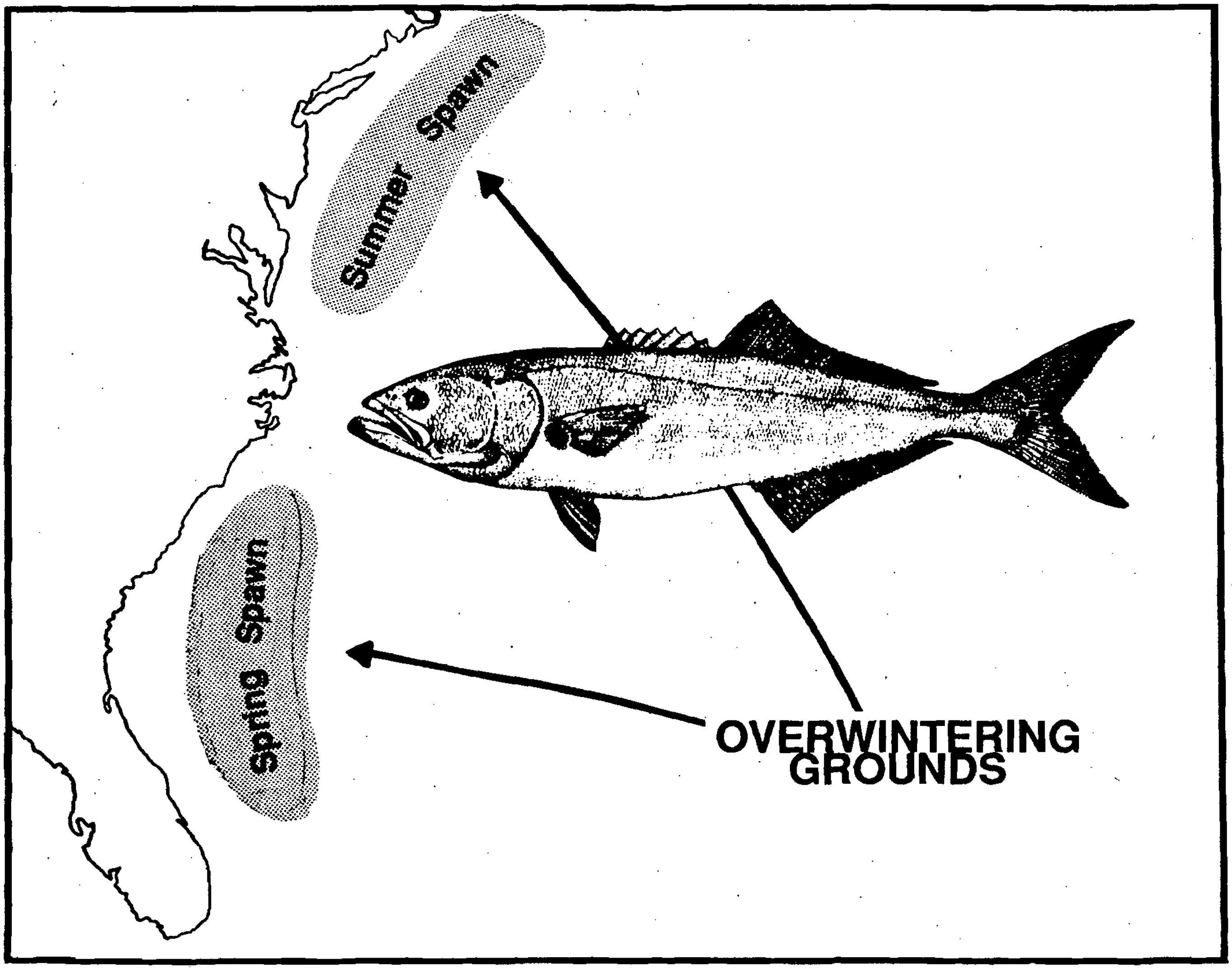
Biological Report 82(11.96)
April 1989

TR EL-82-4

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)

BLUEFISH



Fish and Wildlife Service
U.S. Department of the Interior

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)

BLUEFISH

by

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

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CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons (t)	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (°C)	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (°F)	0.5556 (°F - 32)	Celsius degrees

CONTENTS

ACKNOWLEDGMENTS

We thank Stuart Wilk, U.S. National Marine Fisheries Service, Sandy Hook Laboratory, Sandy Hook, New Jersey, and L. E. Barger, U.S. National Marine Fisheries Service, Panama City, Florida, for reviewing this manuscript.

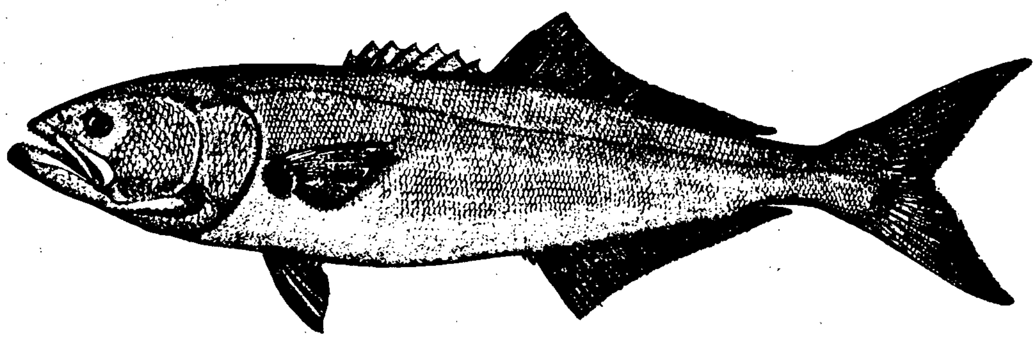

Figure 1. Bluefish.

BLUEFISH

NOMENCLATURE/TAXONOMY/RANGE

Scientific name....Pomatomus saltatrix (Linnaeus)
Preferred common name.........Bluefish (Figure 1)
Other common names...............Blue, snapper, horse mackerel, Hatteras blue, tailor
Class.................... Osteichthyes
Order.......................Perciformes
Family.....................Pomatomidae
(P. saltatrix is the only species.)

Geographic range: The bluefish occurs in most temperate coastal regions of all oceans except the north and central Pacific Ocean (Briggs 1960; Wilk 1977). It is abundant in estuarine and continental shelf waters of the east coast of North America from Nova Scotia southward to Florida and occurs in the Gulf of Mexico westward to Texas (Dahlberg 1975). In the South Atlantic Region (Cape Hatteras, North Carolina, southward to Cape Canaveral, Florida), bluefish are most abundant along the coasts of North Carolina and Florida (Figure 2).

MORPHOLOGY AND IDENTIFICATION AIDS

The first dorsal fin has 8-9 spines; the second dorsal fin has 24-25 rays; and the anal fin has 2-3 spines and 26 rays. The number of lateral line scales is usually 95. Adults are bluish or greenish above and silvery below and have a blackish spot at the base of the pectoral fins (Jordan and Evermann 1896). The large lower jaw projects beyond the upper jaw (Dahlberg 1975). The head is proportionally larger in advanced

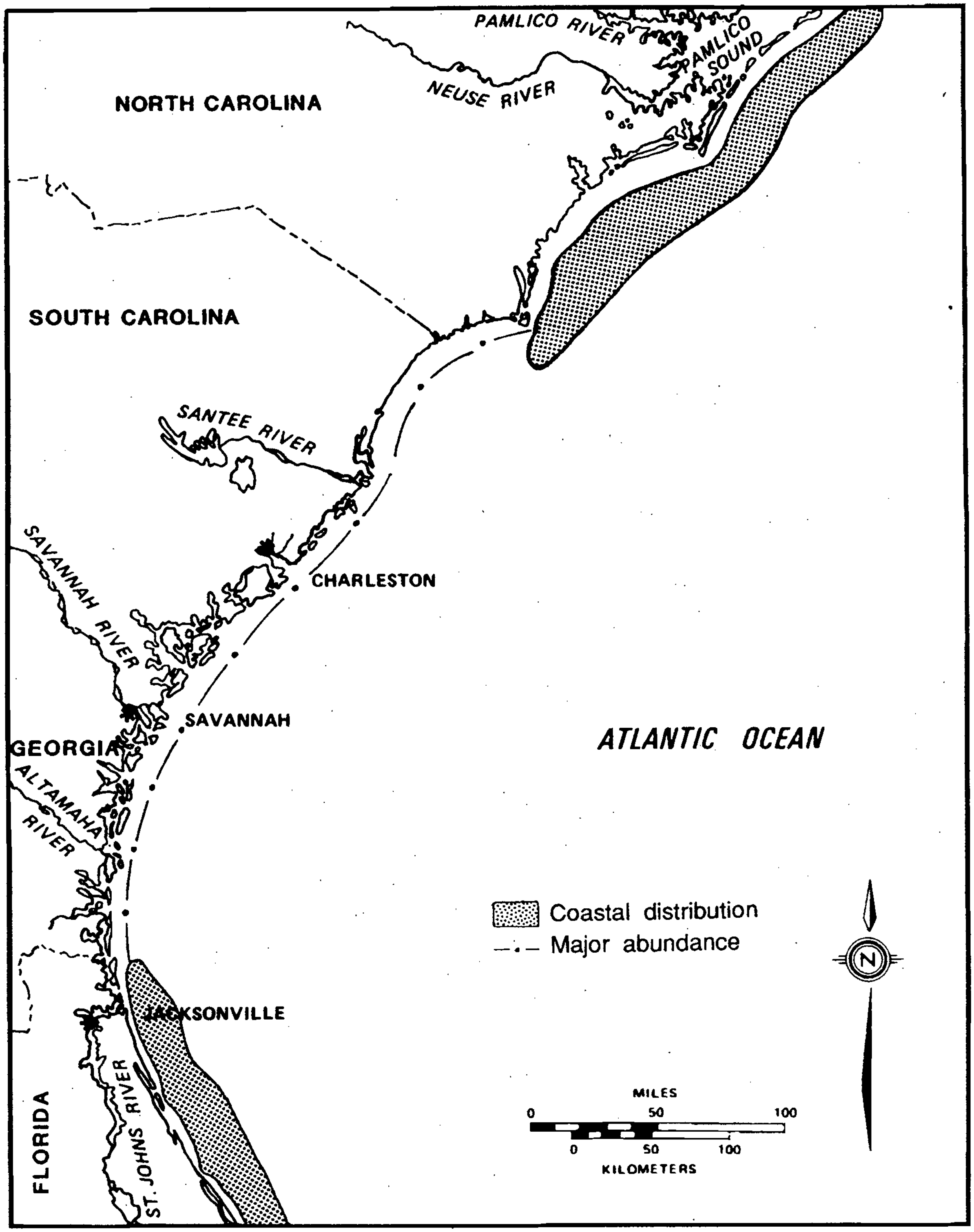

Figure 2. Distribution of the bluefish in the South Atlantic Region. Major centers of abundance are along North Carolina and Florida.

juveniles than in adults (Lippson and Moran 1974). Larvae and juveniles were described by Deuel et al. (1966) and Norcross et al. (1974).

Two stocks of bluefish have been identified along the Atlantic coast. One stock spawns during late summer in continental shelf waters in the Middle Atlantic Region (Cape Cod, Massachusetts, to Cape Hatteras), and the other spawns during spring at the margin of the Gulf Stream in the South Atlantic Region between Cape Hatteras and northern Florida (Lassiter 1962; Kendall and Walford 1979). The two stocks are distinguishable through multivariate analysis of differences in body proportions (morphometrics) as well as growth patterns on the scales of selected year classes. Compared with summer-spawned yearlings of the Middle Atlantic Region, spring-spawned yearlings of the South Atlantic have a relatively larger head and pectoral fin, larger eye in proportion to the head, longer maxillary bone, and shorter dorsal, anal, and ventral fins (Wilk 1977).

REASON FOR INCLUSION IN SERIES

The bluefish is an important recreational and commercial fish along the Atlantic seaboard; the recreational fishery predominates in the South Atlantic Region (Anderson 1978). In the charter boat fishery from Cape Hatteras to South Carolina, the catch of bluefish is exceeded only by that of king mackerel, *Scomberomorus cavalla* (Manooch et al. 1981). Recreational bluefish harvest for 1983 in the South Atlantic Region was about 10 million fish--or about 23% of the total east coast recreational catch of bluefish (NMFS 1985). Due to their abundance and high trophic level, bluefish play a major ecological role in estuarine and continental shelf waters and are dependent on these habitats for spawning and nursery areas. No other Atlantic coast species is as abundant throughout such a wide range and variety of habitats (Wilk 1980).

LIFE HISTORY

Migration of Adults and Spawning

The bluefish is a migratory pelagic species that generally travels northward in spring and summer and southward in fall and winter along the Atlantic seaboard. Concentrations of bluefish are greatest from northern North Carolina to Cape Cod in summer and along the Florida coast in winter (Mid-Atlantic Fishery Management Council 1982). Bluefish in the Gulf of Mexico apparently remain separate from those along the Atlantic coast (Lyman 1974; Barger et al. 1978). The present discussion is limited to the two stocks of bluefish that occur along the Atlantic coast.

In the South Atlantic Region, spawning occurs primarily during spring in waters just shoreward of the Gulf Stream, from southern North Carolina to Florida (Figures 3a, 4a). Ripening bluefish arrive along the coast of the Carolinas in mid-spring. Males with free-flowing milt are more commonly found in coastal areas than are ripe females because the females move offshore before their final stage of ripening (Deuel et al. 1966). There is evidence of relatively minor fall and winter spawning just south of Cape Hatteras (Kendall and Walford 1979).

In the Middle Atlantic Region, spawning occurs in summer (May - September) in waters over the continental shelf (Figures 3b, 4b; Lippson and Moran 1974; Kendall and Walford 1979; Smith et al. 1979). Norcross et al. (1974) found that bluefish north of Cape Hatteras spawned mainly over the outer half of the continental shelf; 80% of the eggs they collected were taken more than 55 km

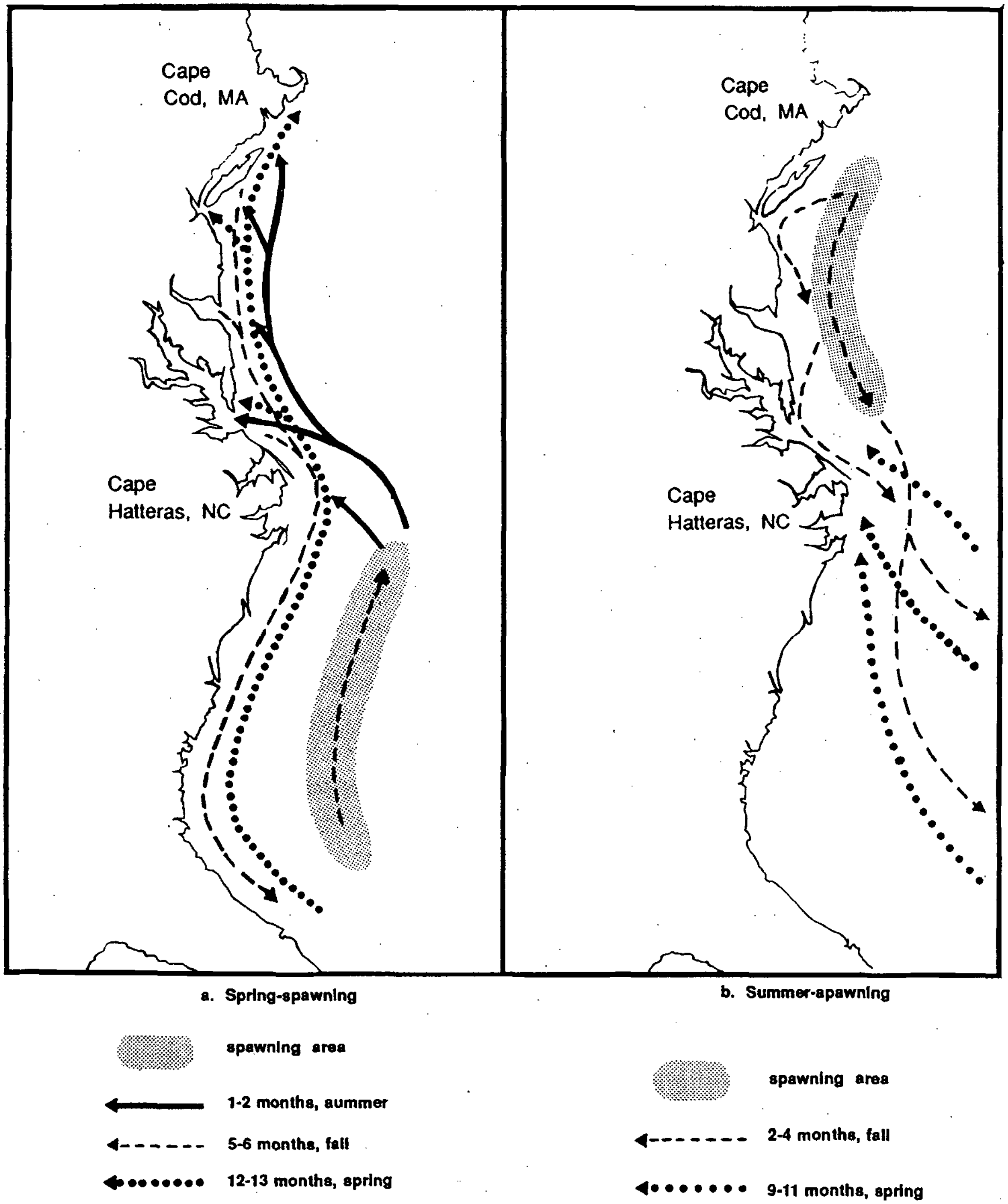

Figure 3. Migration routes of bluefish from hatching until 1 year old.

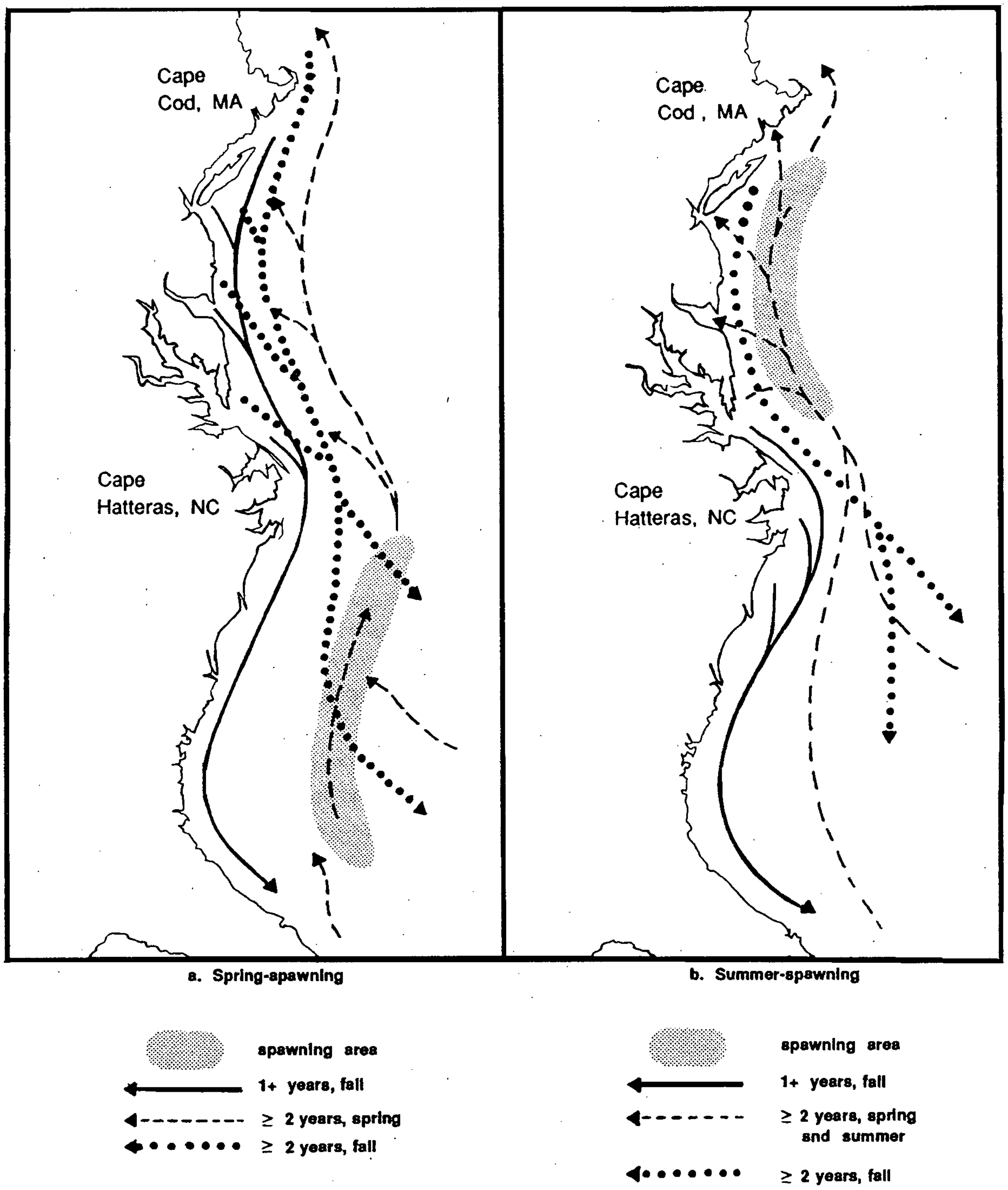

Figure 4. Migration routes of bluefish over 1 year old.

from shore. The depth at which spawning occurs is not known.

In the Middle Atlantic Region, significant numbers of summer-spawning adult bluefish that have apparently completed spawning move inshore into bays and inlets of Long Island Sound and the New Jersey coast during July and August (Figure 4b; Lund and Maltezos 1970). In the South Atlantic Region, younger bluefish (aged < 2 years for spring spawners and aged between 1 and 2 years for summer spawners) inhabit nearshore areas during their southerly migration in fall and winter (Figures 3a, 4a, 4b; Wilk 1977).

Eggs and Larvae

Female bluefish weighing 1.9-2.7 kg contained 600,000-1,400,000 eggs (Lassiter 1962). Fertilized eggs are spherical, 0.9-1.2 mm in diameter, and have an oil globule of 0.22-0.30 mm. In laboratory studies, eggs hatched after 46-48 h at 20 °C, and newly hatched larvae were 2.0-2.2 mm total length (TL) (Deuel et al. 1966). Kendall and Walford (1979) collected larvae as small as 3 mm standard length (SL) in outer continental shelf waters of the South Atlantic Region. Detailed descriptions of embryonic and early larval stages of bluefish were published by Deuel et al. (1966); Norcross et al. (1974) described development from the stage immediately after yolk sac absorption to the early juvenile stage at 17 mm SL.

During spring, concentrations of larvae in the South Atlantic Region were greatest off the New River, North Carolina, and Charleston, South Carolina, near the outer edge of the continental shelf (Kendall and Walford 1979). These larvae apparently are carried northward past Cape Hatteras by the Gulf Stream in April and May (Figure 3) and are dispersed over the continental slope of the Middle Atlantic Region (Kendall and Walford 1979; Smith 1980; Powles 1981). Collins and Stender (1987), however, presented evidence for southward and seaward migration of bluefish larvae that came from spring spawning in the South Atlantic Bight. Larvae from the minor fall and winter spawning in southern waters may find their way inshore south of Cape Hatteras, as indicated by the presence of a few juveniles there during winter (Kendall and Walford 1979; Powles 1981).

Morse et al. (1987) found a high abundance of larvae in summer on the continental shelf of the Middle Atlantic Region. Larvae spawned in the Middle Atlantic Region remain offshore until late summer and then apparently move southward in fall. Their distribution in winter is unknown (Kendall and Walford 1979).

Larval development takes place in outer continental shelf waters, primarily within 6 m of the surface, at temperatures of 18-26 °C and salinities of 30-32 ppt (Kendall and Walford 1979). Larvae undergo diel vertical migrations, concentrating at depths near 4 m during midday and at the surface at night (Kendall and Naplin 1981).

Juveniles and Adults

Bluefish of 13-17 mm SL have full fin ray counts and most of the other characteristics of adults (Lippson and Moran 1974; Norcross et al. 1974). Juveniles from the spring spawn in the South Atlantic Region occur in outer continental shelf waters of the Middle Atlantic Region from April through June (Kendall and Walford 1979). As inshore waters warm, they move shoreward across the continental shelf into estuaries between Cape May, New Jersey, and Long Island, New York, where they reach fork lengths (FL) of 180-200 mm by fall (Wilk 1977; Figure 3). Nyman and Conover (1987) suggest that most young-of-the-year bluefish in New York waters come from the spring spawning area. Juveniles from the summer spawn in the Middle Atlantic Region probably remain at sea, migrate south of Cape Hatteras in early fall, and spend the winter offshore, appearing in the sounds of North Carolina during the following spring (Kendall and Walford 1979).

Bluefish typically reach sexual maturity by age III at about 450 mm FL (Wilk 1977). Adults move in schools of similar-sized individuals; these schools remain loosely associated to form large aggregations that sometimes extend over many square kilometers along the coastline. Movement patterns are determined by several environmental factors, among which temperature and photoperiod are probably the most important (Olla and Studholme 1971).

In fall and winter, most adult bluefish from both Atlantic Coast stocks migrate southward and overwinter along the east coast of Florida. Tagging studies have indicated that the southward migration in fall is closer to shore than the subsequent northerly migration in spring (Wilk 1977). Some adults overwinter between Cape Hatteras and Cape Lookout, North Carolina, where large fish (4-9 kg) have been taken in trawls and gill nets from December through March (J. L. Ross, North Carolina Division of Marine Fisheries, Morehead City; pers. comm.).

GROWTH CHARACTERISTICS

Growth rate of larval bluefish is initially very rapid but decreases after about 3 days. Deuel et al. (1966), who determined growth rates for Long Island bluefish larvae from eggs that were fertilized and hatched in a laboratory, reported average total lengths of 2.1 mm at hatching, 2.8 mm on day 1, 3.0 mm on day 2, 3.2 mm on day 3, and 3.3 mm on day 4. Growth rates for laboratory reared fish, however, may not be representative of growth at sea.

No data on growth of juvenile bluefish have been published, but some information is available on juvenile sizes at different times of the year from collections taken in the Middle and South Atlantic Regions. Spring-spawned fish collected in Middle Atlantic Region estuaries were 25-35 mm FL during summer and grew to about 200 mm FL by fall. Summer-spawned fish were about 230 mm FL when collected in North Carolina waters the following spring and about 290 mm FL in fall (Wilk 1977). Male and female bluefish grow at about the same rate (Hamer 1959; Richards 1976). Von Bertalanffy growth equations have been developed for bluefish collected from North Carolina (Lassiter 1962) and from South Carolina to southern Florida (Barger, unpublished MS), but differences in aging techniques and stocks sampled make comparisons difficult. Wilk (1977) published the most comprehensive summary of age and growth of bluefish along the Atlantic seaboard (Table 1).

Length-weight relationships for North Carolina bluefish are similar to those for bluefish collected from South Carolina to southern Florida. Equations useful for predicting weight (W, in grams) from fork length (mm) are

$$W = (2.45 \times 10^{-5})FL^{2.903}$$

for fish collected off North Carolina (Lassiter 1962) and

$$W = (1.49 \times 10^{-5})FL^{2.985}$$

for fish collected in South Carolina, Georgia, and Florida (Barger, unpublished MS). Wilk et al. (1978) reported the predictive equation for bluefish collected in the New York Bight as

$$W = (1.12 \times 10^{-5})FL^{3.036}.$$

Table 1. Average size of bluefish of different ages collected from Rhode Island to Florida, 1963-68 (Wilk 1977). Averages were based on about 25,000 determinations of age (using scales) and 7,500 measurements of weight.

Age	Fork length (cm)	Weight (kg)
I	21	0.1
II	35	0.6
III	46	1.3
IV	55	2.2
V	62	3.2
VI	66	4.2
VII	72	5.0
VIII	76	5.8
IX	78	6.3
X	80	6.8
XI	82	7.3
XII	83	7.6
XIII	85	8.0
XIV	86	8.4

THE FISHERY

The recreational catch of bluefish in the South Atlantic Region generally exceeds the commercial catch. In 1983, anglers caught about 10 million bluefish, of which 8.2 million were from North Carolina, 1.4 million were from Florida, 0.2 million were from South Carolina, and 0.2 million were from Georgia (NMFS 1985). The 1979 commercial harvest in the South Atlantic Region was less than 5 million lb. The dependence of adult bluefish on nearshore habitats is reflected by the areas from which most of the recreational catch was taken; 60% of the harvest came from areas within 5 km of the shore. Catches from private or charter boats accounted for about 69% of the total bluefish catch, and catches from shore accounted for about 31% (NMFS 1985).

Commercial landings of bluefish increased considerably in the late 1970's and early 1980's, primarily due to increased catches in North Carolina (Table 2). During the early 1970's, long-haul seine fishermen in Pamlico Sound and the Outer Banks landed most of the North Carolina catch, but prices were less than $0.10 per lb. Most of the increase in harvest has come from offshore gillnet catches

Table 2. Reported commercial bluefish landings and values, 1976-81 (Mid-Atlantic Fishery Management Council 1982).

	Commercial landings (thousands of lb)					
Year	North Carolina	South Carolina	Georgia	Florida (E. coast)	Total	Value (per lb)
1976	1,356	1	<1	1,380	2,737	0.10
1977	2,331	10	1	1,500	3,842	0.09
1978	1,948	10	<1	1,230	3,188	0.13
1979	3,407	13	<1	1,348	4,768	0.19
1980	5,444	4	<1	1,762	7,210	0.14
1981	6,610	3	1	2,016	8,626	0.19

(J. L. Ross, North Carolina Division of Marine Fisheries, Morehead City; pers. comm.) and from the winter trawl fishery, which exploits a variety of pelagic species (Street 1983). The bulk of the commercial bluefish harvest is composed of age I-IV fish (Wilk 1977), but many age V-VII fish are taken commercially from Chesapeake Bay southward to Cape Lookout, North Carolina (J. L. Ross, North Carolina Division of Marine Fisheries, Morehead City; pers. comm.). Data on bluefish abundance, mortality rates, recruitment, and other stock characteristics that would be helpful in making management decisions are not available (Wilk 1977).

ECOLOGICAL ROLE

The feeding ecology of larval and postlarval bluefish is not well known. The only published account (Kendall and Naplin 1981) indicated that larval bluefish ate mostly copepods, but also fed on cladocerans and invertebrate eggs. Lassiter (1962) reported that the diet of juvenile bluefish from North Carolina consisted of 18% invertebrates (shrimp, *Penaeus* spp., and squid, *Loligo* spp.) and 82% vertebrates (predominantly pinfish, *Lagodon rhomboides*, and silversides, *Menidia* spp.).

Adult bluefish are visual feeders and are most active during daylight (Olla et al. 1970; Olla and Studholme 1971, 1978). They are predominantly piscivorous; invertebrates play a progressively smaller role in the diet as age of the fish increases (Lassiter 1962; Naughton and Saloman 1984). Important prey in North Carolina included other bluefish; butterfish, *Peprilus triacanthus*; harvestfish, *P. alepidotus*; anchovies, *Anchoa* spp.; seatrout, *Cynoscion* spp.; spot, *Leiostomus xanthurus*; and Atlantic menhaden, *Brevoortia tyrannus* (Lassiter 1962). Naughton and Saloman (1984) described the food habits of 283 bluefish collected along North and South Carolina in 1977-1981; a preference for schooling coastal fish species was evident--the most common prey included Sciaenidae, Clupeidae, Mugilidae, and Engraulidae. A list of the known food of bluefish collected along the entire Atlantic coast contained 16 invertebrate and 67 vertebrate species (Wilk 1977).

Only large predators, such as sharks (particularly mako sharks, *Isurus* spp.), tunas, swordfish (*Xiphias gladius*), and wahoo (*Acanthocybium solanderi*) prey on adult bluefish. Possible competitors are spanish mackerel, *Scomberomorus maculatus*; king mackerel, *S. cavalla*; striped bass, *Morone saxatilis*; large weakfish, *Cynoscion regalis*; Atlantic bonito, *Sarda sarda*; and little tunny, *Euthynnus alletteratus* (C.S. Manooch, National Marine Fisheries Service, Southeast Fisheries Center, Beaufort, North Carolina; pers. comm.).

ENVIRONMENTAL REQUIREMENTS

Temperature and Salinity

Newly spawned bluefish larvae have been found in the South Atlantic Region just shoreward of the Gulf Stream at temperatures of 20-26 °C and salinities of 35-38 ppt (Kendall and Walford 1979; Powles 1981). Spawning in the Middle Atlantic Region occurs at slightly lower temperatures of 17-24 °C and salinities of 30-32 ppt (Norcross et al. 1974; Kendall and Walford 1979; Smith 1980). Bluefish up to about 250 mm TL require temperatures higher than 10 °C for survival (Lund and Maltezos 1970), but adults may be able to survive brief exposures to temperatures as low as 7.5 °C (Wilk 1977). Adults held in a laboratory were able to survive temperatures as high as 30.4 °C (Olla and Studholme 1971). In northeast and east central

Florida, adults occur in nearshore areas where temperatures exceed 27 °C for prolonged periods (Padgett 1970).

Dissolved Oxygen

Data describing effects of dissolved oxygen concentration on bluefish are not available. However, two situations where bluefish avoided areas of low dissolved oxygen have been reported. One report comes from observations of small bluefish preying on spawning Atlantic silversides, *Menidia menidia* (Middaugh et al. 1981). Dissolved oxygen concentration was lowest (less than 1 mg/l) in the area of most intense spawning; bluefish penetrated no further than the 4 mg/l isopleth. In another case, adult bluefish were absent from areas of the New York Bight having depressed dissolved oxygen during summer, but specific oxygen levels avoided were not determined (Azarovitz et al. 1979).

Depth

Bluefish are seldom found beyond the continental shelf, but juveniles and adults occupy nearshore habitats as shallow as 0.15 m (De Sylva 1976). A bluefish can secrete gas into its swim bladder at the fastest rate known for any fish; consequently it can rapidly change depths over a large range (Bentley and Wiley 1982).

Water Movement and Turbidity

Adult bluefish forced to swim against water currents in a laboratory system maintained speeds of 4.0 to 4.6 body lengths per second for at least 30 min. At intermediate and high swimming velocities, bluefish can shift to ram gill ventilation, transferring the workload of ventilation from the branchial to the swimming musculature. This transfer results in significant metabolic savings during rapid swimming (Freadman 1979). Bluefish are powerful swimmers and can swim in turbulent waters. Ogilvy and Dubois (1981) determined that turbulence introduced into a swimming chamber did not reduce the fish's maximum swimming speed.

Turbidity may affect bluefish feeding. Adult bluefish are visual feeders (Olla et al. 1970), and anglers are usually more successful when water is relatively clear than when it is turbid (Padgett 1970).

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the life history, distribution, and environmental requirements of coastal fishes and invertebrates. Profiles are prepared to assist with environmental impact assessment. The bluefish (Pomatomus saltatrix) is a valuable recreational and commercial fish on the Atlantic coast. In the South Atlantic Region the recreational catch exceeds the commercial catch. The bluefish is a migratory pelagic fish that generally travels northward in spring and summer and southward in fall and winter along the Atlantic seaboard.In the South Atlantic Region, spawning occurs primarily during spring in waters just shoreward of the Gulf Stream from southern North Carolina to Florida. Most larvae are carried northward by the Gulf Stream and are dispersed over the continental slope of the Middle Atlantic Region. Adult bluefish inhabit nearshore areas in the South Atlantic Region during their southerly migration in fall and winter. Larval bluefish eat mostly copepods, cladocerans, and invertebrate eggs; juveniles eat larger invertebrates and fishes. Adult bluefish eat fishes and seem to prefer schooling coastal species. Bluefish have been reported to avoid areas of low dissolved oxygen. Water turbidity may affect feeding because bluefish rely on vision to locate prey. Environmental disturbances which affect the dissolved oxygen concentration or turbidity of estuarine and nearshore waters may, therefore, affect bluefish distribution and feeding.

17. Document Analysis a. Descriptors

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b. Identifiers/Open-Ended Terms

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