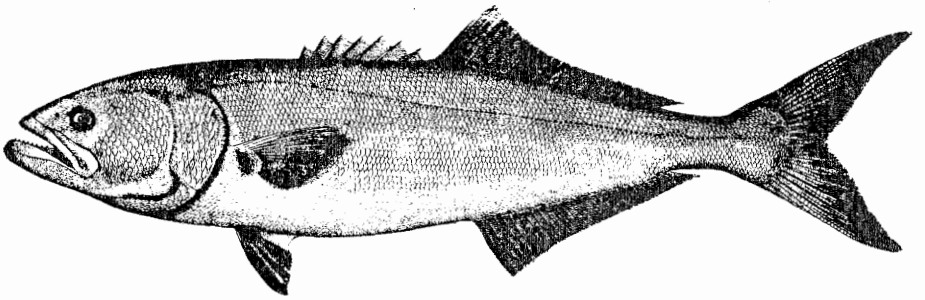

BIOLOGICAL & FISHERIES DATA
ON
BLUEFISH, *Pomatomus saltatrix* (Linnaeus)

AUGUST 1977

Biological and Fisheries Data

on

bluefish, Pomatomus saltatrix (Linnaeus)

by

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IDENTITY

1.1 Nomenclature

1.11 Valid Namee

Pomatomus saltatrix (Linnaeus) 1758

1.12 Synonymye

The following synonymy is after Jordan, Evermann, and Clark (1930):

Perca saltatrix Linnaeus, 1758

Perca lophar Forskol, 1775

Cheiladipterus heptacanthus Lacepede, 1802

Pomatomus skib Lacepede, 1802

Lopharis mediterraneus Rafinesque, 1810

Gonenion serra Rafinesque, 1810

Chromis eqicuroram Gronow, 1854

Sparactoden nalnal DeRochebrane, 1880

1.2 Taxonomy

1.21 Affinities

Classification follows Greenwood, Rosen, Weitzman, and Myer (1966). Taxa higher than superorder are not included.

Superorder - Acanthopterygii

Order - Perciformes

Suborder - Percoidei

Family - Pomatomidae

Genus - Pomatomus

Species - Pomatomus saltatrix

1.22 Taxonomic Status

Bluefish of the world are generally referred to as a single species. It is the only member of its family, the Pomatomidae, which is closely related to the family Carangidae (jacks, pompanos, roosterfish, etc.) (Jordan and Evermann, 1896-1900; Bigelow and Schroeder, 1953).

1.23 Subspecies

Recent publications do not consider subspecies to exist.

1.24 Standard Common Name, Vernacular Names

Bluefish is the common name given Pomatomus saltatrix by Bailey (1970). Some of the names now in common use are blue, tailor, snapper, elf, fatback, snap mackerel, skipjack, snapping mackerel, horse mackerel, greenfish, skip mackerel, chopper and Hatteras blue.

1.3 Morphologye

1.31 External Morphology

The following classical descriptions are those of Jordan and Evermann (1896-1900) for the family Pomatomidae and the genus Pomatomus saltatrix:

FAMILY POMATOMIDAE -

"Body oblong, compressed, covered with rather small scales, which are weakly ctenoid. Caudal peduncle rather stout. Head large, compressed. Mouth large, oblique. Premaxillaries protractile; maxillary not slipping under the preorbital, provided with a large supplemental bone; lower jaw projecting; bands of villiform teeth on vomer and palatines, those on the vomer forming a triangular patch; jaws each with a single series of very strong, compressed, unequal teeth, widely set; upper jaw with an inner series of small depressed teeth; villiform teeth on the base of the tongue. Occipital keel strong; free edge of preopercle produced and serrated. Gill membranes free from the isthmus, not united. Branchiostegals 7; gills 4, a slit behind the fourth. Pseudobranchae large. Gill rakers slender, rather few. Opercle ending in a flat point. Checks and opercles scaly; lateral line present, unarmed. Dorsal fins 2, the anterior of about 8 weak, low spines, connected by membrane and depressible in a groove; second dorsal long, similar to the elongate

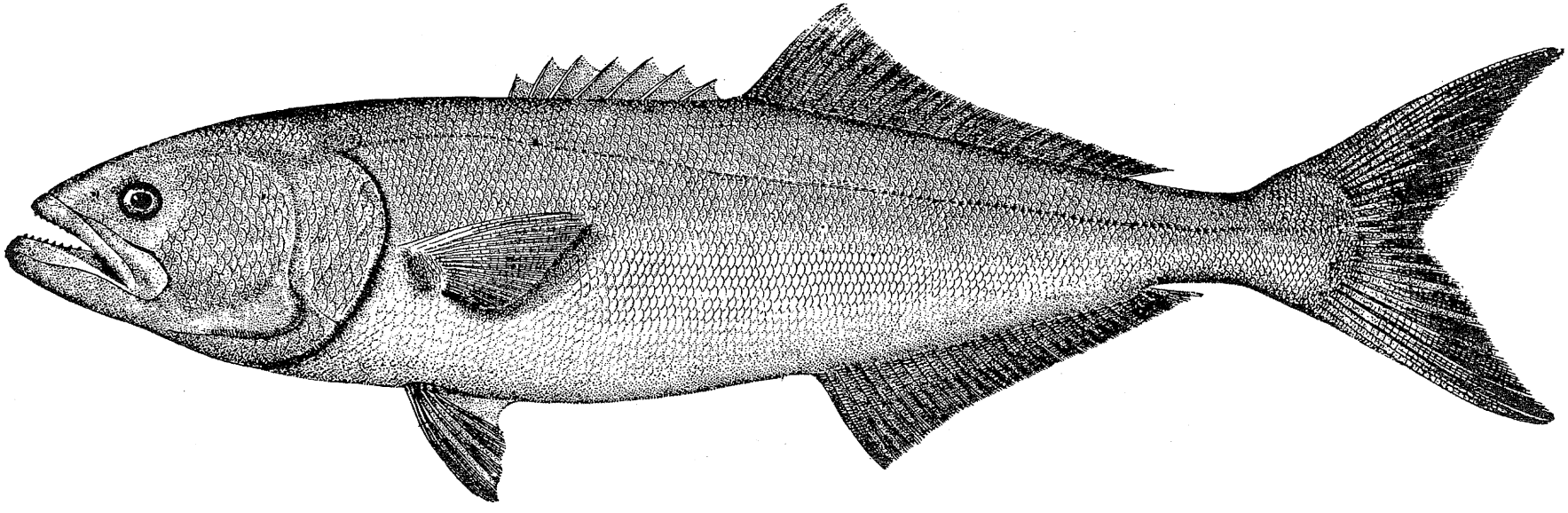

Figure 1. Bluefish, Pomatomus saltatrix (Linnaeus) 1758.

anal, both fins being densely scaly; fin rays slender; 2 very small, free anal spines, sometimes hidden in the skin; ventrals thoracic, 1.5; peduncle stout; pectorals rather short; caudal fin forked, the lobes broad; air bladder simple, with thin walls. Pyloric coeca very numerous. Vertebrae 10+14=24, as usual in Carangidae. A single species, found in nearly all warm seas. This family is closely related to the Carangidae, from which group it seems to be an offshoot toward the Percoids."

POMATOMUS SALTATRIX -

"Head 3 1/3; depth 4. D. VIII-I, 25 A. II-I, 26; scales 95. Body, robust, moderately compressed; belly compressed to a bluntish edge. Head deep; top of head and a ridge on each side above the cheeks naked. Cheeks much longer than opercles. Pectorals placed rather low, their length a little more than half that of head. Coloration blueish or greenish above, silvery below; a blackish blotch at base of pectoral. Length 3 feet."

The following less classical description is from Bigelow and Schroeder (1953):

"The bluefish (the only member of its family) resembles the pompano family in the general structure and arrangement of its fins, there being two dorsals, the first spiny and the second soft, with the ventrals well forward under the pectorals. But it lacks the free spines in front of the anal fin which are characteristic of most pompanos; its caudal peduncle is deeper; its tail is less deeply forked; and its teeth are much larger. It bears a superficial resemblance to certain of the weakfish family in its general body form and in the arrangement of its fins. But it is readily separable from any of the latter by the fact that its anal fin is nearly as long as its soft (second) dorsal, and from the sea-bass family in that its first (spiny) dorsal is much lower than the second."

Miller and Jorgenson (1973) give meristic characteristics from radiographs for four small bluefish. These data are summarized in Table 1.

1.32 Cytomorphology

No data available.

TABLE 1. Meristic characteristics of four bluefish, Pomatomus saltatrix, ranging in size from 142 to 210 mm SL (from: Miller and Jorgenson, 1973).

VERTEBRAE	
Total	26
Precaudal	11
Caudal	15
DORSAL FIN	
Spines	9
Rays	24-25
ANAL FIN	
Spines	3
Rays	26-28
CAUDAL FIN	
Total	35-36
Dorsal Secondary Rays	9-10

1.33 Protein Specificity

Research being conducted; however, results not published to date.

2.e DISTRIBUTIONe

2.1 Total Area (Figure 2)e

In general the bluefish occurs in temperate and warm temperate zones (Briggs, 1960), generally in continental shelf waters. Its occurrence has been recorded as follows:

Atlantic Ocean: Nova Scotia to Texas; Bermuda, Cuba, Venezuela; Brazil to Uruguay; Azores; Portugal to Senegal, including Mediterranean and Black Seas; Angola to South Africa. Indian Ocean: East coast of southern Africa; Madagascar; Malay Peninsula; Tasmania; Southern and Western Australia.

2.2 Differential Distribution

The remainder of this synopsis will focus on the bluefish stocks of the United States owing to the published and unpublished data available to the author.

2.21 Spawn, Larvae, and Juveniles (Figure 3)

Information on the early life history of bluefish, derived from systematic plankton collections over the Atlantic shelf presents a complex pattern (Clark, Smith, Kendall and Fahay, 1969, 1970; Norcross, Richardson, Massmann, and Joseph, 1974; and Fahay, 1975). There appear to be two major areas and seasons of spawning along the United States east coast: one offshore near the inner edge of the Gulf Stream from southern Florida to North Carolina in the spring, chiefly in April and May; the other in the Middle Atlantic Bight (i.e., Cape Hatteras to Cape Cod) over the continental shelf in summer, chiefly June through August (Kendall, ms.; and Norcross et al., 1974).

Spawning of both groups probably proceeds in waves. The survival of the young probably varies from wave to wave and the pattern of spawning and survival probably varies from year to year. We think that young bluefish spawned in the Middle Atlantic Bight, mostly between Cape May and eastern Long Island, and are about 8 inches long (modal fork length) in late summer and early fall.

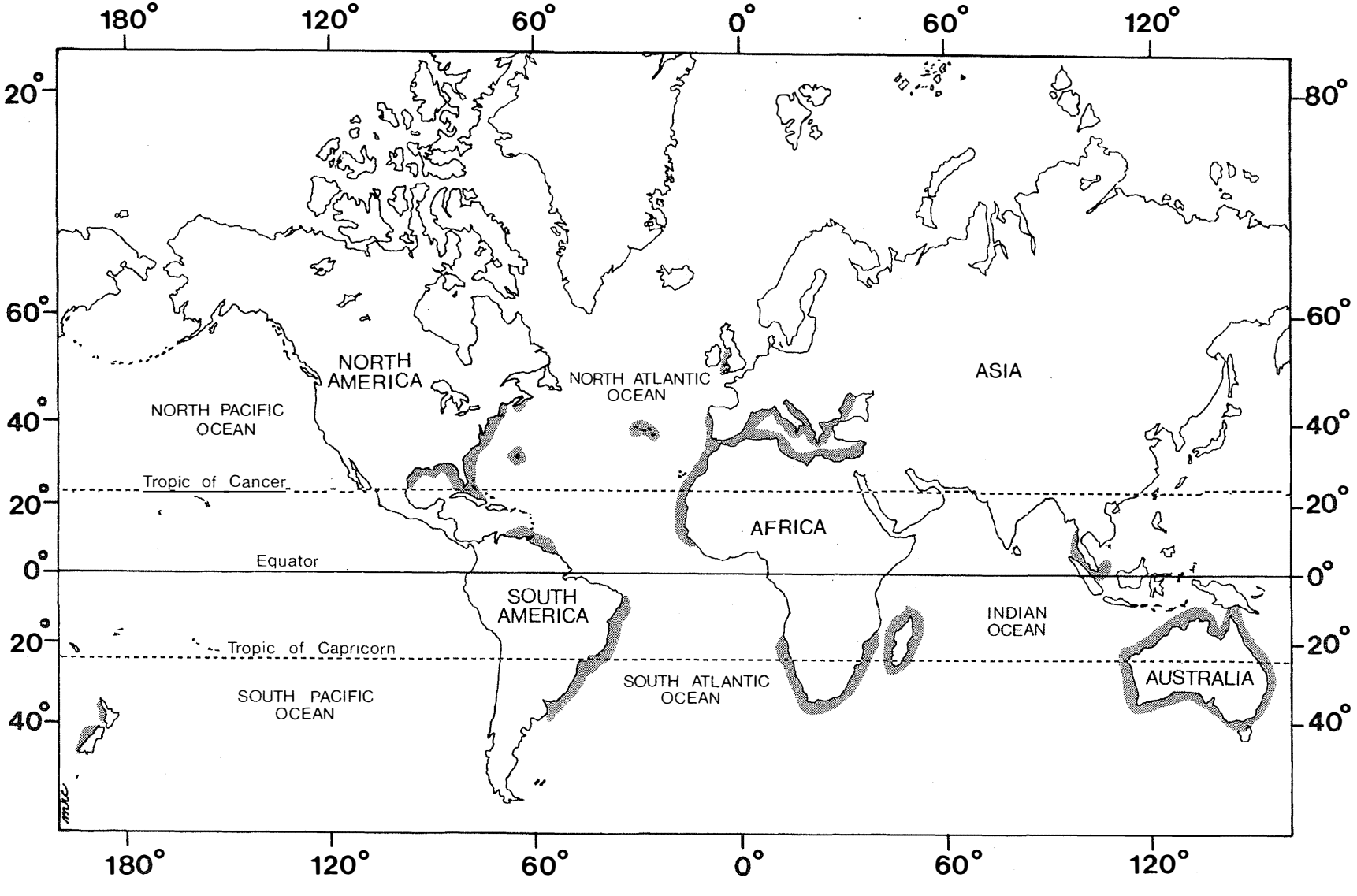

Figure 2. World distribution of bluefish, Pomatomus saltatrix, as reported in literature.

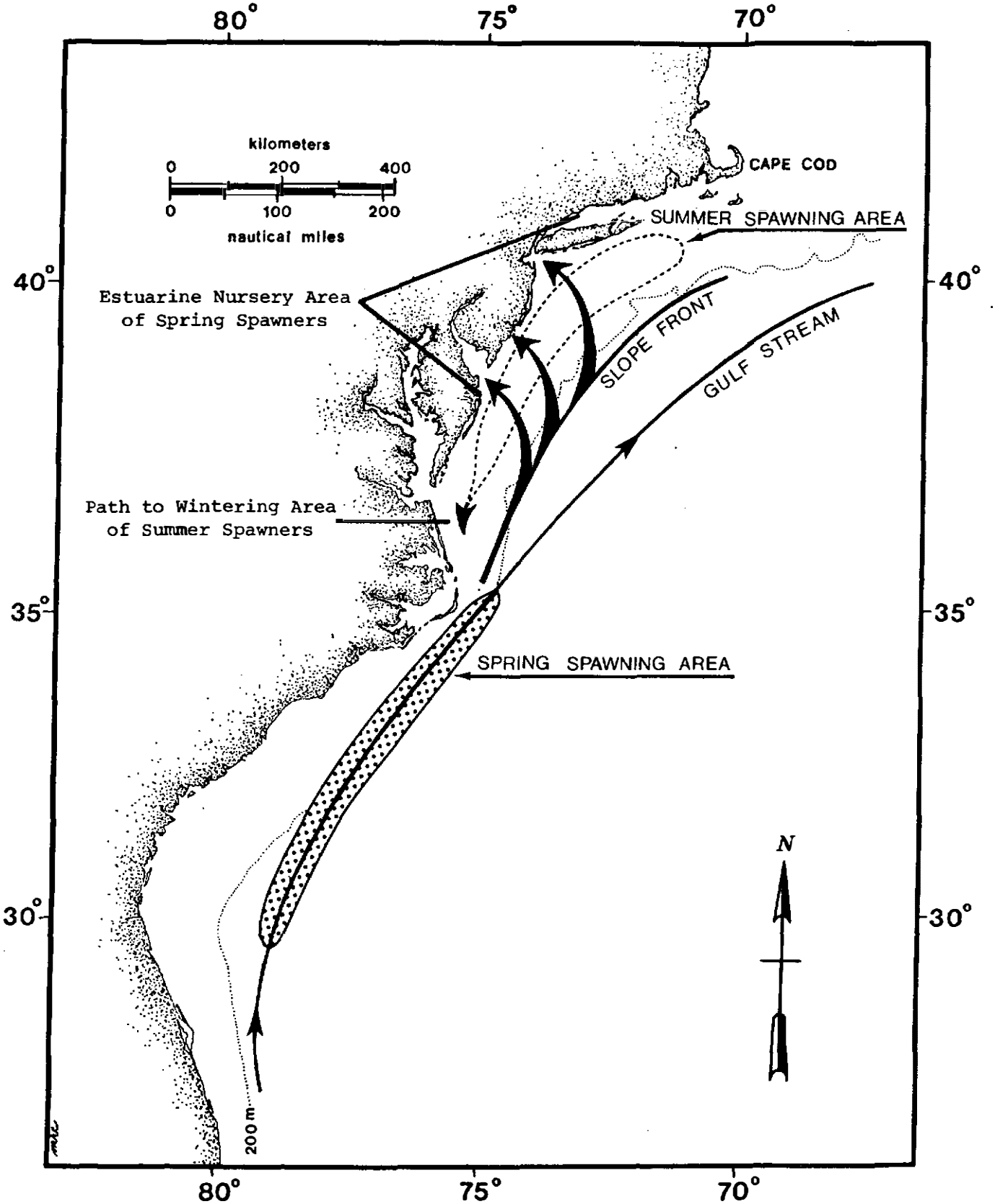

Figure 3. Diagrammatic representation of bluefish, Pomatomus saltatrix, early life history along east coast of U. S. (from: Kendall, ms.).

Bluefish spawned in summer apparently remain at sea and migrate south of Cape Hatteras in early fall when they are 2-3 inches long, and spend the winter offshore, appearing in the spring mostly in the sounds of North Carolina (Kendall, ms.).

Norcross et al. (1974) report the major spawning in the Chesapeake Bight takes place 55 to 148 km offshore and where water temperatures were $\geq$22°C and surface salinities were $\geq$31 o/oo. They suspect that circulation may be the most important factor affecting larval survival.

2.22 Adultse

Atlantic Seaboard: Our information about bluefish distribution depends almost entirely on catches of commercial and recreational fishermen, supplemented by some from research vessels, collections taken in seines, distributions of young stages taken in plantkon nets and midwater trawls, and published check lists. Most of our knowledge is limited to that part of their lives spent in coastal and estuarine waters. However, their distribution is evidently much wider and extends farther out on the continental shelf than has been generally believed.

The bluefish is a migratory pelagic species, generally traveling in groups of like-sized fish, the groups being loosely associated in much larger aggregations which may extend over tens of square miles along the coast. Aggregations travel seasonally, generally northward in spring and summer, southward in fall and winter. Their movements are directed by several features of environment, of which temperature and photoperiod are probably the most important (see section 3.5, Behavior). On the Atlantic coast, bluefish visit some sections of the coast for brief periods, a few weeks at most, en route to their summer or winter "destinations". These "destinations", i.e., sections of coast where they gather and sojourn for several months and where the greatest numbers are caught, center, during summer, in that part of the Atlantic between Cape Cod and Chesapeake Bay, and in the northern part of North Carolina and in its adjoining sounds; and during winter, in the southeastern part of Florida. It is probable, as indicated by Lund and Maltezos (1970), that in winter much of the bluefish population remains offshore and has yet to be discovered.

The groups composed of the largest fish move fastest and travel farthest. They tend to congregate in the northern part of their range.

Gulf of Mexico: In the Gulf of Mexico, bluefish are much less abundant than on the Atlantic seaboard, and are generally less common on the western side of the Gulf than the eastern. On the west coast of Florida, commercial fishermen catch bluefish at one place or another in every month, totaling several hundred thousand to a million pounds in a year. The movements between offshore and inshore waters are irregular, reputedly in reponse to winds effecting change of temperature.

2.3 Determinants of Distribution Changes

See section 3.5, Behavior.

2.4 Hybridization

No data available.

3.s BIONOMICS AND LIFE HISTORYs

3.1 Reproductions

3.s1 Sexualitys

Bluefish are heterosexual. They possess no accessory organs, and there is no way to distinguish the sexes externally. Hermaphroditism in bluefish has not been examined.

3.12 Maturity

Bluefish become sexually mature for the first time in their second year of life (Wilk, ms.).

3.13 Mating

Mating in the literal sense is not known to occur nor is there parental care of eggs or larvae.

3.14 Fertilization

Fertilization is external.

3.15 Gonads

Lassiter (1962) concluded that the number of eggs produced is a function of the age and size. A bluefish 20.8 inches (528 mm) long contained about 900,000 maturing eggs; one

23.0 inches (585 mm) long contained about 1,100,000. From our (National Marine Fisheries Service) examination of males, we conclude that testes mature slightly ahead of ovaries in fish of similar size.

3.16 Spawning

Spawning, hatching and early larval development take place in the ocean. See section 2.21 and Figure 3 for a more detailed explanation.

3.17 Spawn

Fertilized bluefish eggs are spherical, 0.9 to 1.2 mm in diameter (mean of 1.0 mm). The eggs contain an oil globule which ranges from 0.22 to 0.30 mm (mean of 0.25 mm). The egg capsule is transparent, colorless, thin but tough, the yolk pale amber, and the single large oil globule a deeper amber. Incubation takes approximately 48 hours at 21-21°C. Bluefish larva are between 2.0 and 2.2 mm ate hatching and metamorphose at 20-25 mm (Deuel et al., 1966).e

3.2 Preadult Phase

Deuel, Clark, and Mansueti (1966) give an account of hatching and early larval development of the bluefish (Figures 4, 5, 6). These data are very similar to those given by Salekhove (1959) for fertilized and hatched eggs of bluefish from the Yevpatori region of the Black Sea.

Lippson and Moran (1974) have reviewed the works of Deuel et al., 1966; Norcross et al., 1974; and Pearson, 1950 and give the following accounts of spawning, eggs, larvae, and juvenile development (Figure 7):

"Spawning: Offshore, principally on outer half of continental shelf. Dates: Early summer, June to August with peak in July.

"Eggs: Pelagic, highly buoyant. Size: 0.90-1.20 mm. Characteristics: Egg capsule transparent, thin but tough; single large oil globule 0.22-0.30 mm diameter; perivitelline space ca. 1/6 egg radius; embryonic tail does not extend fully around yolk.

"Larvae: Hatching size: 2.0-2.4 mm TL.

"Characteristics: At hatching, yolk-sac more than half body length and oil globule located at posterior of yolk. Development rapid and by ca. 4 mm yolk-sac absorbed, larvae more robust, head large, teeth developed, and myomere count 24.

"Melanophore pattern of early larvae (ca. 3-7 mm) characteristic: few large stellate melanophores over head, one at nape, few

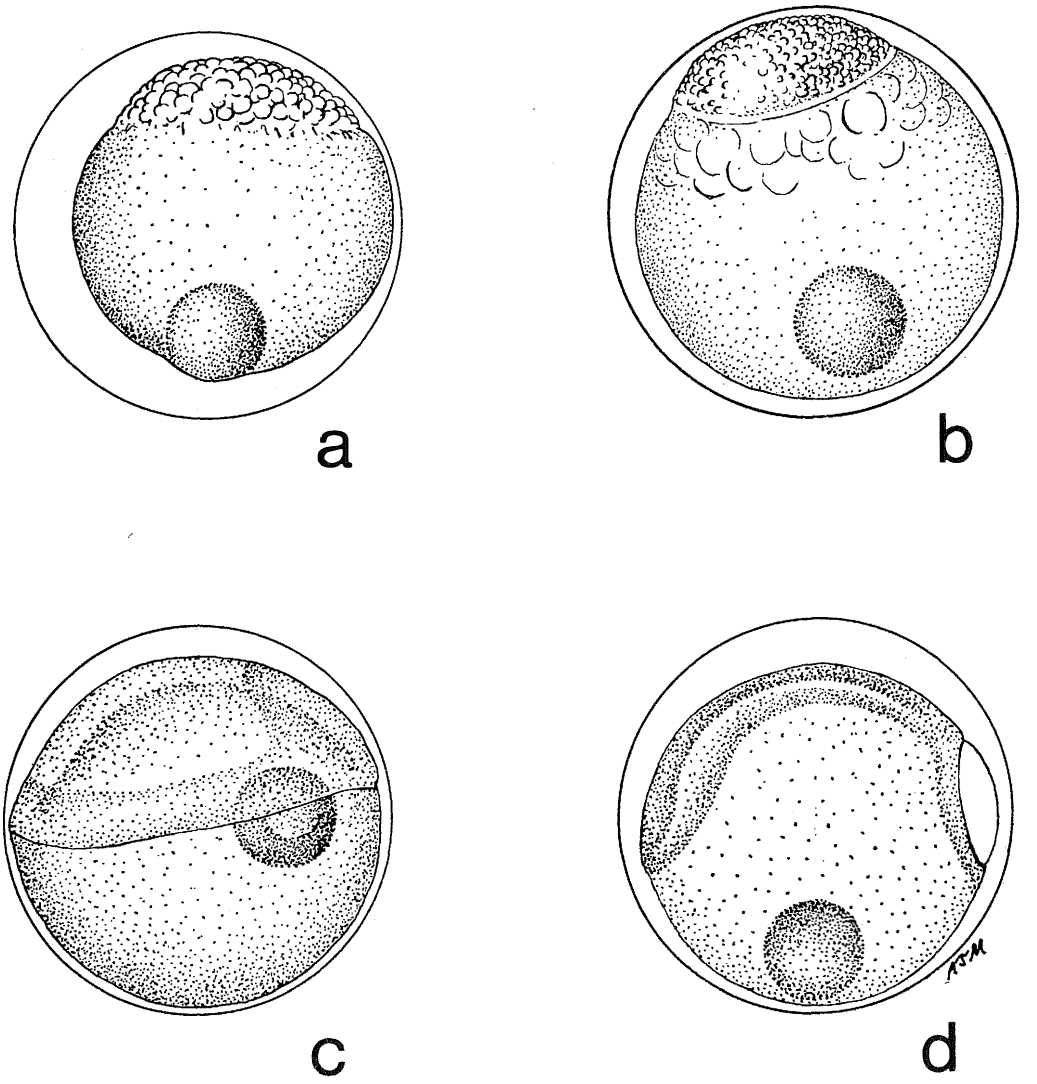

Figure 4. Stages in the development of bluefish, Pomatomus saltatrix, eggs at various periods following fertilization: a. Early morula, 5 h; b. Late morula, 9 h; c. Gastrula, 16 h; d. Embryonic axis, blastopore open, 17 h (from: Deuel et al., 1966).

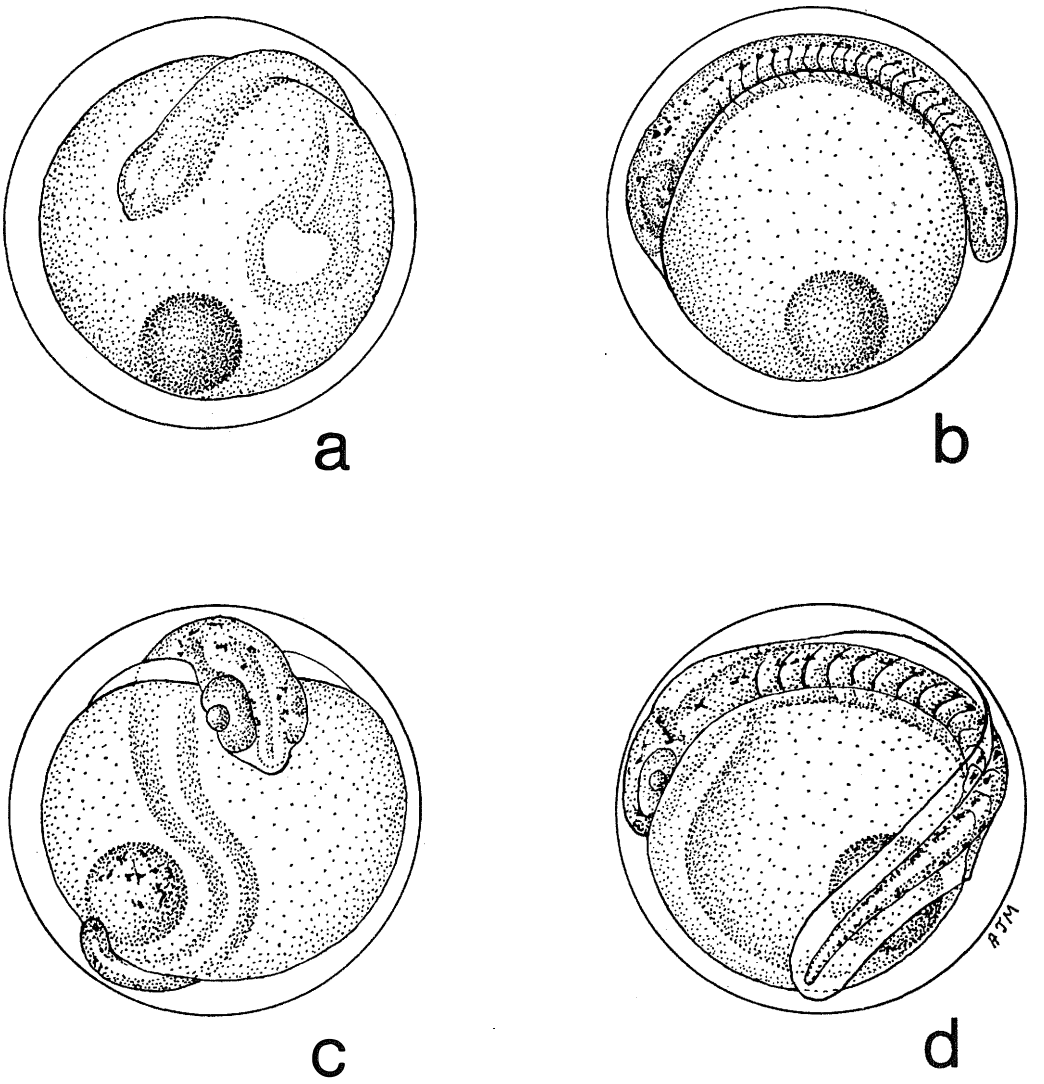

Figure 5. Stages in the development of bluefish, Pomatomus saltatrix, eggs at various periods following fertilization: a. Embryo with notochord and anlagen of eyes, 20 h; b. Tail-free stage, 20 myomeres, 21 h; Advanced embryo, 30 myomeres, 37 h; d. Embryo just before hatching, finfold present (but not seen in this view), 45 h (from: Deuel et al., 1966).

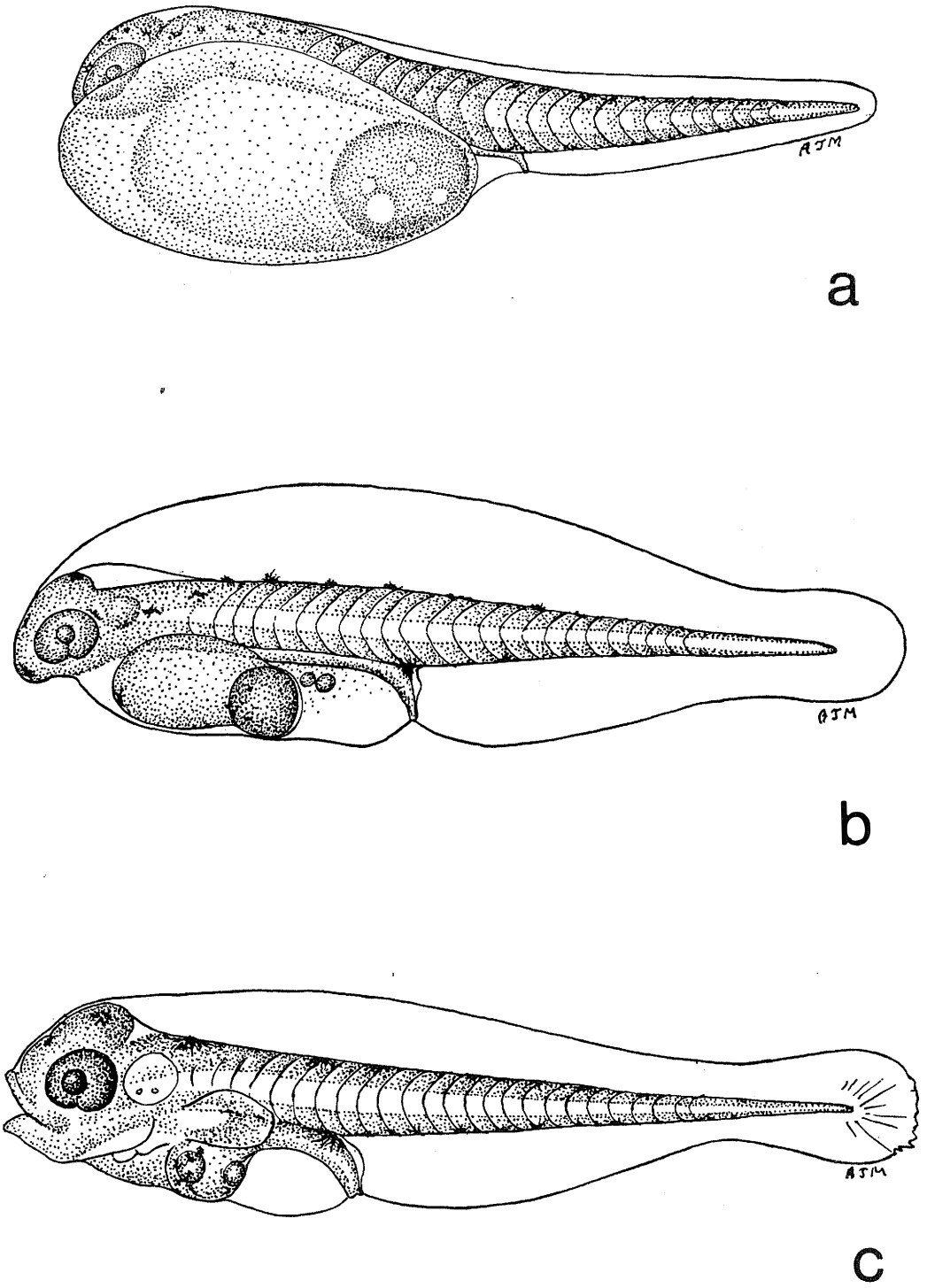

Figure 6. Stages in the development of bluefish, Pomatomus saltatrix, larvae at various periods after hatching: a. Recently hatched, 2.15 mm (total length); b. 2.76 mm, 1 day and 8 h; c. 3.08 mm, 4 days and 4 h (from: Deuel et al., 1966).

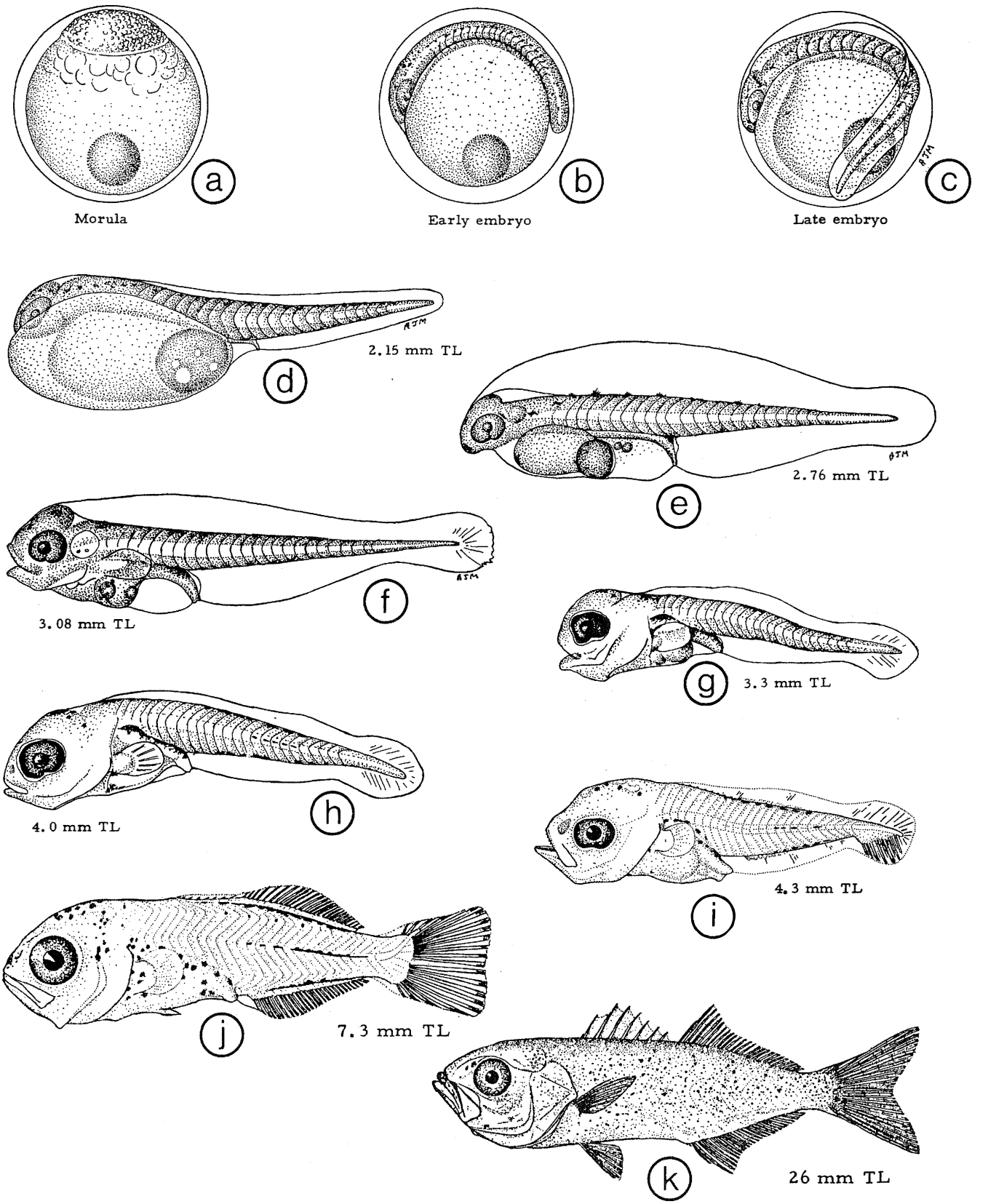

Figure 7. Egg, larvae, and juvenile developmental stage of the bluefish, Pomatomus saltatrix (from: Lippson and Moran, 1974).

small ones over snout and upper jaw, heavy concentrations over dorsal surface of air bladder and hind gut, one at base of pectoral fins, distinct mid-dorsal and mid-ventral rows, and mid-lateral pigment bars evident by 4.0 mm.

"With growth, head melanophores increase in number and decrease in size spreading over head region; mid-dorsal and mid-ventral rows coalesce and form heavy double lines of pigment along bases of dorsal and anal fins. The lateral bars increase in number forming a distinct lateral line. In later larvae, entire body peppered with small melanophores.

"Incipient fin rays evident by ca. 6.0 mm, countable by ca. 8.0 mm, and fin development complete by ca. 13-14 mm.

"Bluefish larvae are similar in appearance to butterfish, P. triacanthus, larvae but can be separated on basis of myomere counts (24 vs. 30) and pigmentation. Although the large head and short guts of bluefish larvae are somewhat similar to sciaenid and black sea bass, C. striata, the differences in shape of head and size and angle of mouth are distinct. For separation of bluefish larvae from other marine forms not encountered in the Potomac see Norcross, et al. (1974).

"Juveniles: Adult appearance and full fin counts attained at least by 13-14 mm, head proportionally larger than in adults, preopercle serrate, caudal peduncle stout, anal fin equal to second dorsal fin."

Young fully developed, 40-50 mm bluefish, the product of spring spawning, move into the northern bays in early June where they spend the remainder of the summer. Growth is rapid with fish reaching 175-200 mm by late September. The progeny of the fall spawning appear to spend their preadult stages in the open ocean.

The young feed upon small shrimp, silversides, killifish, anchovy and the like. They themselves are preyed upon by larger bluefish, striped bass and weakfish, to name a few.

3.3 Adult Phase

3.31 Longevity

Personnel at the Northeast Fisheries Center's Sandy Hook Laboratory have aged over 25,000 bluefish with the oldest being 9 years old; however, larger and presumably older fish have been reported (Wilk and Walford, ms.).

3.32 Hardiness

No data available.

3.33 Competitors

Bluefish, owing to their predatious nature, are in competition with other high predators such as striped bass, Spanish mackerel, king mackerel, and large weakfish.

3.34 Predators

Only the larger predators, such as sharks, tunas, swordfish, and wahoo would pose a threat to the fast swimming bluefish.

3.35 Parasites, Diseases, Injuries and Abnormalities

Anderson (1970) has prepared an annotated list of parasites of bluefish including several new species and an extensive review of the past literature (Appendix Table 1).

Mahoney, Midlige, and Deuel (1973) report bluefish to be one of the most susceptible to the "fin rot" disease of marine and euryhaline fishes in the New York Bight. The most consistent and striking feature of this disease is the necrosis of one or more of the fins (Figure 8). It has been suggested that this disease is limited to the heavily polluted New York Bight.

3.4 Nutrition and Growth

3.41 Feeding

The actual method in which a bluefish feeds will be discussed in detail in section 3.5, Behavior.

3.42 Food (Table 2)

Bluefish feed throughout the water column on a large variety of fishes and invertebrates. Among the fishes most frequently observed are butterfish, menhaden, round herring, sand lance, silverside, Atlantic mackerel, anchovy, Spanish sardine, and young weakfish, spotted seatrout, Atlantic croaker, and spot. Among the invertebrates are shrimps, lobsters, squids, crabs, mysids, and annelid worms (Wilk, ms.).

3.43 Growth Rate (Figure 9)

Growth in First and Second Years: Growth of young fish in two principal nursery areas, i.e., Middle Atlantic Bight and North Carolina sounds, is indicated by progression of modal lengths of fish sampled from early summer through fall. The fish of the smallest size class arriving in the Middle Atlantic Bight in early summer (modal length about 1-1½ inches) grow to about 8 inches long by the time they depart in the fall. During this time no annulus (age mark) develops on their scales. These are fish of the year which had been

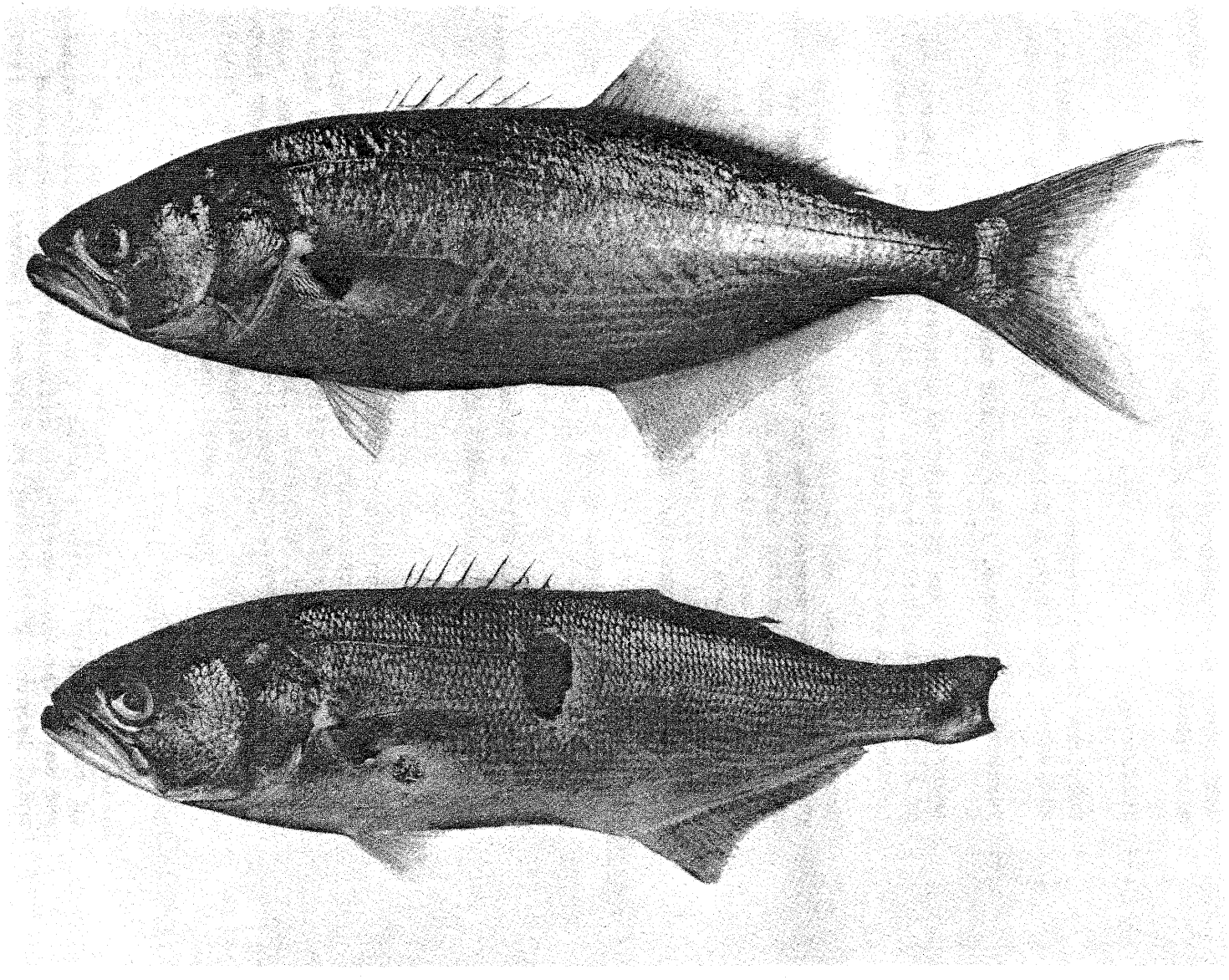

Figure 8. Bluefish, Pomatomus saltatrix, captured in New York Bight. a. Normal specimen; b. "Fin Rot" effected specimen (from: Mahoney et al., 1973).

TABLE 2. Food items of bluefish, *Pomatomus saltatrix*, along the Atlantic coast.

INVERTEBRATES:

- Nereidae
  - *Nereis virens* - sand worm
- Mysidacea
  - *Mysid* sp., - mysids
- Peneidae
  - *Penaeus* sp., - shrimps
- Homaridae
  - *Homarus americanus* - American lobster
- Hippidae
  - *Hippa (Emerita) talpoida* - sand bug
- Cancridae
  - *Cancer irroratus* - rock crab
  - *Cancer borealis* - northern crab
- Portunidae
  - *Portunus* sp. - portunus crabs
  - *Callinectes sapidus* - blue crab
  - *Ovalipes ocellatus* - calico crab
  - *Carcinides maenas* - green crab
- Ocypodidae
  - *Uca pugnax* - fiddler crab
- Loligindae
  - *Loligo pealii* - common squid
  - *Loligo brevis* - short-bodied squid
- Ommastrephidae
  - *Ommastrephes illecebrose* - short-finned squid
- Scutellidae
  - *Echinarachnius parma* - sand dollar

VERTEBRATES:

- Petromyzontidae
  - *Petromzon marinus* - sea lamprey
- Carcharhinidae
  - *Mustelus canis* - smooth dogfish
- Squalidae
  - *Squalus acanthias* - spiny dogfish
- Rajidae
  - *Raja* sp. - skates
- Anguillidae
  - *Anguilla rostrata* - American eel
- Clupidae
  - *Alosa aestivalis* - blueback herring
  - *Alosa pseudoharengus* - alewife
  - *Alosa sapidissima* - American shad
  - *Brevoortia tyrannus* - Atlantic menhaden
  - *Clupea harengus harengus* - Atlantic herring
  - *Etrumeus teres* - round herring
  - *Opisthonema oglinum* - Atlantic thread herring
  - *Sardinella anchovia* - Spanish sardine
- Engraulidae
  - *Anchoa hepsetus* - striped anchovy
  - *Anchoa mitchilli* - bay anchovy
  - *Engraulis mordax* - northern anchovy
- Synodontidae
  - *Synodus foetens* - inshore lizardfish
- Gadidae
  - *Merluccius bilinearis* - silver hake
  - *Microgadus tomcod* - Atlantic tomcod
  - *Pollachius virens* - pollock
  - *Urophycis chuss* - red hake
  - *Urophycis regius* - spotted hake
- Ophidiidae
  - *Rissola marginata* - striped cusk-eel
- Zoarcidae
  - *Macrozoarces americanus* - ocean pout
- Exocoetidae
  - *Hemiramphus brasiliensis* - ballyhoo
  - *Hyporhamphus unifasciatus* - halfbeak
- Cyprinodontidae
  - *Cyprinodon variegatus* - sheepshead minnow
  - *Fundulus heteroclitus* - mummichog
  - *Fundulus majalis* - striped killifish
- Atherinidae
  - *Menidia beryllina* - tidewater silverside
  - *Menidia menidia* - Atlantic silversides
- Syngnathidae
  - *Hippocampus erectus* - lined seahorse
  - *Syngnathus fuscus* - northern pipefish
- Serranidae
  - *Centropristis striata* - black sea bass
- Pomatomidae
  - *Pomatomus saltatrix* - bluefish
- Carangidae
  - *Caranx crysos* - blue runner
  - *Caranx hippos* - crevalle jack
  - *Chloroscombrus chrysurus* - Atlantic bumper
  - *Decapterus macarellus* - mackerel scad
  - *Decapterus punctatus* - round scad
  - *Selar crumenophthalmus* - bigeye scad
  - *Selene vomer* - lookdown
  - *Trachurus lathami* - rough scad
  - *Vomer setapinnis* - Atlantic moonfish
- Pomadasyidae
  - *Orthopristis chrysoptera* - pigfish
- Sparidae
  - *Diplodus holbrooki* - spottail pinfish
  - *Lagodon rhomboides* - pinfish
  - *Stenotomus chrysops* - scup
- Sciaenidae
  - *Bairdiella chrysura* - silver perch
  - *Cynoscion nebulosus* - spotted seatrout
  - *Cynoscion nothus* - silver seatrout
  - *Cynoscion regalis* - weakfish (gray seatrout)
  - *Leiostomus xanthurus* - spot
  - *Menticirrhus saxatilis* - northern kingfish
  - *Micropogon undulatus* - Atlantic croaker
- Labridae
  - *Tautoga onitis* - tautog
  - *Tautogolabrus adspersus* - cunner
- Mugilidae
  - *Mugil cephalus* - striped mullet
  - *Mugil curema* - white mullet
- Ammodytidae
  - *Ammodytes americanus* - American sand lance
- Scombridae
  - *Scomber scombrus* - Atlantic mackerel
- Stromateidae
  - *Peprilus alepidotus* - harvestfish
  - *Peprilus triacanthus* - butterfish
- Triglidae
  - *Prionotus* sp. - searobins
- Bothidae
  - *Paralichthys dentatus* - summer flounder
- Pleuronectidae
  - *Limanda ferruginea* - yellowtail flounder
- Cynoglossidae
  - *Symphurus plagiusa* - blackcheek tonguefish
- Tetraodontidae
  - *Sphoeroides maculatus* - northern puffer

spawned in southern waters in the spring. Fish of the dominant size class arriving in the North Carolina sounds in the spring (modal fork length about 9 inches) form an annulus on their scales in May, remain in the sounds through summer and fall until they depart. At that time they average $11\frac{1}{2}$ inches. These are fish that had been spawned in the summer of the previous year in northern waters. Some of the spring spawned fish also enter the North Carolina sounds in the summer. These do not form their first age mark on the scales until the following spring.

Annual incidence of age rings on scales was confirmed by three lines of evidence: 1) progressive growth between center of scales and first year ring, and between the first year ring and margin of scale; 2) from annuli on scales of tagged fish recovered after a year at sea; 3)e from aquarium specimens. These were kept in a large tank at Sandy Hook for several years at almost uniforme temperature and regular supply of food. When these fish,e which were the subject of extensive behavioral studies,e were finally removed from the tank, their scales weree found to be marked with age rings corresponding in numbere with their years in captivity. Evidently year marks aree laid down in response to inherent physiological cyclese rather than to seasonal changes of temperature or foode supply.e

Growth in Length and Weight During Life: Figure 9 gives the average lengths and weights for bluefish at ages one through fourteen years. These data are based on over 25,000 age determinations from scale readings and 7,500 weights of bluefish sampled from Rhode Island to Florida between 1963 and 1968 (Wilk and Walford, ms.).

Richards (1976) gives the following age length, weight data for 64 bluefish taken in Long Island Sound during 1975:

23 cm FL at 1+ year; 40 at 2+ years; 49 at 3+ years (1,816 g); 58 at 4+ years (3,178 g); 64 at 5+ years (4,086 g); 69 at 6+ years (4,540 g); and 71 at 7+ years (5,448 g).

3.44 Metabolism

No data available.

3.5 Behavior

3.51 Migration and Local Movement

Staff of the Sandy Hook Marine Laboratory (National Marine Fisheries Service, Northeast Fisheries Center) tagged 15,689 bluefish in Atlantic coastal waters between

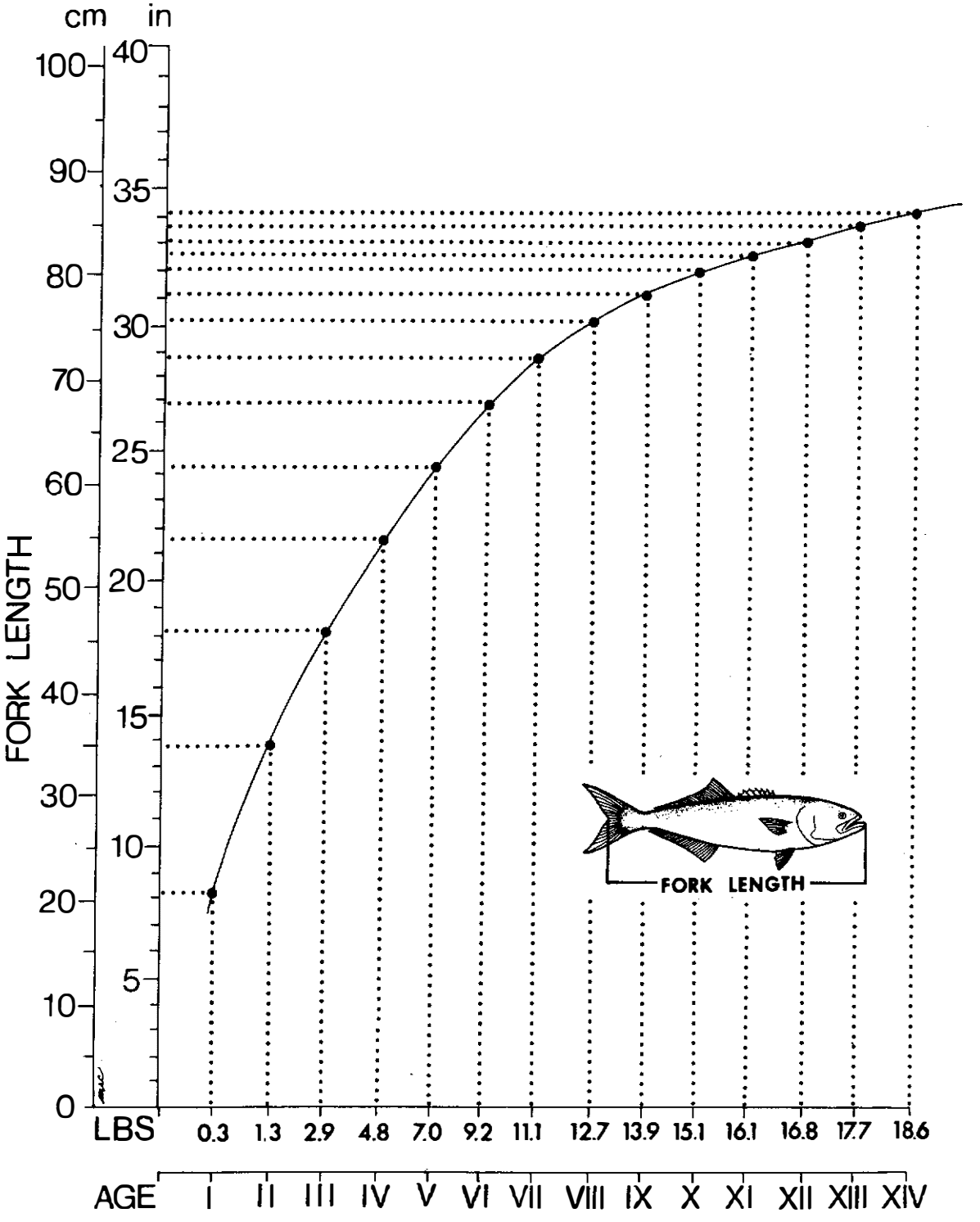

Figure 9. Relationship between age, length, and weight of bluefish, Pomatomus saltatrix (from: Wilk and Walford, ms.).

Massachusetts and Florida from 1963 through 1967 (Deuel, ms.). Of this number, 1,116 (7.11%) were recaptured, the vast majority of them within a year of tagging. Only 100 were at liberty longer than one year, four of them as long as four years.

Judging from these tag return data, bluefish up to three pounds migrate between southeastern Florida and the New York-New Jersey area. Fish summering in the areas between New York and North Carolina migrate offshore and south in fall and early winter. These fish seem to occur in the Florida winter fishery only one year.

A northerly coastal migration in spring from Florida is represented by only a few tag returns, suggesting a considerable offshore distribution during the summer, beyond the usual range of the fishermen. The southerly migration in fall is closer to shore than the northerly migration in spring.

Almost all recaptures one year after tagging were from the general areas where the fish had been tagged, indicating that bluefish probably return to the same coastal areas for one or more years. Fish tagged from New Jersey northwarde continue to return to the same general areas in the second, third and fourth year after tagging. Fish tagged frome Virginia south to Florida, however, returned to this area only one year after tagging. Two of the three of thesee fish at liberty over one year (about 1½ years) were recaptured in New Jersey, suggesting a northerly shift ofe bluefish from southern coastal areas as they increase in size. This conclusion is supported by studies of scalee characteristics (Wilk and Walford, ms.).e

Lund and Maltezos (1970) give the following brief account (abstract) of their tagging studies conducted in the New York-Connecticut area during the middle and late 1960's:

"Bluefish were tagged in and near Long Island Sound between 1964 and 1969. Tag returns support the belief that there is a discrete northern race of bluefish as more than 75% of the returns from fish at large more than one season return to the general area of Long Island Sound. Small bluefish move southward along the coast during late fall while adults, fish over approximately 45 cm total length, have an inshore-offshore migration.

"Bluefish first arrive in the area when the water temperatures reach 12 to 15 C which is usually during May. The fish follow the warmer water by entering the inner bays of Long Island or going to the western end of Long Island Sound. Large numbers of bluefish arrive in the general area during late July and

August after spawning in offshore waters. The fall migration takes place when the water temperature drops to approximately 13 to 15 C."

Local or short-time movements in and out of bays and inlets, are probably triggered by changes in tide, weather, season, food supply, and size.

3.52 Schooling

Schooling by size and begin to school as preadults.

3.53 Response to Stimuli - Experimental Studies of Bluefish Behavior

Until recently, information about the behavior of marine fish species has come mainly from indirect evidence of anglers, commercial fishermen, and researchers. This kind of information still leaves many questions unanswered as to the precise role played by various environmental stimuli on normal patterns of behavior. One approach to answering these questions is to study the behavior of selected species, such as bluefish, under controlled conditions in the laboratory. The following is a synopsis of studies carried out on a small school of adult bluefish, held under controlled conditions of light and temperature in a 32,000 gallon multi-windowed sea-water aquarium at the Sandy Hook Laboratory (Olla and Marchioni, 1968; Olla and Studholme, 1971, 1972; and Olla, Katz, and Studholme, 1970):

DAILY ACTIVITY -

The bluefish in the experimental tank showed a diurnal rhythm of activity, with swimming speed increasing at light onset and decreasing during the late afternoon and evening. Although speeds and general responsiveness were sharply reduced during the night "rest" phase, the fish continued to swim. They could be easily aroused by the introduction of certain odors (e.g., ground up fish), the introduction of bait fish, or other stimuli related to feeding or fright. Corresponding to changes in swimming speed, schooling patterns also fluctuated rhythmically, the fish forming a cohesive school during the day and dispersing at night.

SEASON ACTIVITY -

We found that day length was an important factor influencing activity levels. During day lengths which corresponded to those occurring from spring to fall, the captive bluefish swam at significantly higher speeds than during the shorter winter indicating that photoperiod may act to trigger the northern spring migration and southern fall migration.

FEEDING -

Feeding studies have shown that although bluefish are reponsive to various olfactory stimuli, they rely primarily on vision to locate and capture prey fish. The size of prey is an important factor in feeding motivation. Bluefish which are apparently satiated on small bait fish can be stimulated to resume feeding when they are offered larger ones of the same species.

RETINAL RHYTHMS -

Studies on retinal changes in juvenile bluefish reinforced our findings that these fish were highly visually oriented. Not only did the retina undergo photomechanical changes in response to changes in light and dark but under constant darkness, cones continued to exhibit a diurnal rhythm. This internal control may predispose the retina to light onset, a significant adaptation for a predator which is highly active during morning twilight.

RESPONSE TO TEMPERATURE -

As temperature slowly departed from the fish's preferred range of 66-72°F, swimming speed increased. Signs of stress, i.e., disruption of normal diurnal changes in swimming speed and schooling, and changes in satiation levels, were evident at 53.4°F and 84.6°F, indicating that for the fish being studied, these were behavioral thresholds. This increase in activity may serve to move the animals from regions of adverse temperatures.

4.e POPULATIONe

4.1 Structure

During the period 1963-1968 the Sandy Hook Laboratory (U. S. Department of Interior, Bureau of Sportfish and Wildlife) regularly obtained information on the sex, age, size composition, unit stocks, and distribution of Atlantic coast bluefish by regularly sampling commercial and recreational fisheries. Age was determined from scales (see section 3.43, Growth Rate). Whenever possible, sexes, weights, and body measurements were simultaneously collected.

4.11 Sex Ratio

The sex ratio at each age remains essentially the same from area to area and from year to year. There are equal numbers of males and females at all ages and bluefish do not appear to school by sex during any time of life.

4.12 Age Composition

During our study (Wilk and Walford, ms.) 1-4 year-old fish made up the bulk of the bluefish sampled. However, the old fish (>4-years-old) were quite evident especially in the area from Maryland to southern New England.

Year classes 1962, 1963, 1964, 1965, and 1966 all appeared to be equal in strength judging from their incidence in the catches we sampled.

4.13 Size Composition

Owing to the bimodal nature of spawn there are large variations in length and weight within each age group.

4.2 Abundance and Density

No data available.

4.3 Natality and Recruitment

No data available.

4.4 Mortality and Morbidity

No data available.

4.5 Dynamics of Population(s)

Our data (National Marine Fisheries Service), as stated above, seem to indicate two principal populations of bluefish on the Atlantic coast which spawn in different areas and different seasons. These may be distinguished by the difference of scale characteristics and of body proportions.

Difference of Scale Characteristics: In some years infant survival of the two populations seems to be concentrated at opposite ends of seasons in which they had been spawned, and for those year classes we can distinguish the two groups throughout life easily by growth characteristics on their scales. In other words, scale characteristics are useful

in some years for distinguishing spring from summer spawned fish; but not always, for the average amount of growth between the center of the scales and the time when the first age ring is laid down varies according to the time of birth.

Differences of Body Proportions: Yearling bluefish sampled the same season in the North Carolina sounds and the Middle Atlantic Bight differ in several features of their external anatomy. The fish taken in North Carolina have a larger head those those taken in the Middle Atlantic Bight. Also, they have a longer maxillary, larger eye in proportion to the head, smaller ventral fins, larger pectoral, smaller dorsal and anal fins, and the two dorsal fins are farther apart. These differences are individually small; but when treated statistically the sum of them provides a basis of discriminating one group from the other. Furthermore, they are independent of the time when the fish are spawned, and they seem to be consistent from year to year.

It must be added that Lund (1961) and Lund and Maltezos (1970) also point out that several distinct racial groups (populations) of bluefish exist along the Atlantic coast.

Meaningful abundance, density, natality, and recruitment estimates with a view towards fishery management must take account of the different populations of bluefish on the United States Atlantic coast. These vary in abundance independently of each other. At present, there are several principal ones and others which are evidently relatively small, or which might simply be at a low period in the cycle of their numbers.

At any given time, bluefish are widely and spottily distributed. The fish group by size. The sizes of groups vary with age. The fish swim continuously, day and night, at speeds varying with their size and the temperature of the water. Availability in coastal waters evidently diminishes with age of the fish. The different populations are distinguishable only by statistical analysis and, as they get older, they mix during part of the year. Northern spawners and southern spawners of like size but different ages mix in proportions which vary in different areas and different years. Our data (National Marine Fisheries Service) support the hypothesis that they separate for spawning.

To measure the age composition and relative abundance of the various bluefish populations, we need continuous biologically representative sampling. So far we have not been able to achieve this by sampling fishermen's catches. We cannot get it from commercial fishermen, for their individual catches

are fairly minor, highly selective, and opportunistic, and they land them at many small ports along the coast. Neither can we get it from recreational fishermen, for even though they take 17 times as much as commercial fishermen, their individual catches are small and they too land them at many places along the coast and at all hours of the day and night. Nor can we get it from research vessels, for fishing by trolling is too slow to be productive; fishing with long-lines has not been successful; fishing with gill-nets or haul seines is too selective; otter-trawls only occasionally bring up bluefish. The only time in their life cycle when bluefish might be sampled effectively is during their egg and early larval stages, when they drift passively, do not aggregate, and are therefore susceptible to systematic sampling with plankton nets. Thus, the sizes of the spawning stocks may be measured by the numbers of eggs and early larvae, and the strength of the incoming year classes by the numbers of older larvae and juveniles.

Until the problem of biologically significant sampling is solved, questions relating to year class strength, age composition of the populations, and status of the stocks will remain unanswered. If management of bluefish fisheries were to be indicated, it would require cooperation of all the coastal states.

4.6 The Population(s) in the Community and the Ecosystem

No data available.

5.e FISHERYe

The following sections under "FISHERY" will be combined:

5.1 Fishing Equipment

5.2 Fishing Areas

5.3 Fishing Seasons

5.4 Fishing Operations and Results

The seasonality of the fisheries for bluefish are as follows: Northern section (southern New England to Delaware Bay) - May through November, with a peak generally in August or September. Central section (North Carolina) - in some years all year round, but usually April through December, with peaks in May, July, and September. Southeastern section (east coast of Florida) - September,

to early May, with peaks variously occurring between October and April. West coast of Florida - irregular from year to year, but in general, late fall through spring from Tampa south; spring through fall from Tampa north.

Commercial fishermen take bluefish with gill nets (Figure 10a), haul seines (Figure 10b), pound nets (Figure 10c), hook and lines, otter trawls (Figure 11a), purse seines (Figure 11b), and in olden days they also took them with fyke and hoop nets (Figures 12a, 12b). The catches by states from 1880 to 1974 are tabulated in Table 3. Figure 13 gives a graphical account of bluefish commercial landings between 1925 and 1974 including 5- and 50-year averages. Figure 14 graphically represents thee 5-year averages by coastal regions.

Anglers take bluefish from boats while trolling, chumming, casting, live-bait fishing, jigging, still fishing and drift fishing. They take them from shore while casting, still fishing, live-bait fishing, jigging, and chumming (Freeman and Walford, 1974a, 1974b, 1974c, and 1974d).

Bluefish is one of our most important recreational fishes. It provides both sport and food for people fishing in bays and sounds, along ocean beaches and as far over the continental shelf as they care to go. Indeed, no other species of the Atlantic coast occurs during such a long season, over such a great distance, in such a variety of locations or in such numbers. No other species is as important to all sorts of anglers. People catch them in bays as well as the surf; and from private boats, rental skiffs, charter boats, and party boats. It is unlikely that any other species could completely replace it were it to disappear. While bluefish have been important to anglers for the last century and a half, it has only been during the last decade or so that estimates of the catches were made. During 1960 (Clark, 1962) the anglers' catch reached nearly 51 million pounds and ranked sixth in weight among all species caught in the United States. During 1965 (Deuel and Clark, 1968) it reached over 90 million pounds and ranked second, and during 1970 (Deuel, 1973), over 120 million pounds and ranked first. Every year throughout this period about a million anglers fished for bluefish and caught them. Figure 15, 16, and 17 illustrate, by years of saltwater anglers survey, total catch (wt. and no.); numbers of anglers and their average catch (wt. and no.); and average weight of catch, respectively.

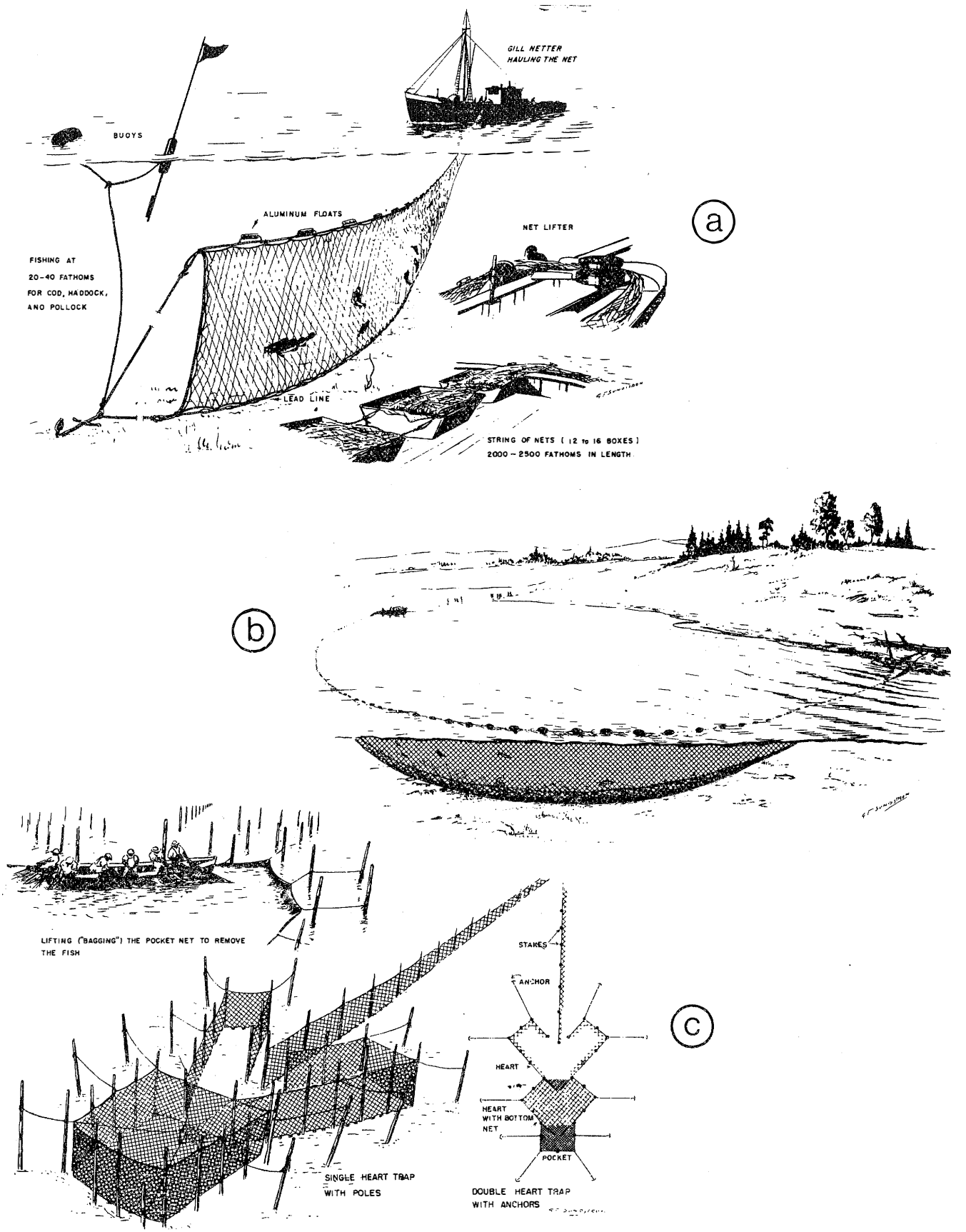

Figure 10. Commercial fishing gear used to capture bluefish, Pomatomus saltatrix: a. Gill net; b. Haul seine; and c. Pound net (from: Sundstrom, 1957).

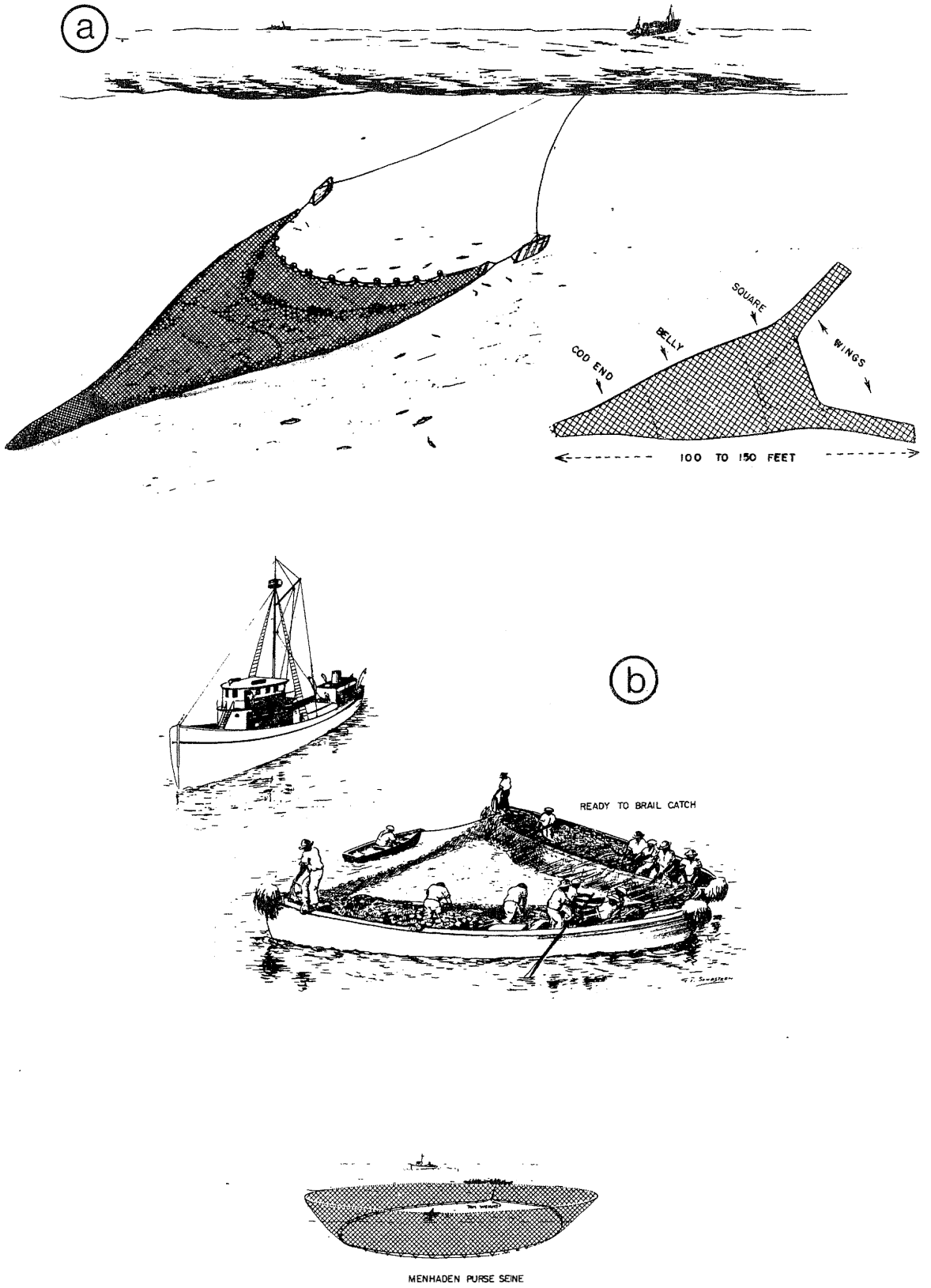

Figure 11. Commercial fishing gear used to capture bluefish, Pomatomus saltatrix: a. Otter trawl; and b. Purse seine (from: Sundstrom, 1957).

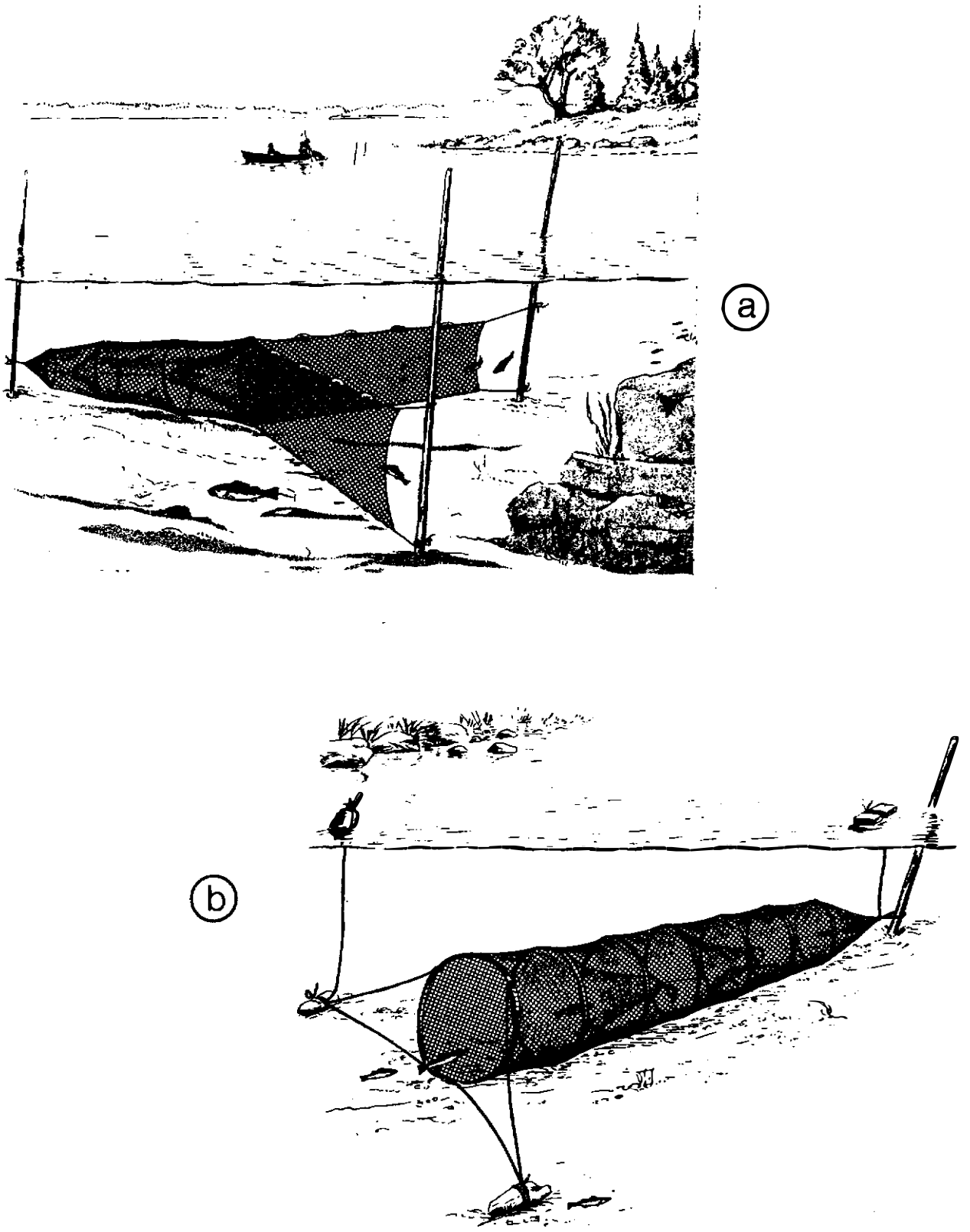

Figure 12. Commercial fishing gear used in the past to capture bluefish, Pomatomus saltatrix: a. Fyke net; and b. Hoop net (from: Sundstrom, 1957).

TABLE 3. Commercial landings of bluefish (Pomatomus saltatrix) by states, 1880-1974 (thousands of lbs.). A dash (-) indicates information not available and an asterisk (*) indicates less than 500 lbs. caught.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL East Coast	FL West Coast	AL	MS	LA	TX	Total
1880	-	-	-	-	-	3000	3635	46	10	1546	600	200	5	25	44	-	-	-	-	9111
1887	-	-	-	-	-	2853	4789	-	383	1286	761	158	7	-	-	-	73	13	7	10380
1888	-	-	-	-	-	3454	4661	-	576	2111	847	151	6	-	246	-	78	15	6	12151
1889	-	-	-	-	-	5027	8565	-	-	-	1078	110	-	5	364	58	90	13	24	15334
1890	-	-	-	-	-	5740	9291	-	460	1472	1539	100	-	7	420	56	96	13	26	19220
1891	-	-	-	-	-	5509	7228	-	516	1842	-	-	-	-	-	-	-	-	-	15093
1897	-	-	-	-	-	11146	5164	-	187	1505	1910	40	-	46	265	204	33	4	30	20534
1901	-	-	-	-	-	9351	6110	-	100	755	-	-	-	-	-	-	-	-	-	16316
1902	-	-	-	-	-	-	-	-	-	-	1049	1	-	82	350	21	12	*	16	1531
1904	-	-	-	-	-	11414	2723	-	91	567	-	-	-	-	-	-	-	-	-	14795
1908	-	-	-	-	-	3191	1850	-	14	242	1258	7	-	580	372	5	18	3	10	7550
1918	-	-	-	-	-	-	-	-	-	-	323	3	5	561	271	-	-	-	-	1163
1920	-	-	-	-	-	-	-	-	74	178	-	-	-	-	-	-	-	-	-	252
1921	-	-	-	-	-	1083	2243	1	-	-	-	-	-	-	-	-	-	-	-	3327
1923	-	-	-	-	-	-	-	-	-	-	897	7	-	1101	418	4	6	-	1	2434
1925	-	-	-	-	-	-	-	-	58	157	-	-	-	-	-	-	-	-	-	215
1926	-	-	-	-	-	262	628	10	-	-	-	-	-	-	-	-	-	-	-	900
1927	-	-	-	-	-	-	-	-	-	-	852	13	-	772	620	46	30	6	1	2340
1928	-	-	-	-	-	-	-	-	-	-	754	4	50	599	390	31	27	-	1	1856
1929	-	-	50	73	219	773	2960	30	212	510	631	-	28	609	513	103	16	*	1	6728
1930	-	-	210	243	251	880	2962	31	268	230	843	*	1	400	753	21	19	-	*	7112
1931	-	-	191	121	407	671	2535	71	473	343	676	2	-	566	642	35	18	-	3	6754
1932	1	-	226	134	285	913	3844	10	360	551	687	4	-	907	515	12	5	-	2	8456
1933	-	-	430	194	296	1132	2115	5	119	684	-	-	-	-	-	-	-	-	-	4975
1934	-	-	-	-	-	-	-	-	329	936	1766	3	-	1445	489	29	-	-	-	4997
1935	-	-	91	144	118	1002	1960	14	313	340	-	-	-	-	-	-	-	-	-	3985
1936	-	-	-	-	-	-	-	-	129	317	2028	10	-	3176	608	72	-	-	-	6340
1937	-	-	46	140	33	858	1484	6	81	528	1657	30	-	2870	709	28	-	-	-	8470
1938	-	-	71	39	10	250	1038	3	51	303	1849	43	-	3628	852	21	-	-	-	8158
1939	-	-	10	15	8	219	682	-	57	83	1009	6	-	2383	768	23	-	-	-	5263
1940	-	-	26	15	-	25	105	-	4	15	448	4	-	1366	597	24	-	-	-	2629
1941	-	-	-	-	-	-	-	-	16	22	-	0	-	-	-	-	-	-	-	38
1942	-	-	10	2	-	45	167	-	63	43	-	-	-	-	-	-	-	-	-	330
1943	-	-	30	3	7	122	148	-	-	-	-	-	-	-	-	-	-	-	-	310
1944	-	-	4	19	13	91	114	-	99	47	-	-	-	-	-	-	-	-	-	387
1945	-	-	3	11	11	105	265	-	102	121	627	11	-	1274	557	31	1	-	-	3119
1946	-	-	1	4	6	105	-	-	73	203	-	-	-	-	-	-	-	-	-	392
1947	-	-	2	14	10	116	399	*	138	254	-	-	-	-	-	-	-	-	-	933
1948	-	-	2	17	21	241	611	5	131	272	-	-	-	-	-	6	*	1	-	1307
1949	-	-	25	25	10	251	1055	63	87	305	-	-	-	-	564	5	2	5	2	2399
1950	-	-	61	56	20	127	1296	21	106	311	1272	10	-	990	408	4	1	3	*	4688
1951	-	-	28	37	54	191	1100	5	85	179	926	12	-	1431	594	26	*	-	-	4668
1952	-	-	1	48	90	208	1439	1	111	144	737	11	-	1115	917	24	4	-	*	4850
1953	-	-	30	80	56	163	1139	2	46	175	542	7	-	1104	968	10	4	-	*	4326
1954	-	-	31	91	24	402	1261	2	89	185	323	8	-	804	1229	5	-	-	*	4354
1955	178	-	37	31	32	469	1015	3	63	220	435	39	-	1013	672	15	2	-	*	4224
1956	-	-	19	48	13	371	1019	3	101	224	633	53	-	771	780	6	3	-	*	4044
1957	-	-	25	59	19	438	916	5	93	193	816	71	*	1107	1092	5	4	-	2	4845
1958	-	-	3	10	2	116	91	6	32	156	437	3	-	845	1438	103	10	*	*	3252
1959	-	-	5	20	6	262	376	4	30	183	740	1	-	1284	900	11	2	*	-	3824
1960	-	-	15	34	5	414	443	1	10	130	615	*	-	1090	718	1	4	-	-	3480
1961	-	-	18	49	11	505	462	-	19	294	752	1	*	979	624	4	18	-	-	3736
1962	-	-	34	110	31	758	1092	8	64	524	955	5	-	1393	944	1	4	-	-	5923
1963	-	-	47	82	52	697	823	21	42	632	813	114	*	1362	889	4	5	-	-	5583
1964	-	-	42	90	60	675	541	-	6	395	515	316	-	1202	779	11	15	-	-	4647
1965	-	-	143	108	60	1036	870	-	7	205	704	84	-	855	859	5	72	-	-	5008
1966	-	-	127	72	56	933	1008	1	17	242	821	158	1	1353	584	9	102	-	-	5484
1967	-	-	70	79	62	550	502	-	18	120	888	48	-	1346	513	4	79	-	-	4490
1968	-	-	87	81	62	577	765	-	141	241	872	24	-	1910	556	4	83	-	-	5403
1969	-	-	150	124	83	1119	680	-	54	223	41	5	-	1728	355	31	25	-	-	4618
1970	-	-	68	321	85	1602	1062	-	68	636	15	8	-	2046	650	21	21	-	-	6603
1971	-	2	120	271	83	1211	979	-	141	611	578	13	-	1625	510	13	10	*	-	6167
1972	-	-	146	311	49	1003	812	1	59	1216	1168	-	-	1876	511	22	14	*	-	7188
1973	59	-	556	278	96	1412	888	3	276	2905	2008	3	-	1583	493	27	10	*	-	10597
1974	30	-	390	267	89	1067	1003	6	553	3137	2183	*	-	1272	501	9	16	11	-	10534

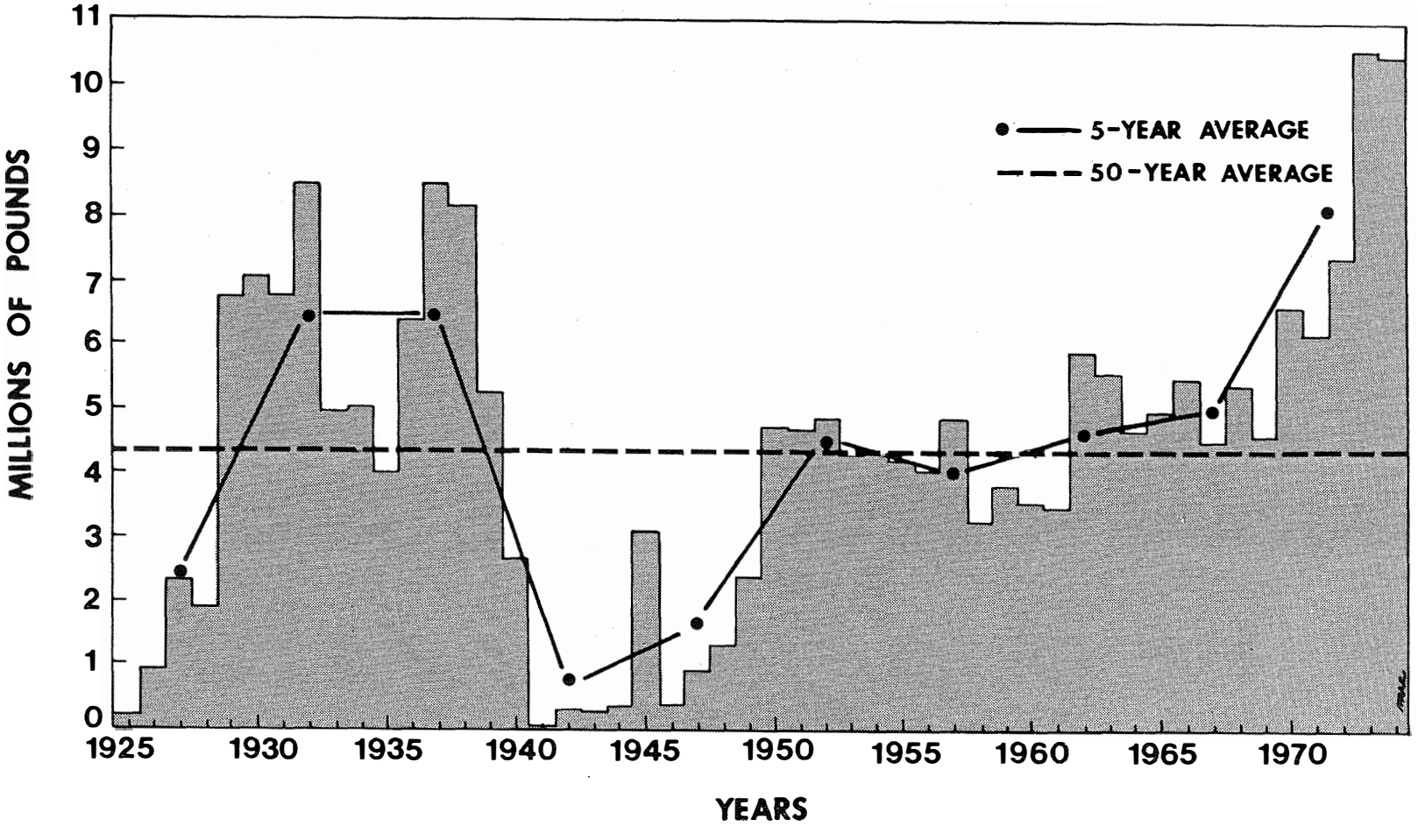

Figure 13. U. S. commercial landings of bluefish (Pomatomus saltatrix) 1925-1974, including 5- and 50-year averages.

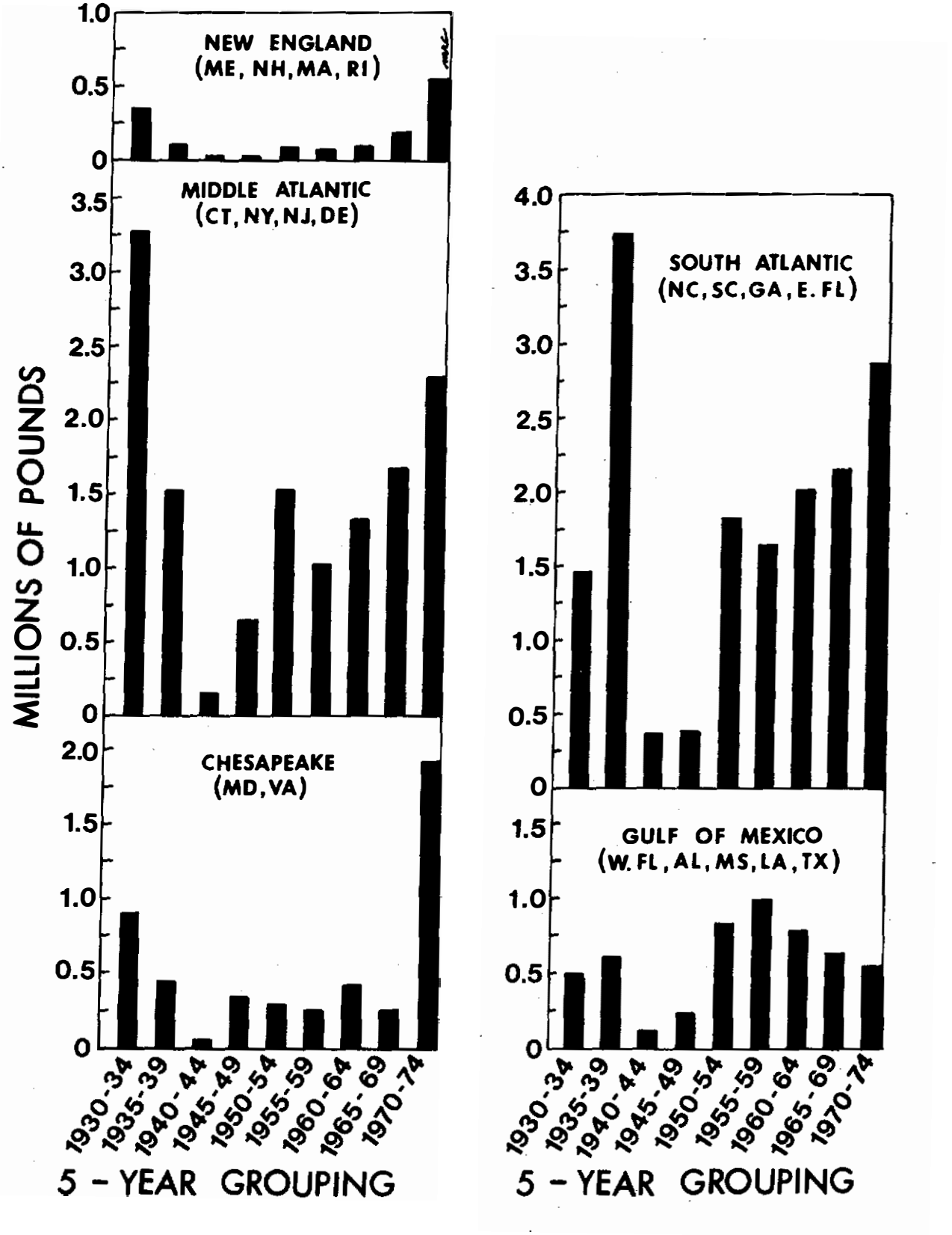

Figure 14. U. S. commercial landings of bluefish (Pomatomus saltatrix) 1930-1974, 5-year averages by regions.

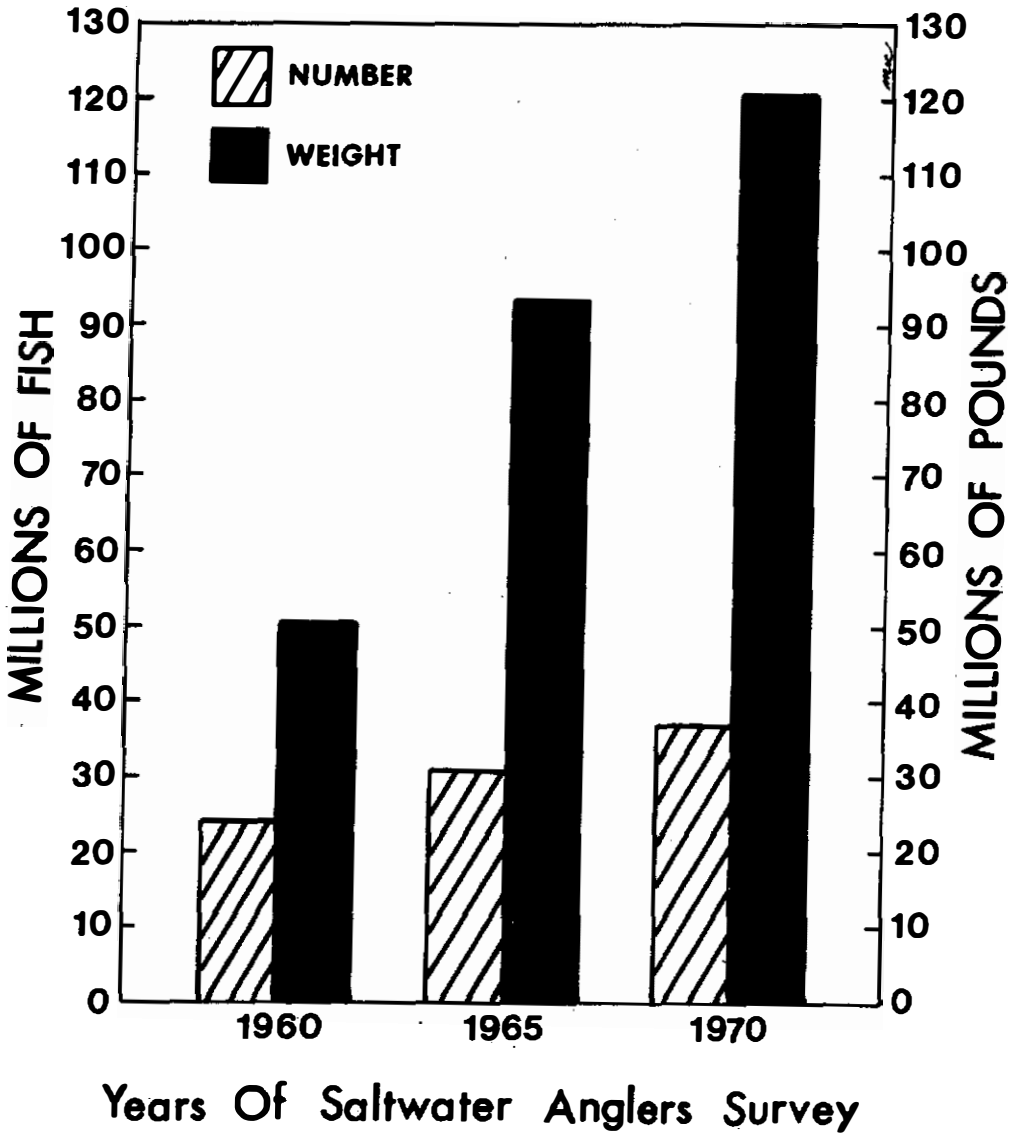

Figure 15. Recreational catch (no. and wt.) of bluefish (Pomatomus saltatrix) during 1960, 1965, and 1970 (from: Clark, 1962; Deuel and Clark, 1968; and Deuel, 1973).

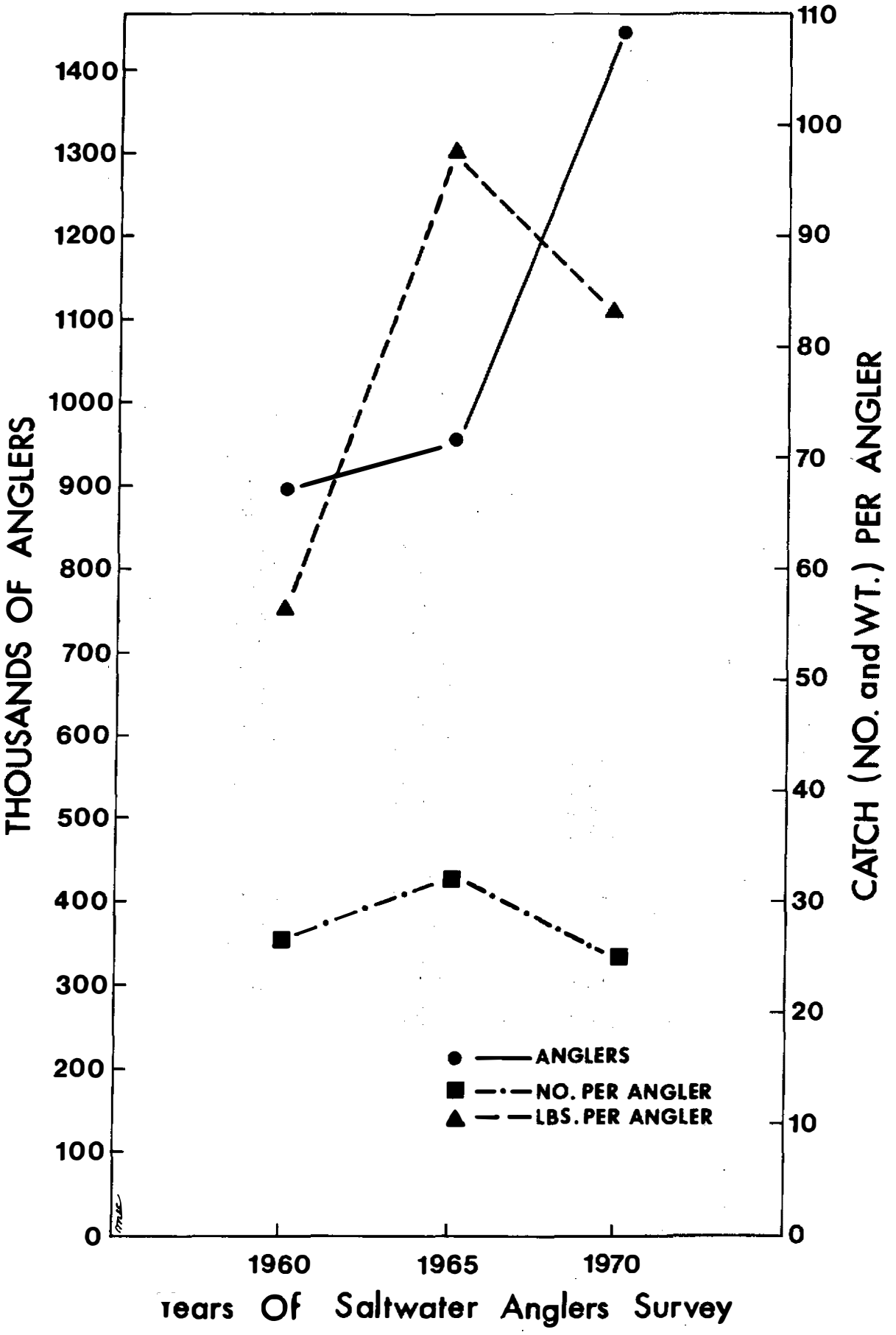

Figure 16. Number of anglers fishing and their average catch (no. and wt.) of bluefish (Pomatomus saltatrix) 1960, 1965, and 1970 (from: Clark, 1962; Deuel and Clark, 1968; and Deuel, 1973).

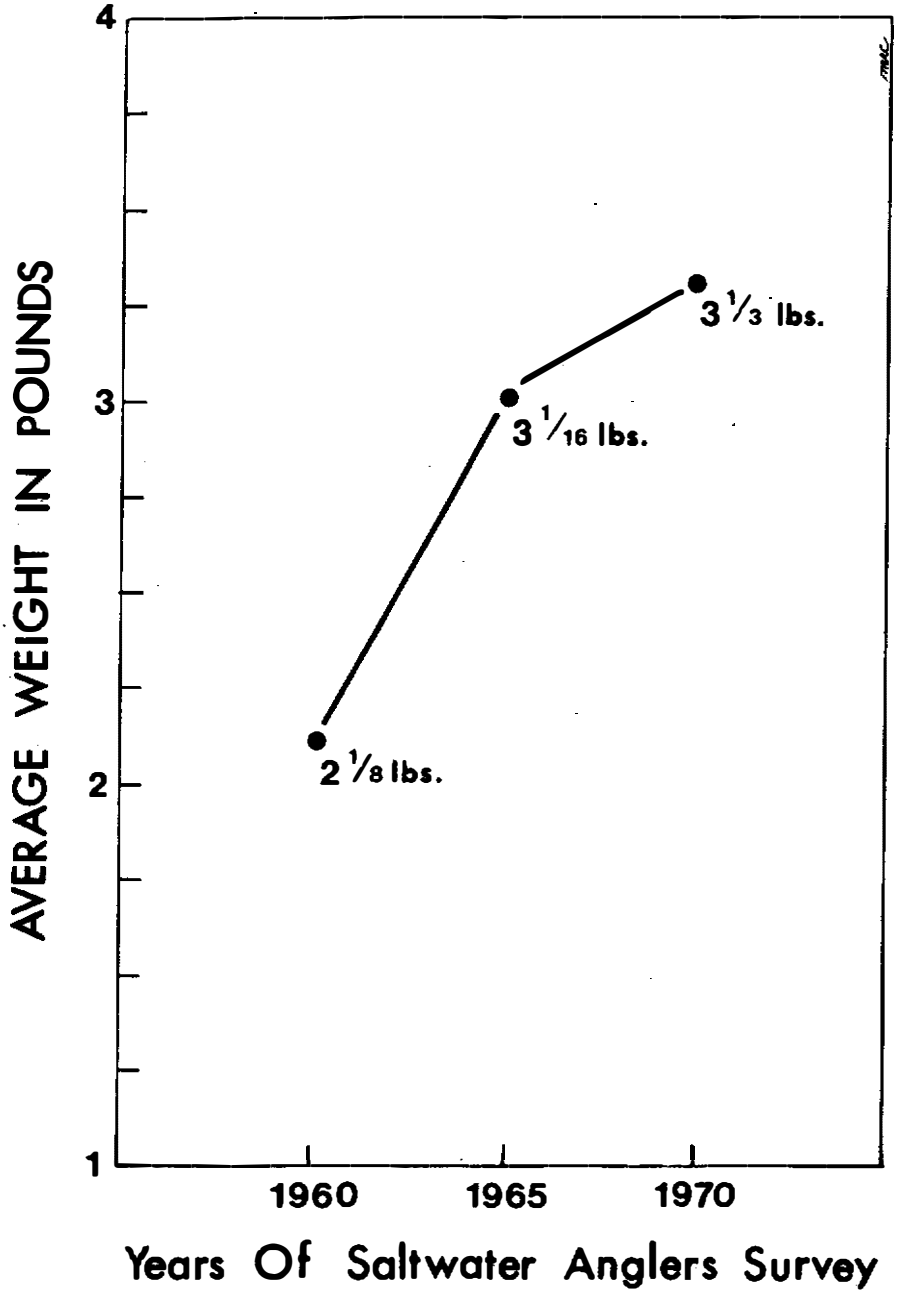

Figure 17. Average weight of bluefish (Pomatomus saltatrix) taken by anglers during 1960, 1965, and 1970 (from: Clark, 1962; Deuel and Clark, 1968; and Deuel, 1973).

Bluefish are so well known and publicized that wherever they occur nearshore there is a recreational fishery for them. Though there is some fishing for them in the eastern part of Maine, and even some along the southwestern tip of Nova Scotia, where they occur occasionally, the regular fishery for bluefish begins along the western shore of Casco Bay, Maine. From there to Cape Cod Bay, the recreational fishery though small, is of some consequence. Young-of-the-year, yearling, and some larger bluefish appear along the coast and in the estuaries of coastal rivers, usually in small schools. From Billingsgate Shoal in Cape Cod Bay to about Cape Lookout, North Carolina, angling for bluefish is particularly important. People fishing from Cape Cod to Cape Hatteras account for 63% by numbers and 83% by weight of all the bluefish caught in the United States. Here bluefish occur from shore out to at least the edge of the continental shelf. Young-of-the-year and yearlings are caught mostly in the bays and sounds while older ones, some weighing as much as 30 pounds, are generally caught offshore. From Cape Lookout to about Cape Canaveral, Florida, bluefish become less important to anglers because of the irregular appearance of the migrating schools. They may occur along a section of beach and stay for a day, a week or a month during a six month period, or they may not occur inshore for years at a time. From Cape Canaveral south to about Pompano Beach, Florida, bluefish are very important again, but south of Pompano Beach they are less important because their occurrence is sporadic and unpredictable (Freeman and Walford, 1974a, 1974b, 1974c, and 1974d; Freeman, pers. comm.).

6.0 PROTECTION AND MANAGEMENT

6.1 Regulatory (Legislative) Measures

There are both state and international regulations in effect regarding the bluefish. The state regulations are given in Table 4. International agreements involving winter fishing (January-April in U.S.A.) on outer continental shelf waters (50-100 fathoms) are now in effect with several foreign countries.

The purpose of the aforementioned state regulations are to insure successful year classes by limiting the capture of young-of-the-year fish (8-9 inches). International agreements limit the capture of bluefish during their stay on wintering grounds. The state laws, in most cases, have been on the books for many years and probably have little or no effects on the fishing due to lack of enforcement and the inconsistency of the rules or lack of rules from state to state.

TABLE 4. Fishing regulations for bluefish, Pomatomus saltatrix, by state.

State	Commercial Fishing	Recreational Fishing
Maine	None	None
New Hampshire	None	None
Massachusetts	None	None
Rhode Island	None	None
Connecticut	only bluefish measuring more than 9" may be retained.	None
New York	only bluefish measuring more than 9" may be retained.	None
New Jersey	only bluefish measuring more than 9" may be sold.	None
Delaware	None	None
Maryland	only bluefish measuring more than 8" may be retained.	only bluefish measuring more than 8" may be retained.
Virginia	None	None
North Carolina	None	None
South Carolina	only bluefish measuring more than 10" may be retained.	None
Georgia	None	None
Florida	only bluefish measuring more than 10" may be retained.	None
Alabama	None	None
Mississippi	None	None
Louisiana	None	None
Texas	None	None

6.2 Control or Alteration of Physical Features of the Environment

No data available.

6.3 Control or Alteration of Chemical Features of the Environment

No data available.

6.4 Control or Alteration of Biological Features of the Environment

No data available

6.5 Artificial Stocking

No data available.

7. AQUACULTURE

No data available.

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APPENDIX TABLE 1. Annotated list of bluefish, Pomatomus saltatrix, parasites (from: Anderson, 1970).

PHYLUM ARTHROPODA
SUBORDER ISOPODA
FAMILY CYMOTHOIDAE

1.e Livoneca ovalis (Say, 1818)e

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras, N. C. and Seabastian, Fla.

SITE.--Gills.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Richardson, 1905), and seven other host species from Woods Hole and along the Atlantic and Gulf Coastal States to Biloxi, Miss. (Richardson, 1905).

SUBCLASS COPEPODA
FAMILY CALIGIDAE

2.e Caligus schistonyx Wilson, 1905e

LOCALITY.--Marathon and St. Petersburg, Fla.

SITES.--Oral and gill cavaties.

Previously reported hosts and localities.--Bluefish and Brevoortia tyrannus from Woods Hole, Mass. (Wilson, 1905), Lepisosteus osseus and Mugil cephalus from Alligator Harbor, Fla. (Pearse, 1952), and other unidentified host species at Beaufort, N. C. (Wilson, 1932).

FAMILY LERNAEIDAE

3.e Lernaeenicus radiatus (LeSueur, 1824)e

LOCALITY.--This parasite was not found in bluefish during the present study.

SITE.--Skin of various parts of the body.

APPENDIX TABLE 1. (continued)

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Wilson, 1932), and 10 other host species from Woods Hole, Long Island, N. Y. and the North American coast (Wilson, 1932).

4.e Lernaeenicus longiventris Wilson, 1917e

LOCALITY.--Sandy Hook, N. J., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Palm Beach, and Marathon, Fla.

SITE.--Skin.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Wilson, 1932), and eight other host species from Woods Hole, