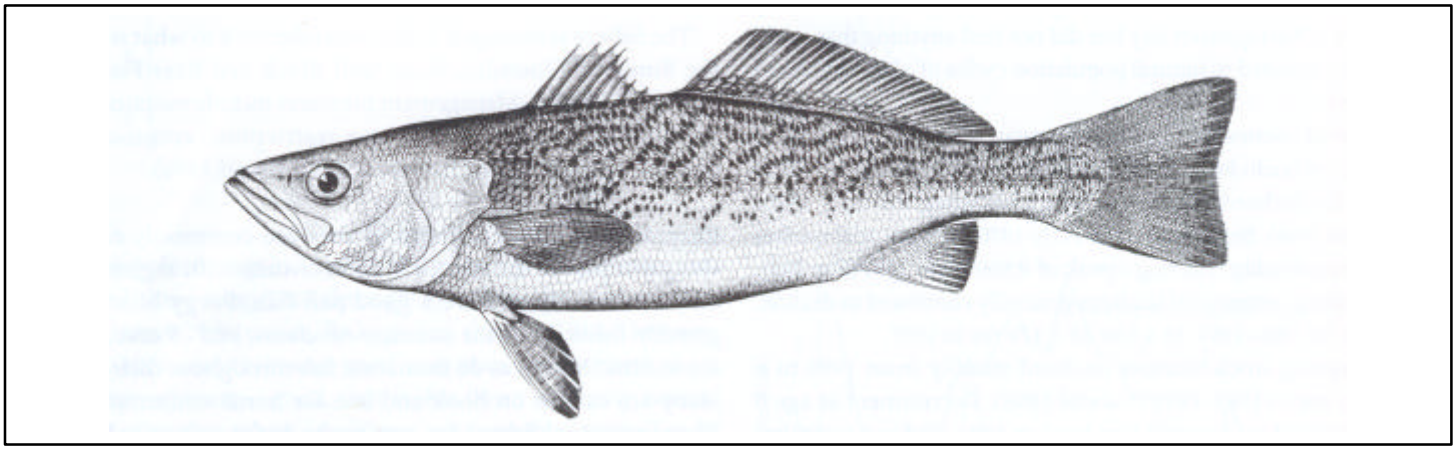
WEAKFISH / *Cynoscion regalis* (Bloch and Schneider 1801) / Squeteague, Sea Trout, Gray Trout /Bigelow and Schroeder 1953:417-423



Description. Body slim, shapely; about four times as long as deep (to caudal fin base), only slightly compressed with rather stout caudal peduncle (Fig. 236). Head about one-third as long as body; snout moderately pointed, mouth large, with projecting lower jaw. Upper jaw armed with two large canine teeth; narrow bands of teeth on sides of upper and lower jaws. First dorsal fin triangular, originating a little behind pectoral fins. Second dorsal originating close behind first, more than twice as long as first and roughly rectangular. Anal fin less than half as long as second dorsal. Pelvic fins below pectorals, which they resemble in size and pointed outline. Caudal fin moderately broad, slightly concave in outline. Body covered with moderate sized scales. Lateral line distinct and slightly arched.

Meristics. Dorsal fin rays X, I, 24-29; anal fin rays II, 10-13; lateral line scales 76-86; 4 or 5 gill rakers on upper arch and 10-12 on lower (Tagatz 1967); 13 precaudal + 12 caudal = 25 vertebrae (Miller and Jorgenson 1973).

Color. Dark olive green above with back and sides variously burnished with purple, lavender, green, blue, gold, or copper and marked with a large number of small black, dark green, or bronze spots, which are vaguely outlined and more or less run together, especially on the back, forming irregular lines that run downward and forward. Spots most numerous above the lateral line; none on lower part of sides or belly. Lower surface, forward to tip of jaw, either chalky or silvery white. Dorsal fins dusky, usually more or less tinged with yellow; caudal olive or dusky with its lower edge yellowish at the base; pelvics and anal yellow; pectorals olive on outer side, but usually yellow on inner side.

Size. Fish heavier than 7.0 kg or longer than 100 cm TL are rare. Off southern Massachusetts, the largest fish run 2.7-4.5 kg, whereas most taken there weigh 0.5-3 kg and are 35-70 cm long. The all-tackle game fish record is shared by two 8.67-kg fish, one taken at Jones Beach Inlet, Long Island, N.Y., in October 1984 and the second from Delaware Bay in May 1989 (IGFA 2001).

Distinctions. The relative sizes and shapes of the fins of weakfish and their color are such ready field marks that they are among the most easily identified fishes. The slightly emarginate tail distinguishes them from mackerels and jacks, and this same character combined with a short anal fin and a first dorsal fin higher than the second gives them an appearance quite different from bluefish. The second dorsal being much longer than the first, the presence of only two anal spines, and the slender body together obviate all possibility of confusing them with striped bass or white perch. The shape of the head and of the dorsal and caudal fins and the absence of a chin barbel distinguish them at a glance from kingfish. The lack of chin barbels separates them from drum.

Habits. Adult weakfish are usually found in shallow waters along open sandy shores and in larger bays and estuaries, including salt-marsh creeks. They even run up into river mouths, but never into freshwater. Depth distribution is surf zone to 100 m. They have been taken in salinities from 6.6 to 32.3 ppt (Dahlberg 1972) and temperatures from 17° to 26.5°C (Merliner 1976). They cannot tolerate temperatures below 5°C, as many dead and numb ones were found at this temperature in North Carolina. Schwartz (1964a) subjected weakfish collected at 20.7°C to normal winter water temperatures and found swimming speed decreased as temperature approached 10°C, feeding ceased at 7.9°C, and all fish died at 3.3°C. Weakfish move in schools, often small but sometimes consisting of many thousands. They have been described as swimming near the surface, this being the general rule near New York and along the southern New England coast, where great numbers are caught on hook and line within a few feet of the surface. They usually remain in the upper 10 m in summer.

Male weakfish produce sounds, especially during the breeding season. These are deep thumps like a drumbeat and bursts of high-pitched croaking. They also produce loud knocks and rapid bursts of croaking associated with alarm, defense, and offense. Weakfish have a large carrot-shaped swim bladder with three anterior diverticula that are vibrated by external paired sonic muscles. Sonic muscle mass increased threefold concomitant with increased plasma androgen levels at the peak of the spawning season (April and May) in Delaware Bay (Connaughton and Taylor 1994). Females lack these specialized muscles and do not make drumming sounds. Both sexes have well-developed pharyngeal patches of strong re curved canines close to the swim bladder that are associated with bursts of higher-pitched clucking (Fish and Mowbray 1970).

Food. Weakfish feed on a wide variety of prey, including crabs, amphipods, mysid and decapod shrimps, squids, shelled mollusks, and annelid worms, but Chiefly on smaller fishes such as anchovies, menhaden, herring, silverside, jacks, spot, Atlantic croaker, scup,

butterfish, sand lance, and flounders (Welsh and Breder 1924; Merriner 1975; Chao and Musick 1977; Wilk 1979; Bowman et al. 2000). The precise diet varies with locality, that is, with what is most readily available, although small clupeids and anchovies are probably the most important components. Weakfish smaller than 20 cm TL feed mostly on crustaceans (especially *Neomysis americana* and *Crangon septemspinosa),* 74-96% of the diet by weight for two smaller size-classes (Bowman et al. 2000). Larger weakfish prey mostly on fishes, 60-94% of the diet for six larger size-classes. Merriner (1975) studied the diet of weakfish in North Carolina and reviewed much of the previous food habit data. He concluded that they feed on any locally abundant organism, but there was an apparent preference for shrimp, anchovies,
and clupeid fishes throughout the species range. In North Carolina the dominant food items were penaeid and mysid shrimps, anchovies, and clupeid fishes. The importance of shrimps in the diet decreased from age 2 on, when older fish began to feed mainly on clupeids that were dominant in a given area. There was some gear bias in stomach content studies as weakfish caught in pound nets fed on fishes trapped in the net. For example, thread herring occurrence in the diet was high, but only in weakfish taken from pound nets. Weakfish are very visually oriented when feeding and have a well-developed chemosensory response mechanism (Wilk 1979). On open coasts they often feed on bottom right in the surf zone. They also feed on bottom in estuarine waters when preying on bottom-living animals, but in upper water layers when preying on small fishes. The prey-capture sequence includes visual fixation and orientation toward the prey; active pursuit; and, once within striking distance (20-50 cm), rapid beating of the caudal fin and a forward and upward lunge with jaws agape and opercles spread (Lascara 1981). In the Chesapeake Bay area, weakfish are important top carnivores in areas of eelgrass beds and appear to forage along the periphery of these beds during the low-light periods of dusk and dawn (Lascara 1981).

Predators. The main predators on young weakfish are older weakfish, bluefish (Maurer and Bowman 1975), and striped bass (Wilk 1979). Other fish predators include dusky shark, spiny dogfish, smooth dogfish, clearnose skate, angel shark, goosefish, and summer flounder (Rountree 1999). Cannibalism by adults on young weakfish was considerable in the Delaware River (Thomas 1971), probably in shallow estuarine areas where adults and juveniles co-occur.

Parasites. A parasitic isopod *Lironeca* sp. is a common ectoparasite of weakfish in Delaware (Thomas 1971). Linton (1905) described 14 parasites of weakfish from North Carolina, including the cestodes *Scolex polymorphous, Rhinobothrium* sp., *Rhynchobothrium spedosum, Otobothrium crenacolle, Tetrarhynchus bisulcatus,* and *Symbothrium* sp.; trematodes *Distomum vitellosum, Distomum polyorchis,* and *Microcotyle* sp.; acanthocephalan *Echinorhynchus pristis;* and nematodes, *Ascaris* sp.

Breeding Habits. Weakfish are multiple spawners with indeterminate fecundity and a spawning season from May to August in the Chesapeake Bay region (Lowerre-Barbieri 1994). Fecundity estimates ranged from 4,593 eggs for a fish of 203 mm TL (Shepherd and Grimes 1984) to 4,969,940 eggs for a fish of 569 mm SL (Merriner 1976). Length and weight are equally predictive of fecundity (Shepherd and Grimes 1984). The number of eggs produced is a function of size and geographic location of the stock. There appears to be latitudinal variation in age at maturity, growth, and fecundity, which suggests physiological responses to different environmental conditions or, perhaps, distinct stocks. Fish from North Carolina have greater fecundity and mature earlier than fish from the New York Bight; however they only reproduce up to age 5, whereas northern fish have the potential to reproduce up to age 10, thereby realizing the same reproductive potential over a lifetime (Shepherd and Grimes 1984).

Both male and female weakfish in North Carolina begin to mature at age 0. Some 52% of age-O females and 62% of males were mature. By age 1 all females larger than 175 mm SL were mature, and all age-2 females were mature. Size of individual fish rather than age was the dominant determining factor for sexual maturity. In the vicinity of Morehead City, N.C., at least 50% of males about 130 mm SL and 50% of females 150 mm SL were mature. In Pamlico Sound, N.C., at least 50% of males 145 mm SL and 50% of females 190 mm SL were mature (Merriner 1976). In the New York Bight, the calculated length at which 50% of the collected individuals reached maturity was 256 mm TL for females and 230 mm TL for males. The smallest mature male and female both measured 200 mm TL; the maximum size for immature fish was 400 mm TL for females and 330 mm TL for males. This corresponded to 230 mm and 180 mm for females and males, respectively; from North Carolina (Shepherd and Grimes 1984). In New Jersey; males mature at 2-3 years and females at 3-4 years, with the majority on the spawning grounds at Cape May being 4-6 years old (Welsh and Breder 1924).

There is no specific information on courtship, although male weakfish possess specialized drumming muscles that are not present in females, which indicates that there is probably some type of auditory display as males do make drumming noises. Large schools of weakfish were observed assembling on the eastern side of Delaware Bay in depths of 5-,9 m, and spawning took place over mud and sand bottom in the early evening and at night (Welsh and Breder 1924). A "milling" behavior was observed during spawning in Great South Bay; Long Island, N.Y., at which time weakfish broke the surface (Poole in Mercer 1983).

Weakfish eggs were collected from March to August between Cape Hatteras, N.C., and Narragansett Bay; R.I., predominantly in the inner one-half to one-third of shelf waters (Berrien and Sibunka 1999: Fig. 58). Spawning takes place chiefly at night in inlets, bays, or sounds in larger estuaries or close to mouths of estuaries (Ferraro 1980). Spawning begins as early as March or April off Cape Hatteras and spreads rapidly in nearshore waters extending to New Jersey in May; Long Island in June, and in some years to Narragansett Bay in July. In the New York Bight, the peak spawning period varied with the size of the fish. The largest individuals entered estuaries first, in May; and spawned by mid-May; whereas smaller ones arrived later and reached a spawning peak in June (Shepherd and Grimes 1984). Batch spawning was found in weakfish in North Carolina. Peak activity occurred from late April through June, but ripe females were found from March to September, and there was evidence of two batches of oocytes in the ovaries (Merriner 1976). Multiple spawns were not evident in fish from the New York Bight (Shepherd and Grimes 1984).

