8.8 to 37.8 ppt and temperatures of 5.6° to 30.4° C (Cupka et al., 1973).

Adult black sea bass are found in offshore areas in depths of 10 to 120 m. In the northern part of their range, black sea bass are migratory. In the Middle Atlantic Bight black sea bass move inshore and northward in spring and offshore and south in fall (Musick and Mercer, 1977). Black sea bass are rarely encountered in salinities less than 12 ppt and are most common at salinities above 18 ppt.

Mercer (1978) established von Bertalanffy growth parameters for black sea bass in the Chesapeake. Her low estimate of K (growth coefficient) = 0.219 indicates that black sea bass attains its maximum size slowly. Using otoliths and back-calculating lengths, Mercer (1978) reported standard lengths at age to be: age one, 87 mm; age two, 141 mm; age three, 177 mm; age four, 205 mm; age five, 231 mm; and age six, 244 mm.

The aquaculture potential of black sea bass was recognized as early as 1970, when Hoff successfully induced spawning in the southern subspecies of black sea bass.
using chorionic gonadotrophins. He believed that the black sea bass should be considered for future culture ventures due to its hardiness and growth rates in captivity. While there has been sporadic interest in black sea bass culture over the past two decades, no significant progress has been made in commercial applications.

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**SPECIES PROFILE: Tautog (Tautoga onitis)**

The tautog, *Tautoga onitis*, is found from the coastal region of Nova Scotia to South Carolina and is abundant from Cape Cod to the Delaware Capes. It prefers areas with rock reefs, piers, and high-relief habitat, but will also utilize eelgrass, kelp, and gravel beds. Since the tautog does not migrate long distances, it is particularly susceptible to local stresses in the coastal region along its range (Auster 1989).

Inshore habitats are occupied by the tautog from April until late October, and seasonal movements are greater in adult tautog than juveniles. Their winters are generally spent in deeper waters (25 to 45 m) with complex topography. When temperatures reach between 5° and 8° degrees C, the fish settle into individual shelters.
and remain torpid until spring when water temperatures increase. Almost no feeding occurs during this period of temperature debilitation (Olla et al., 1974). The tautog also requires shelter for protection at night, when it becomes quiescent. As a result, shelter sites may become a limiting factor of population size within a particular habitat, and competition for shelter sites may occur (Olla et al., 1974).

Tautog reach sexual maturity at 3-4 years of age, when males average 20.0 cm in length and females average 19.0 cm in length. They move inshore in late spring to spawn, requiring temperatures of 10° - 26° C and salinities of 26-29 ppt. The spawning season generally extends from mid-May to mid-August and peaks in June (Colton et al., 1979). Large mature tautog have been observed spawning in pairs and groups in the laboratory. Younger sexually mature tautog may spawn only in groups because small males are unable to compete aggressively with larger males for females (Olla and Samet, 1977).

Fecundity is size-specific in the tautog. Fish that were 214-678 mm in fork length (weighing 170-175 g, 207g, and 3-20 years old) contained 5,000 to 673,500 mature eggs. Tautog eggs have no oil globule and egg size varies from year to year; reported diameters range from 0.70 to 1.14 mm diameter. This variation may be explained by the time of sampling; mean diameters of eggs generally decrease as the spawning season progresses. This decrease is attributed to increasing water temperature. Eggs are buoyant and are generally confined to the coastal waters. Incubation time is
approximately 42-45 hours at 20° - 22° C (Auster 1989).

Tautog larvae measure approximately 2.2 mm at hatching and grow to about 3.3 mm in 96 hours at 20° - 22° C. At this length, the yolk sac has been absorbed and the mouth is formed and functional. At 10 mm length, dorsal and anal fins are distinct. At 30 mm, the fish show the general morphological characteristics of the adults (Auster 1989).

Tautog forage during the daytime, feeding heavily on benthic organisms and predominantly on mussels throughout the year (Olla et al., 1975). Male tautog grow faster than females in length but slower in weight. Tautog are relatively slow-growing; they require 9-10 years to reach a weight of two pounds (Cooper 1967). The maximum recorded length of a tautog is 92 cm (Bigelow and Schroeder, 1953), and the oldest recorded tautog was 34 years old (Cooper 1967).

South of Cape Cod, tautog are an important recreational species, and a much smaller commercial fishery is supported. Coastwide, the recreational fishery landed about ten times as many fish as the commercial fishery (8,828,000 vs. 842,000 pounds) between 1982 and 1991, but the percentage of fish taken by the commercial fishery has risen to around 15% of the total in recent years. Total commercial landings of tautog in Virginia waters from 1966-1992 fluctuated in an unpredictable manner, ranging from 50 to 7,450 pounds. The dollar value also fluctuates widely and unpredictably. The
average annual recreational catch from Virginia appears to be between 300,000 and 400,000 fish in recent years, but this estimate is undoubtedly low since data is not collected during January and February, when tautog are one of the few species available to the recreational fisherman (VMRC 1994).

The tautog's slow growth and seasonal site tenacity may make it susceptible to overfishing. In some coastal states, minimum size limits are in effect for commercial and recreational fishermen. Virginia is not one of them; however, a recent downward trend in the number of citation fish (minimum size of 9 pounds) registered may represent an early warning of a decline in this fishery. From 1980-1986, a developing tautog fishery off Virginia's eastern shore was largely responsible for a surge in citation numbers. The two most recent world record tautog were caught during that period. In the late 1980s and early 1990s, however, the numbers of citation fish registered were significantly lower than those during the years from 1983-1986. These numbers are not completely reliable since they are based on estimates of the number of recreational anglers participating in the tautog fishery; however, anecdotal evidence suggests substantially increased numbers of participants. There has also been a significant decline in the number of citation tautog taken from the Chesapeake Bay Bridge Tunnel complex, where fishing pressure has likely remained more consistent (VMRC 1994).

Due to its slow growth and lack of prominence in the marketplace, consideration of the species as a candidate for aquaculture would be directed towards production for
restocking efforts. Their relatively sedentary nature is a distinct advantage in efforts to achieve restocking success. Research involving spawning the tautog has been conducted at the National Marine Fisheries Service (NMFS) Middle Atlantic Coastal Fisheries Center in New Jersey and at the NMFS Milford Laboratory in Connecticut. Specific topics of study have included courtship and spawning behavior, effects of elevated temperature on early embryonic development, and correlates between number of mates, shelter availability and reproductive behavior. Spawning techniques have been described, and embryos have been successfully reared to hatching; however, at this time, it seems that no information on the fingerling production of this species is available.

Bibliography


SPECIES PROFILE: Northern Puffer (*Sphoeroides maculatus*)

The northern puffer (family Tetradontidae, *Sphoeroides maculatus*) is an abundant coastal inhabitant, ranging from Cape Cod to northern Florida. Commonly known as "blowfish," "swell toad," or "puffer," it is both a recreational and commercial fisheries species. The commercial fishery for puffers (marketed as "sea squab") became important during World War II when meat was rationed (McHugh 1972). Since that time, while its popularity as a food fish has not changed, its abundance has fluctuated widely (Lyczkowski 1971). The decade of the 1960s was the time of greatest commercial landings for puffers. In 1965, total U.S. commercial landings for puffers were 13,403,000 pounds; Chesapeake Bay contributed 12,535,000 pounds to this total or 93.5% of all U.S. landings. Reported commercial landings of puffers in Virginia have fluctuated greatly over the past 25 years. According to the Virginia Marine Resources Commission (VMRC), landings of less than 100 pounds were reported in both 1975 and
1979. However, in 1991 and 1992, Virginia landings had increased to 475,000 pounds and 401,000 pounds, respectively. Since then there has been another reduction in landings, with only 22,500 pounds being reported in 1996. Puffers consistently yield high prices for the commercial watermen of Virginia, with returns in excess of $2.00 per pound not being unusual.

In Chesapeake Bay, the puffer is a "summer fish", found from about April to November. With the onset of colder water temperatures, puffers will move to deeper offshore waters and spend the winter in a quiescent state. Dovel (1971) reported that larval and juvenile puffers in Chesapeake Bay are found in water temperatures ranging from 16° to 26° C. Richards and Castagna (1970) found adult puffers on Virginia's eastern shore in water temperatures ranging from 10.0° to 34.1° C. In Dovel's (1971) survey, he found larvae and juvenile puffers in salinities from 12 to 21 parts per thousand (ppt), while Richards and Castagna (1970) found juveniles on the seaside of the Eastern Shore up to 32.2 ppt. Tagatz and Dudley (1961) reported the salinity range for adults to be 6.7 to 34 ppt.

Considered primarily a sluggish, demersal fish, puffers will move about the entire water column in their pursuit of food. Food items include a wide variety of invertebrates ranging from pelecypod and gastropod mollusks (including scallops), crustaceans, annelids, echinoderms and even tunicates. It is unknown as to how long puffers live, but maximum size is about 35.6 cm, with most being less than 25.4 cm in
length (Sibunka and Pacheco, 1981). Female puffers attain a larger maximum size than males.

Most of the life cycle for puffers is known. However, mating has not been observed in nature. It is assumed to take place during daylight hours, as puffers are known to lie quietly on the bottom at night. While little is known about the breeding habits, it is assumed that they are polygamous and promiscuous. The spawning season is protracted in the Chesapeake Bay beginning in late spring. The number of spawnings in a season is unknown, but it is suspected that males may spawn more than once per year as they are found in the ripe stage longer than females. Peak spawning occurs in June and July (LaRoche and Davis, 1973, Lyczkowski 1971). Sexual maturity is achieved at age one (Lyczkowski 1971).

Welsh and Breder (1922) described the eggs for northern puffers. Merriner and LaRoche (1977) investigated the fecundity of northern puffers in Chesapeake Bay. They demonstrated that total fecundity increases both as a linear function of fish weight and a function of total length, and provided equations describing these relationships. According to Merriner and LaRoche (1977) the average relative fecundity of female puffers is 5,204 eggs per gram of ovarian net weight and 751 eggs per gram body weight (for examples, a fish with a total length of 139 mm, will produce approximately 620,000 eggs; a fish with a total length of 282 mm, will produce approximately 2,748,000 eggs). At 20° C egg incubation takes approximately 112 hours. Hatched
larvae are about 2.4 mm in length and have a small yolk sac filled with oil globules. In 48 hours the yolk material is reduced and the mouth and vent are open. After 72 hours, the larvae's mouth is functioning.

Marcellus (1972) calculated the linear growth rate for young of the year to be about 1.0 mm per day over a 60 day period. LaRoche and Davis (1973) stated that for puffers from the lower Chesapeake Bay, most of their growth takes place during the first growing season from June to October. The longevity for puffers is unknown.

Puffers can recover better from heat shock than from cold shock (Sibunka and Pacheco, 1981). They have been demonstrated to be able to withstand temperatures of 32.5° C for up to 72 hours, however cannot tolerate temperatures below 8° C.

Puffers were the subject for aquacultural research in the early 1970s. *National Fisherman* magazine (1975) reported that scientist at the New York Ocean Science Laboratory (Fort Pond Bay, Montauk, Long Island) tested the feasibility of raising northern puffers on a commercial basis. The magazine article reported that the scientists had "great success" with inducing out of season spawning and growing puffers from eggs to adults. It was reported that an "artificial" diet that was acceptable to the puffers was developed using ground up trout pellets (high protein content), vitamins (unidentified) and gelatin, combined into "pattie" form. This sounds very much like a variation on the prepared diet that is used by the VIMS aquarium. Attempts to
find additional information on this project have been unsuccessful.

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SPECIES PROFILE: Cobia (*Rachycentron canadum*)

Cobia, *Rachycentron canadum*, are large migratory fish with world-wide distribution. In the northwest Atlantic, cobia are found from Massachusetts through Florida and into the Gulf of Mexico. Cobia are found within the Chesapeake Bay from May to mid-October (Richards 1967) and along the North Carolina coast in May and June (Hassler and Rainville, 1975). Cobia have been reported to have a north-south/spring-fall movement pattern along the southeastern United States (U.S.). Fishermen have been known to track their movement from Florida to South Carolina and a cobia tagged off Charleston, South Carolina in June 1984 was recovered in April in the Gulf of Mexico (Shaffer and Nakamura, 1989). Tagging studies conducted in Chesapeake Bay indicate that there was a distinct group that returned to the Bay every summer (Richards 1977).

Commercial and recreational harvests in the Gulf of Mexico and Atlantic waters have been irregular; an estimated 920 MT were harvested by recreational fishermen in 1965 and 408 MT were landed in 1970. Since then recreational harvests ranged from 570 to 1198 MT from 1981-1987. Commercial harvests ranged from 28.5 to 117.4 MT from 1978-1987. Virginia commercial landings have ranged from 600 to 2400 pounds for the same period. Cobia is generally considered as an incidental catch in most U.S. commercial fisheries. However, cobia are considered a target for commercial fisheries in several foreign countries. In the United States, cobia is managed by the Gulf of
Mexico and South Atlantic Fisheries Management Councils and is included in the fishery management plan for coastal migratory pelagics. Current regulations consists of minimum size (33 inches or 84 cm FL) and catch limits of two fish per day for both commercial and recreational fisheries.

Cobia is a highly prized food fish. It is suitable for fresh, frozen or smoked product (Seafood Leader 1987). The development of a significant commercial market for cobia has been precluded by small and unpredictable catches (Hassler and Rainville, 1975). Recently, due to the increased availability both in the recreational and commercial fisheries, cobia is becoming more available and desirable in seafood markets and restaurants.

Cobia spawn in coastal and near shore waters in the Gulf of Mexico between May and June. Eggs were collected at the mouth of Chesapeake Bay and further offshore during June, July and August, with the largest number collected in July (Joseph et al., 1964). Hassler and Rainville (1975) collected eggs 15-30 miles off of Cape Hatteras, North Carolina during May and June. Richards (1967) contends that spawning most probably occurs near Virginia’s Eastern Shore in the Chesapeake Bay or the Atlantic Ocean. Substantial evidence exists to support the existence of a spawning population in Virginia’s near shore and coastal waters. Fecundity estimates by Richards (1967) for cobia in the Chesapeake Bay ranged from 1.9 to 5.4 million eggs for fish weighing from 26.25 to 57.75 pounds.
Growth rates calculated by Richards (1966, 1977), Hassler and Rainville (1975) indicated rapid growth and a long life span with a faster growth rate for females. Age two fish were recorded at 5.2 pounds for females and 3.4 pounds for males. Hassler and Rainville (1975) recorded a 23.1 cm (TL) juvenile cobia weighing 80 grams or 0.17 pounds after 131 days from hatching and reared in captivity. Larval development and ecology of cobia has been described by Ditty and Shaw (1992), Hassler and Rainville (1975) and Ryder (1887).

Little work has progressed on the culture of cobia since the work by Hassler and Rainville (1975). Caylor et al., (1994) were unsuccessful in fertilizing cobia ova with cryopreserved cobia sperm in an attempt to overcome the problem of having to capture ripe males and females for spawning. Hassler and Rainville (1975) collected fertilized cobia eggs from oceanic waters east of Cape Hatteras, North Carolina. They were successful in hatching and rearing cobia larvae and juveniles using wild plankton (rotifers, copepod nauplii and adult copepods) and later shrimp, cooked bluefish and trout chow. Laboratory raised rotifers and brine shrimp were also used. They concluded that cobia were a good candidate for aquaculture due to their fast growth and ease of handling. Joseph et al., (1964) successfully maintained juvenile cobia on a diet of bits of fresh fish. Cobia are carnivorous fish feeding on crabs, other invertebrates and other fish. Based on observed growth rates, both in the wild and in captivity, advances in aquaculture systems technology, manufactured finfish diets, it would not be unreasonable to expect market sizes fish of three to five pounds in 18
months from fingerling stocking. However, it is apparent that much more information and research is needed for successful aquaculture on a commercial scale. In addition, marketability and production economics remain a question as currently there is no commercial demands for cobia as a seafood. With the ever increasing production of salmon, tilapia and other commercially acceptable species, the production of cobia as a new seafood product will have to proceed carefully.

With increasing fishing pressure on cobia and the recognition that cobia stocks are fully or over exploited, the successful culture of cobia could also play a role in stock enhancement and recovery. Although the restoration of marine finfish stocks through aquaculture is currently a hotly debated subject with many diverse opinions, the information on tag returns for cobia may offer encouragement. Richards (1977) tagged 16 cobia in the Chesapeake Bay during 1967 and 1968 with six returns. Three returns were recorded between one and five years after tagging within 32 nautical miles from release site. Cobia returned during the same year of tagging were recovered between 12 and 36 nautical miles from release site. Tag returns suggest that a distinct, repetitive, summer habitation occurs and that Chesapeake Bay cobia may be a distinct group or subpopulation.

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