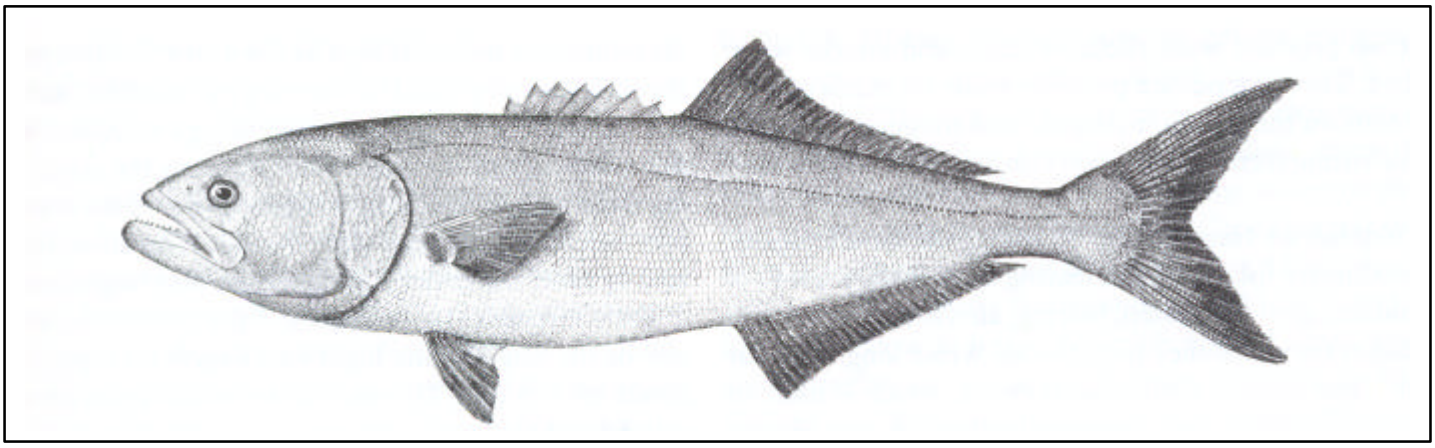
BLUEFISH / *Pomatomus saltatrix* (Linnaeus 1766) / Bigelow and Schroeder 1953:383-389



Description. Moderately stout-bodied (large individuals about one-fourth as deep as long) (Fig. 213). Belly flat-sided but blunt-edged below; caudal peduncle moderately stout; head deep; snout moderately pointed; mouth large and oblique, with projecting lower jaw and prominent teeth. "Snappers" (young-of-the-year bluefish) relatively deeper. First dorsal fin originates over middle of pectoral fins, low; rounded, and depressible in a groove. First dorsal separated by a very short interval from second dorsal, which is more than twice as long as first and about twice as high, tapering backward with slightly concave margin. Anal fin similar to second dorsal but with a somewhat less concave outer margin, originating somewhat farther back, preceded by two very short detached spines often hidden in skin. Pelvic and pectoral fms moderate-sized. Caudal fin broad and moderately or deeply forked. Body, most of head, and second dorsal and anal fins clothed with medium-sized scales. Lateral line complete, slightly arched over pectoral fin.

Meristics. Dorsal fin rays VII-IX, I, 23-26; anal fin rays II or III, 25-28; pectoral fin rays 18; vertebrae, 11 precaudal + 15 caudal = 26.

Color. Sea green above, silvery below. Second dorsal, caudal, and pectoral fins are of the general body tint, with black blotch at base of pectoral fin.

Size. Maximum length about 115 cm. The all-tackle game fish record was a 14.40-kg fish caught at Cape Hat teras, N.C., in January 1972 (IGFA 2001). A 114.3-cm fish weighing 12.3 kg was caught off Nantucket in 1903 and one of 9 kg was taken off Montauk, N.Y., in August 1951. It is said that fish of 13.6 or even 22.7 kg were not unheard of during the last half of the eighteenth century, but these huge fish may not have been weighed. The general size of the largest fish that are currently caught off the American coast is approximately 4.5-6.8 kg.

Distinctions. Bluefish are separable from jacks (Carangidae) by their jaws: in bluefish, the upper and lower jaws are armed all around with a single series of stout, conical, canine teeth (3-6 mm long in a 5-kg fish), whereas crevalle jack have canines, and only two of them. Furthermore, the caudal peduncle of bluefish is stouter than that of any jack. They are sharply differentiated from mackerels (Scombridae) by the absence of dorsal and anal finlets. They superficially resemble sea trouts (Sciaenidae) in general body form and in arrangement of the fins, but they are readily separable from them by the fact that the anal fm is nearly as long as the second dorsal. They differ from sea bass (Serranidae) in that the first dorsal fin is much lower than the second.

Habits. Bluefish are oceanic, found both inshore and offshore, as well as in many parts of the ocean, usually in continental shelf waters. They are warm water fish and are never found in any numbers in temperatures lower than about 14°-16°C (at least in summer), appearing along the u.s. coast as warm-season migrants. They can tolerate temperatures of 11.8°-30.4°C, but exhibit signs of stress at both extremes (Olla and Studholme 1971). They can survive temporarily in waters of 7.5°C butjuveniles cannot survive below lo°C (Lund and Maltezos 1970). Juveniles lose equilibrium at temperatures of 34.5°-35.6°C (Olla et al. 1985). Bluefish enter Long Island Sound waters when temperatures reach 12°-15°C and leave when they drop below 15°C in the fall (Lund and Maltezos 1970). Bluefish swim continuously in a definite rhythm, moving faster by day than by night (Olla and Studholme 1972). This activity rhythm is characterized by a sharp increase in speed from the last hour before sunrise to the first after sunrise, and a more gradual increase during the next 6-7 h. During the afternoon, swimming speed decreases rapidly and then tapers off within 1-2 h after dark, and swimming is slower throughout the night. This rhythm appears to have an endogenous component as it persisted under constant low light for several days.

Temperature also affects bluefish activity. Response to both high- and low-temperature stress was an increase in swimming speed that was 3.5 and 1.5 times higher than acclimation speeds at high and low temperatures, respectively.

Bluefish are powerful swimmers. Maximum velocity was calculated as 3.8 m.s-l when the fish were startled. Average speeds varied from 0.18 to 1.6 m.s-l. They use two different swimming patterns. At speeds between 0.5 and 1 m.s-l, the two sides of the body being used symmetrically for thrust; at higher speeds they swim using a more asymmetric thrust (Dubois et al. 1976). A bluefish tagged in New Jersey was recaptured 379 kIn to the south 20 days later for an average distance of 18 kIn.day-l (Deuel1964a).

Bluefish are schooling fish that travel in similar-sized groups, often in schools of many thousands; in 1901, for example, a school 8-9 kIn long was reported in Narragansett Bay. There is a high degree of group interaction during the day, favoring large schools, but these

tend to break down into smaller schools at night (Olla and Studholme 1972).

Bluefish produce weak clicks, thumps, and knocks when disturbed. These sounds are probably made by bands of villiform teeth on the vomer, palatines, and tongue and on the series of strong teeth on the jaws (Fish and Mowbray 1970).

Food. Bluefish are considered to be among the most ferocious and bloodthirsty fish in the sea, leaving in their wake a trail of dead and mangled menhaden, herring, alewife, mackerel, and other fishes on which they prey. Goode wrote long ago, that bluefish, "not content with what they eat, which is itself of enormous quantity, rush ravenously through the closely crowded schools, cutting and tearing the living fish as they go, and leaving in their wake the mangled fragments." In contrast to most piscivores, bluefish are capable of severing prey into pieces (Juanes et al. 1994). The effects of bluefish predation are as significant as Goode noted. The prey biomass consumed by bluefish annually along the u.s. Adantic coast is equal to eight times the biomass of the bluefish population (Buckel et al. 1999c). Bluefish consume a much higher biomass of squid and butterfish than is currendy harvested by commercial fisheries for these species.