Spawning occurs after spring migration and appears to be regulated by water temperature and photoperiod, as it has been induced in the laboratory by manipulating these parameters. Water temperature was lowered to 13°-14°C and day length shortened from 12 h light/ 12 h

dark to 8 h light/ 16 h dark over a 3-week period. Fish were held under these conditions for 11 weeks; then the temperature was raised to 22°- 23°C and the light exposure changed gradually to 14 h light/ 10 h dark gradually, at which point they began to spawn (Epifanio et al. 1988).

Early Life History. The eggs are buoyant, spherical, transparent, 0.68-1.18 mm in diameter (Welsh and Breder 1924; Merriman and Sclar 1952; Lippson and Moran 1974), with one to six (usually one) pale amber oil globules that coalesce into a single large one as development progresses. Average diameter of the single oil globule is 0.22 mm and it has pigment in the later stages Uoseph et al. 1964). There is a narrow perivitelline space. Incubation takes 36-40 h at a temperature of 18°- 24°C. The eggs can tolerate 12°-31.5°C and 10-33 ppt salinity. Reduction of dissolved oxygen to 4.3 ppm reduces successful hatching, and 2.4 ppm prevents hatching. Changes in temperature and salinity of 6°C and 5-6 ppt may have deleterious effects on embryos (Harmic 1958). Eggs have been taken in tow nets at various localities in temperatures of 12°-24°C and salinities of 28-30.9 ppt.

Weakfish eggs resemble those of mackerel, but the latter have only one oil globule, a larger mean diameter (1.13- 1.15 mm vs. 0.84-0.96 for weakfish), and usually occur in salinities over 30 ppt. Weakfish eggs resemble scup and butterfish eggs; both of the latter have only one oil globule but are otherwise very similar. All sciaenid eggs have similar general characteristics, but the only sciaenid likely to spawn north of Cape Cod is the northern kingfish, *Menticirrhus saxatilis*, and they have 1-18 oil globules and a slightly larger perivitelline space (Hardy 1978b).

Newly hatched larvae are 1.49-1.99 mm long (mean 1.8 mm TL) (Harmic 1958). The yolk sac is large and contains the oil globule at the posterior end, adjacent to the anus. The body is elongate and slender. Pigmentation at hatching shows yellow chromatophores grouped behind the eye, in a transverse band behind the otocyst, on the underside of the snout, and on the yolk sac. There are scattered black melanophores on the dorsal surface of the body and the oil globule. About 8 h after hatching, the yellow pigment is more aggregated around the eye and behind the otocyst and forms two bands on the body behind the anus. Some 24 h later there is another band of yellow chromatophores posteriorly (Welsh and Breder 1924). At about 3 mm, larvae resemble silver perch and Atlantic croaker but are distinguishable by their small teeth. The only sciaenid larva likely to co-occur with weakfish north of Cape Cod are northern kingfish, which are more heavily pigmented on the body and have an anal spine (Fahay 1983).

At 30 mm, young weakfish have attained most of the structural characters of adults, but until they are 15-20 cm long they ire much deeper and more compressed, the head and eyes are relatively larger, and the caudal fin is obtusely pointed with center rays much the longest, instead of concave. Smaller fish (38-46 mm) are marked with four dark, saddle-shaped patches extending downward on the sides to a little below the lateral line; these are not lost until a length of about 114 mm is reached. As young fish grow, other bands of pigment are interpolated below the lateral line, adult coloration not being fully developed until they are 178-203 mm.

Larval and juvenile weakfish have been collected from near shore to 70 km offshore (Hildebrand and Cable 1934; Berrien et al. 1978), as well as in estuaries and tidal passes. Larvae become demersal at 1.5-8 mm TL and probably utilize subsurface currents to move to lower-salinity nursery grounds (Hildebrand and Cable 1934; Harmic 1958). Juveniles are euryhaline and have been collected in freshwater (Thomas 1971). They are more frequently found in deeper waters of rivers, bays, and sounds than close to shore or on shallow flats (Dahlberg 1972; Chao and Musick 1977). Sampling of North Carolina sounds by that state's Division of Marine Fisheries showed that juvenile weakfish occurred most often in shallow bays or navigation channels at moderate depths, in slightly higher salinities, and on sand or sand-grass bottoms (Mercer 1983).

Food of larval weakfish in Delaware Bay consists primarily of cyclopoid copepods and their eggs. Other organisms consumed were calanoid copepods, tintinnids, and polychaete larvae (Goshorn and Epifanio 1989). Juveniles 67-183 mm feed primarily on clupeids, *Anchoa mitchilli*, and shrimp, *Neomysis americanus*. Smaller weakfish feed mainly on crustaceans and larger ones on fishes (Chao and Musick 1977).

Age and Growth. Age composition and growth have been estimated from annual rings on scales, otoliths, and vertebrae, and from length frequencies. Estimates vary considerably from season to season, year-to-year, and area of collection (Wilk 1979). Scale analysis, the most frequently used aging technique, demonstrated that annulus formation occurred from April to June (Shepherd and Grimes 1983). Lowerre-Barbieri et al. (1994) found that transverse otolith sections are the best to age weakfish and that the scale method was imprecise and apparently inaccurate at more advanced ages. Maximum ages in Chesapeake and Delaware bays in the 1990s were 11 or 12 years but one fish collected in Delaware Bay in 1985 was 17 years old (Lowerre-Barbieri 1994).

There are differentials in growth and life span of weakfish from six geographical regions of the Mid-Atlantic Bight (shepherd and Grimes 1983), with three distinct regions with respect to growth: I, Delaware Bay and Cape Cod; II, Chesapeake Bay; and III, Cape Hatteras. Length-at-age was greater for females in all regions, and the difference increased with age. These differences were not statistically significant until age 6 except for Region III where it was noted at age 2. Growth from Region III was highest in the first year, but slower thereafter, and these fish did not live as long. Length-weight coefficients approach the cubic power of fish length (2.67-2.98) for both males and females (Mercer 1983).

Weakfish young grow at so variable a rate during the first summer that they may be anywhere between 92.6 and 152 mm in the fall, when they are about 6 months old. The smallest fish seen in spring are 193-254 mm. Thereafter the rate of annual growth is slower. Variation in the length attained by the young during their first summer and autumn, consequent to the protracted spawning season, combined with the fact that scale studies of this species have proved puzzling, makes it difficult to group the older age-classes by size. Growth data for young-of-the-year and age-1 weakfish from different areas along the Atlantic coast were summarized by Chao and Musick (1977).

General Range. Eastern coast of the United States from Florida to Massachusetts Bay, straying northward to the Bay of Fundy and Nova Scotia. The center of abundance for weakfish is along the coast of the Mid-Atlantic states from the Virginia Capes to New York.

Occurrence in the Gulf of Maine. Weakfish occur regularly as far north and east as Cape Cod. However, abundance fluctuates widely on the southern New England coast, and it is only during periods of

great abundance there that they appear in any numbers in Cape Cod and Massachusetts bays, which may be set as the northern limit of the range except for strays. In years in which they have passed Cape Cod in appreciable numbers, they have always been far more plentiful along the inner side of the Cape and in Cape Cod Bay at Provincetown, Truro, Brewster, and Sandwich than north of Boston, where they have been found at Nahant, Manchester, and Cape Ann. However, even in the Cape Cod Bay region, there has been only one period of abundance in the past century and a half and that lasted for about 9 years.

Migrations and Movements. In the southern part of their range, weakfish are considered to be resident; however, from the offshore waters of Virginia and the Carolinas, they undergo a spring migration northward to estuarine spawning areas, spending summer inshore and withdrawing again in autumn to overwintering grounds (Nesbit 1954). Weakfish younger than age 4 move out of inshore and estuarine areas and south to Florida along the coast in fall and north again in spring and summer. Larger fish, usually older than age 4, move south but offshore in fall, probably no farther than North Carolina, and return to inshore grounds in spring. The largest fish move the fastest and tend to gather in the northern part of the range (Wilk 1979).

Seasonal migrations occur in conjunction with movements of the 16°-24°C isotherms (Shepherd and Grimes 1983). For Chesapeake Bay, the fishing season usually lasts from the middle of April, commencing a week or two later up the bay, to the middle of November, with good catches occasionally made as late as December. On the southern New England coast, as typified by Woods Hole, weakfish are caught from May (some years as early as April, other years not until June) until the middle of October. Probably they are not to be expected north of the elbow of Cape Cod until june nor later than October for most disappear from the Mid-Atlantic coast before the end of October.

Capture of weakfish in some numbers between the offings of Chesapeake Bay and off Cape Hatteras by otter trawlers during winter months has dispelled some of the mystery regarding the wintering grounds of this species. The fact that several were caught in the lOO-m zone off Rhode Island and Martha's Vineyard is evidence that some of those that summer to the north only. move offshore to escape falling temperatures.

Importance. Weakfish were plentiful off southern New England toward the end of the eighteenth century and, from fishermen's reports, were well known in Massachusetts Bay at that time, but they vanished so completely sometime prior to 1800 that when a stray specimen was taken at Provincetown in June 1838, it was sent to Boston for identification. This disappearance evidently involved the whole northern part of the range, for they also vanished from the Nantucket-Martha's Vineyard region sometime between 1800 and 1837. By 1867 they had reappeared off southern Massachusetts, and the catch in the Cape Cod Bay-Massachusetts Bay region, localized chiefly on the outer side of Cape Cod and in Cape Cod Bay, was larger for the next few years. They appeared in such numbers in Cape Cod Bay in 1900 that the catch there for that year jumped to more than 49,000 kg, and a few were taken even as far north as Boston Harbor and Gloucester. This marked the start of a period of local abundance, which was entirely unexpected and which, with its equally sudden eclipse, is perhaps the most interesting event in the history of local fisheries. Unfortunately, reliable catch statistics are not available for the crucial years, but weakfish were so plentiful in Cape Cod Bay in 1901 as to glut the market; while in 1902 and 1903 pound nets in Cape Cod Bay were often filled with schools of large weakfish, averaging about 2.3 kg. This abundance continued through 1904, by which time it seems to have been accepted as the normal state of affairs and no longer worth comment. But it seems to have culminated in that summer or the next, for weakfish were reported as less plentiful in 1906. There is no reason to suppose that they have entered Cape Cod Bay in any numbers since that time.

It is doubtful whether any large numbers of weakfish have reached the northern side of Massachusetts Bay since 1909, when 90 kg were reported from a pound net off Gloucester. Large landings were reported from the northern part of the Massachusetts coast (Essay County) in the 1940s, but one cannot assume that any of them were caught north of Cape Cod, for all fish taken by vessels sailing out of Gloucester during those years were credited to that port, irrespective of where caught or landed.

There is no explanation for this unexpected invasion of weakfish north of Cape Cod about the turn of the twentieth century or for its equally sudden eclipse, the opportunity having passed long since for obtaining any information as to sizes and ages of the fish, their movements, and the physical state of the water at the time. It was not a local event, however, but part of a corresponding fluctuation in the population as a whole east and north of New York. Thus the catch for the southern coast of New England was more than eight times as great in 1904, but thereafter declined so markedly that in 1908 both the commercial fishermen and the anglers of Rhode Island and of southern Massachusetts complained of the scarcity. Weakfish nearly vanished from the southern shores of Massachusetts by 1920 and 1921. Partial recovery took place off the southern Massachusetts coast during the period 1931- 1938, but did not bring weakfish back to Cape Cod Bay.

Currently, weakfish are of no importance in the Gulf of Maine, commercially or to the angler, although they were a very valuable addition to shore fisheries of Cape Cod Bay during their brief period of plenty there. However, they are one of the most important food fishes along more southern coasts, and a favorite game fish that has been the subject of many accounts from the angler's standpoint. A summary of their commercial and recreational importance (Wilk 1981) and management and protection of the fishery (Mercer 1983) are further summarized in the Atlantic States Marine Fisheries Commission management plan (ASMFC 1985).

Stocks. There is evidence that there may be three stocks based on body length-scale length relationships and differences in growth and longevity (Shepherd and Grimes 1983): Region I, Cape Cod to Ocean City, Md.; II, Ocean City to Virginia Beach, Va.; III, Virginia Beach to Cape Fear, N.C. Other authors have hypothesized the existence of two (Pearson 1941; Joseph 1972) or three (Seguin 1960) subpopulations. Most thought that the separation point was at Cape Hatteras. Results of electrophoretic studies of young-of-the-year and adults from Long Island, Delaware Bay, York River in Virginia, and Cape Hatteras (Crawford et al. 1989) and mitochondrial DNA from populations along the Atlantic coast of the United States (Graves et al. 1992a) indicate that weakfish comprise a single gene pool, so the fishery should be managed as a single, interdependent unit.