On the continental shelf and Georges Bank, bluefish feed on a wide variety of prey; 28 species of bony fishes and more than 10 species of invertebrates (Buckel et al. 1999b: Table 1). Both spring- and summer-spawned young-of-the-year bluefish diets on the shelf are dominated by bay anchovy (Buckel et al. 1999b). The adult diet is dominated by schooling species such as squids, clupeids, and butterfish (Buckel et al. 1999b; Bowman et al. 2000). On Georges Bank in 1994, percent frequency and percent weight figures for squids were 29.6% *F;* 23.7% W for *Loligo pealei* and 11.1% *F;* 8.4% W for *n/ex il/ecebrosus;* for butterfish 27.8% *F;* 18.6% \v; and for Adantic herring 7.4% *F;* 11.3% W (Buckel et al. 1999b). From Cape Hatteras to Montauk, bay anchovy were the single most important item at 25.9% *F;* 21.4% w: Fish prey include eel, menhaden, round herring, alewife, anchovies, killifishes, silversides, silver hake, mullet, longhorn sculpin, sea robins, spot, Adantic croaker, scup, weakfish, butterfish, cunner, sand lance, mackerel, gobies, and flatfishes (Wilk 1977; Naughton and Saloman 1984; Bowman et al. 2000). Bluefish also eat squids, amphipods, decapods, and polychaetes. In the Indian River estuary; Del. (Grant 1962), mummichog made up 40.5% of the diet followed in importance by menhaden (15.8%), silversides (13.9%), and anchovy (8%). Some of the menhaden consumed were half the size of the bluefish predator. Bluefish in the New York Bight ate primarily anchovy, menhaden, round herring, silversides, sand lance, mackerel, and butterfish. Invertebrate prey included shrimps, squids, crabs, mysids, and annelid worms (Wilk 1982). Deuel (1964b) found a sea lamprey in a bluefish stomach.

Feeding behavior studies have shown that bluefish rely primarily on vision to locate and capture prey, although they are responsive to olfactory stimuli (Olla et al. 1970). Responses to live mummichog were classified into six categories: (1) initial perception (schooling ceased and swimming speed increased when prey were sensed); (2) visual fixation; (3) pursuit-chasing (at swimming speeds as high as 0.8-1 m.s-1); (4) capture and ingestion (accomplished by lowering the mandible, arching the head, extending the opercles, and making a sharp 90-180° turn in the direction of the attack while ingesting the prey); (5) feeding intention and searching (swimming toward the point where prey had previously been sighted); and (6) satiation (characterized by more selectivity and capture of only larger prey). Early juveniles (18-74 mm FL) from continental shelf waters of the Mid-Adantic Bight feed largely on copepods until about 60-100 mm TL, when they switch to larval teleosts (Marks and Conover 1993; Creaser and Perkins 1994). Food of juveniles inshore in Sandy Hook Bay; *N.l.,* consisted of crustaceans, teleosts, and polychaetes (Friedland et al. 1988). Prey that dominated the diets in percent frequency of occurrence, numerical abundance, or weight included three shrimps, *Neomysis americana, Crangon septemspinosa,* and *Palaeomonetes vulgaris,* and three fishes, *Anchoa mitchelli, Fundulus majalis,* and *Menidia menidia.* During their first summer in the Hudson River estuary, juvenile bluefish consume a variety of prey fish species such as striped bass, American shad, and bay anchovy (Juanes et al. 1993, 1994; Scharf et al. 1997). Bluefish predation may account for 50-100% of the total estimated loss of young- of-the-year striped bass in the Hudson River estuary (Buckel et al. 1999a). On a percent weight basis, the dominant prey species of juvenile bluefish (81-200 mm FL) in Maine included mud shrimp *(Crangon septemfasciata),* alewife, silverside *(Menidia menidia),* mummichog, and unidentified fish remains (Creaser and Perkins 1994). Consumption and growth rates of juvenile bluefish increased with increasing temperature and decreased with increasing fish size in short-term experiments (Buckel et al. 1995). Daily ration estimates for spring-spawned bluefish are 3.7-9.0 g{(g X day) X 100]-1 (Buckel et al. 1999b).

Predators. Several species of sharks prey on bluefish, including bigeye thresher, white, shortfin mako, longfin mako, tiger, blue, sandbar, smooth dogfish, spiny dogfish, and angel shark (Medved et al. 1985; Kohler 1988; Rountree 1999; Bowman et al. 2000). Bluefish are the main component of the diet of shortfin mako shark, constituting 77.5% of the diet by volume (Stillwell and Kohler 1982). They are more important in the diet of sharks caught inshore than offshore. Mako may consume 4.3-14.5% of the available bluefish resource in the area between Cape Hatteras and Georges Bank, and is the most important predator on bluefish except for man.

Cod, bluefish, and summer flounder are also predators (Rountree 1999). Bluefish ranked fourth in number and occurrence and third in volume in swordfish diets; however, most swordfish containing bluefish remains were collected off the Carolinas, whereas overall samples were taken from Cape Hatteras to the Grand Banks (Stillwell and Kohler 1985).

In southwestern Maine young-of-the-year bluefish are caught by the birds Adantic puffin *(Fratercula a. arctica),* Arctic tern *(Sterna paradioaea),* and roseate tern *(Sterna d. dougalli)* to feed their young (Creaser and Perkins 1994). Common tern compete for food with bluefish off Long Island. Both feed on
sand lance and bay anchovy (Safina and Burger 1985). The tern season is from early May to November; bluefish enter the area in late May and leave in September.

Parasites. A total of 37 parasites of bluefish are known, 16 of which occur frequendy (Anderson 1970). These include an isopod *Lironeca ovalis;* copepods *Lernanthropu.s pomatomi* and *Lernaenicas longiventris;* acanthocephalan *Serrasentis socialis;* platyhelminthes

Scolex pleuronectes, Nybelinia bisulcata, Callitetrarhynchus gracilis, Otobothrium crenacolle, and *Pterobothrium filicolle;* trematodes *Microcotyle pomatomi, Bucephaloides arcuatus, Distoma finestrum,* and *Trypanorhynchas* sp., and unidentified nematodes.

Breeding Habits. A bluefish 58 cm long contained about 1.1 million eggs, and one 53 cm long about 900,000 (Lassiter 1962). The average from European specimens is 112,000-195,000 (Hardy 1978b). Bluefish become sexually mature at age 2 (Wilk 1982). Fecundity data on fish collected off New Jersey indicated a linear relationship between fork length and number of eggs per female in the size range 56-80 cm FL (Boreman 1983). Females with large ova approaching ripeness are taken off North Carolina in spring and off various parts of the coast farther north in summer. Ripe males have been taken inside Chesapeake Bay inJune andJuly. There were thought to be two major areas and seasons of spawning along the east coast: offshore near the edge of the Gulf Stream from southern Florida to North Carolina mainly in April and May and the MidAtlantic Bight in summer from June through August (Wilk 1977, 1982; Kendall and Walford 1979). However, more recent data indicate that bluefish spawn continuously from about March to at least September as they migrate northward along the coast (Hare and Cowen 1993). Offspring spawned in the middle of the spawning season may have a lower probability of recruitment, thereby creating a bimodal pattern of survival.

Biologists have not observed spawning by bluefish; however, sports fishermen off No Man's Land in Rhode Island Sound, Coney Island, N.Y., and in the eastern parts of Boston Harbor have made observations. Females swam slowly, at depths of less than 30 m, escorted by several males. They rolled on their sides and extruded eggs, and the males did the same at a faster rate while extruding milt. Males and females were not seen to make physical contact with one another (Lyman 1987). Judging from egg collections, most spawning probably takes place offshore, deep in the water column. Off Chesapeake Bight, spawning occurs mainly over the midcontinental shelf and seaward at temperatures between 18°-25°C; no spawning took place below 18°C, and maximum spawning occurred at 25°C. Distribution was also related to salinity, which ranged from 26.6 to 34.9 ppt, but eggs were most numerous in waters that were 30 ppt or higher. Optimum temperature and salinity for spawning are 25.6°C and 31 ppt. The minimums were 18°C at 31.7 ppt and 20.5°C at 26.6 ppt (Norcross et al. 1974). Peak spawning occurs near sundown (1900-2100 hours [Norcross et al. 1974]).

Early Life History. Bluefish eggs are pelagic and spherical, 0.9-1.2 mm in diameter with an oil globule ranging from 0.22 to 0.30 mm. The egg is transparent and colorless with a thin tough membrane and a narrow perivitelline space (Fahay 1983). It has a pale amber yolk and a deep amber oil globule. Bluefish eggs have been collected from Cape Hatteras to Long Island from June to August (Norcross et al. 1974; Fahay et al. 1999b: Fig. 3) at water temperatures of 18°-22°C and salinities higher than 31.0 ppt. Although eggs of scup, weakfish, and butterfish are similar in appearance to those of bluefish, the latter can be distinguished from scup eggs by the larger oil globule, and their larger size distinguishes them from weakfish (0.75-0.87 mm) and butterfish eggs (0.68-0.82).

Development was observed on laboratory-spawned eggs at about 20°C. The egg develops to the blastula stage within 12 h and gastrulation quickly follows. The embryo appears at about 17 h and develops to the tail-free stage between 20 and 30 h. Black pigment appears on the oil globule in two rows along each side of the notochord and encircling the eyes. By 31-40 h, pigment increases in stellate patches and a row of melanophores appears along the ventral aspect of the tail. The heart develops and begins to beat at 34 h, and the embryo begins to twitch at 37 h. The tail never completely encircles the yolk.

Hatching occurs after 46-48 h at 18.0°-22.2°C (Deuel et al. 1966). Newly hatched larvae are 2.0-2.4 mm. The oil globule is posterior in the yolk sac, which is more than 50% of the larval length. Larvae float head down at a 45° angle near the surface of the water. Occasionally they swim by rapid tail movements for about 40 s. They remain near the surface for about 1 h and then sink to midwater. Pigmentation at hatching consists of two rows of stellate melanophores widely separated on the head, but converging posteriorly. The eyes are unpigmented. The first day after hatching, yellow and yellow-green pigment spots appear on the dorsal and ventral finfold margin. Later, black pigment appears on the yolk sac and oil globule; melanophores enlarge on the head, nape, and dorsal and ventral edges of the body. There is a distinctive melanophore at the curve of the gut above the anus. By 4.0 mm there is a stripe of black pigment on the midline, as well as dorsal and ventral lines of melanophores. Morphologically, bluefish larvae have a relatively large head and slender body, which deepens as development proceeds. The swim bladder is visible in larvae of 3-10 mm and then is obscured. The finfold begins to break up into fins at 5 mm, when the caudal fin begins to form and flexion occurs. Dorsal and anal fins maintain their relative positions after formation. The space between the end of the first and beginning of the second dorsal fin is small. The origin of the second dorsal fin is vertical to that of the anal fin and both are equal in length. Small preopercular spines develop in 3-mm- long larvae (Norcross et al. 1974).

Several other similar species of larvae co-occur with bluefish but they can be separated by myomere numbers (bluefish 24, scup 30, red hake 40) and by body pigmentation. Bluefish have dorsal, lateral, and ventral lines of pigment; butterfish have a ventral line and red hake have dorsal and lateral lines. Atlantic mackerel larvae, which spawn earlier and are larger at hatChing, resemble bluefish but can be distinguished by a myomere count of 30 and by the presence of finlets after dorsal and anal fms develop. Some carangids *(Trachurus)* resemble bluefish, but they have more pronounced preopercular spines.

Larvae attain their full complement of adult fin rays at a length of 14 mm (Norcross et al. 1974). Scales form above and below the lateral line anterior to the caudal peduncle at 12.5-14 mm. By 36 mm, specimens developed the adult scale pattern, and scales begin to develop ctenii around 66 mm (Silverman 1975).

Bluefish larvae are found offshore between Cape Cod and Palm Beach, Fla., during every season of the year, and are closely associated with the surface (Kendall and Walford 1979). They have been taken in lower Chesapeake Bay (Pearson 1941) and Narragansett Bay (Herman 1963) but they are much more common offshore. There are two major concentrations of larvae, with distinct temperature and salinity regimes. One is south of Chesapeake Bay near the Gulf Stream in spring at 20°-26°C and 35-38 ppt and the other is north of Cape Hatteras over the middle of the continental shelf in summer at 18°-26°C and 30-32 ppt. Movement is inshore as

the season progresses. South of Cape Hatteras juveniles spend most of the summer in estuaries, and then migrate south along the shore in fall. In the Mid-Atlantic Bight, juveniles appear in coastal waters and estuaries in late summer and early fall and move southward out of the bight in late fall. No one knows, as yet, where they go in fall and winter (Kendall and Walford 1979). They are found along ocean beaches, tidal inlets, estuaries, creeks, and rivers in Florida in early summer (Padgett 1967).

When they do come inshore, multitudes of little ones or snappers, run up into harbors and estuaries along the coast, from Delaware Bay to Cape Cod. Larger bluefish, arriving somewhat later, also often come close enough to beaches west and south of Cape Cod for many to be caught by anglers casting in the surf.

Young bluefish of 1.9-7.6 cm, which have often been taken along shore in summer not only south of Cape Cod but even in the Gulf of Maine in some years, are presumably the product of that season's spawning. They grow to a length of 10.6-22.8 cm by autumn, fish of that size being common in October, and achieve a length of 20.3-30.5 cm by the following spring.

Age and Growth. Maximum age is about 12 years (Terceiro 1998a). Richards (1976a) determined age by scale analysis and back-calculated a growth curve on fish from central Long Island Sound. Boreman (1983) presented growth curves of fish from the Gulf of Mexico and North Carolina. Mean length at age from Penttila et al. (1989) is presented in Figure 214. Growth of juveniles was studied by Nyman and Conover (1988), Chiarella and Conover (1990), McBride and Conover (1991), and Hare and Cowen (1994).

General Range. Found in eight major isolated populations in coastal temperate and subtropical waters of all ocean basins except the eastern Pacific (Goodbred and Graves 1996). The known range includes the eastern coast of the Americas, northward regularly to Cape Cod, occasionally to outer Nova Scotia, south to Brazil and Argentina; Bermuda; eastern Atlantic, Azores, off Spain, and northwestern Africa; the Mediterranean and Black seas; both coasts of southern Africa and Madagascar; eastern Indian Ocean and Malay Peninsula; southwestern and southeastern Australia.

Occurrence in the Gulf of Maine. Bluefish have been found at one time or another all around the western side of the Gulf. They have seldom been seen east of Penobscot Bay (reported at Mt. Desert in 1889); Bigelow and Schroeder heard of only one taken in the Bay of Fundy, a fish caught in Minas Basin in July 1951, and there are no records of bluefish off the Nova Scotian coast or the open Gulf of Maine. One was caught off Halifax in 1925, another was taken near Liverpool on the outer coast of Nova Scotia, and they were reported «common" near Port Medway; N.S., in the summer of 1951. In recent years, there have been more reports from Maine east into Canadian waters. Juveniles (39-218 mm TL) have been reported from southwestern Maine from August to September (Creaser and Perkins 1994).

In the Gulf, too, they seem to be confined to the vicinity of the coast, but since the mid-1970s many have been caught by research vessels on Georges Bank and in offshore Mid-Atlantic waters. Snappers run up into brackish water, as in the Parker River, Mass., but larger bluefish (1 kg or more) keep to outside waters.

The geographic distribution of the localities where they have been recorded would suggest at first glance that bluefish are practically universal in the western side of the Gulf. But this is true only for brief terms of years and at long intervals, for whereas they have been known to swarm there for several summers in succession, they may then be so rare over periods of many years that the capture of a single fish is notable. It is only in the northern part of its range that the bluefish falls periodically to a very low level, which is to be expected as that is near the boreal boundary. Bigelow and Schroeder give a detailed chronology of these population fluctuations from the 1600s to the early 1950s.

In the years when bluefish pass Cape Cod in any numbers, they usually appear in Cape Cod and Massachusetts bays about the middle of June, sometimes as early as the first of that month, and they are seen off and on all summer. Most of them depart late in September, but an occasional fish lingers into late autumn. Bluefish have been caught around Provincetown even as late as December.

Migrations and Movements. In general, bluefish travel north in spring and summer and south in autumn and winter (Wilk 1982). These movements are probably environmentally induced. Two important factors are temperature and photo period (Olla and Studholme 1971, 1972). The destination of these migrations during the summer centers in the New York Bight and southern New England and the northern section of North Carolina. During the winter, the center is in the southeastern part of Florida. "Bluefish," wrote Lyman (1987), "appear off the southern coast of Florida in midwinter," and by "late March anglers take them off the Florida coast in good quantities. Large schools pass the Carolinas during March and April, appear off Delaware during April, and are first taken off New Jersey and Long Island, N. Y., during April and May;" by commercial fishermen working well offshore. The earliest commer-

cial catches are reported off southern Massachusetts in late May: But it is not until about a month later that they work inshore in any numbers. Except for an occasional belated individual, bluefish disappear wholly from the entire coast northward from Maryland by early November. The winter home of this northern contingent has long been the subject of speculation. But the fact that one was trawled in 105 m off Martha's Vineyard in mid-January in 1950 and that several hauls of 80-636 kg per trip were brought in from the region of the Hudson Gorge by otter trawlers early that same February makes it likely that most of the northern contingent merely move offshore on bottom to pass the winter in the warm zone along the outer edge of the continent. It is certain, however, that some migrate far southward (as has often been suggested for the stock as a whole), for one that was tagged off New York in August 1936 was recaptured off Matanzas, Cuba, in January 1939.

Tagging returns for adults from near Long Island Sound show that they return to the same general area year after year, but this pattern was not found among juveniles. In fact juvenile migration patterns differ from those of adults in that the former have a coastal southward migration in the fall whereas adults have an inshore-offshore migration (Lund and Maltezos 1970).

Importance. Bluefish are an excellent table fish, but have never been plentiful enough to support a fishery of any magnitude in the Gulf of Maine. Nevertheless, its presence or absence there may be a matter of

direct importance to fishing interests, for it may drive away mackerel, if not herring and menhaden as well.

A favorite game fish, many anglers troll for bluefish in Cape Cod Bay in seasons when there are enough of them to be worth following, and many are caught in the surf in good years by anglers casting from the beach as far northward along the coast as the outer shore of Cape Cod. Bluefish and scup dominated the recreational fishery in the North Adantic from 1979 to 1986, accounting for over 57% of the total catch in numbers. The most important method of fishing is from private/ rental boats followed by beach/bank (Boreman 1983). A very interesting book (Lyman 1987) on bluefishing also contains an accurate summary of bluefish biology and ecology in addition to everything an angler might want to know about how to fish for them.

In 1985, a Federal survey found that polychlorinated biphenyls (PCBs) in larger bluefish (over 500 mm FL) exceeded the U.S. Food and Drug Administration tolerance level of 2 ppm (Eldridge and Meabutn 1992). Health risks can be minimized by avoiding consumption of too many large bluefish.

Bluefish are managed under a fishery management plan developed by the Mid-Adantic Fisheries Management Council and the Adantic States Marine Fisheries Commission (Terceiro 1998a). Total landings of bluefish along the Adantic coast peaked in 1981 at an estimated 51,400 mt (Terceiro 1998a). Landings have since declined substantially: the 1994-1996 average of 11,400 mt was only 27% of the 1977-1986 average
of 41,600 mt. Bluefish spawning stock biomass declined to 22,700 mt in 1997 (Fig. 215). Atlantic coast bluefish have been overexploited since 1979 and the stock is currently well below levels needed to produce maximum sustainable yield (Terceiro 1998a).

Stocks. No mitochondrial DNA haplotypes were shared among samples from six widely separated populations of bluefish from different parts of the world (Goodbred and Graves 1996), but no significant genetic differences were detected among spring-spawned bluefish and yearling bluefish from different geographic locations along the Mid-Atlantic coast (Graves et al. 1992b).

Lund (1961) identified six stocks of bluefish along the Atlantic Coast based on the number of gill rakers on the first branchial arch. In warmer months these six stocks were found as follows: Massachusetts to New York; New Jersey; Delaware; Chesapeake Bay to Cape Lookout, North Carolina; Cape Lookout to Georgia; and Florida. Wilk (1977) used morphometric characters and scale peculiarities and concluded that there were two spawning stocks off the Atlantic coast: one in the Mid-Atlantic Bight, from Cape Hatteras to Cape Cod, from June to July (summer spawning season), and the other in the South Atlantic Bight, from southern Florida to Cape Hatteras, from March to May (spring spawning season) off North Carolina. Some early life-history studies (Kendall and Walford 1979; Collins and Stender 1987; Nyman and Conover 1988; McBride and Conover 1991) supported the two-stock conclusion but it is now believed that there is a single, migratory spawning stock along the east coast of the United States (Graves et al. 1992; Hare and Cowen 1993, 1996; Smith et al. 1994; Able and Fahay 1998; Terceiro 1998a).

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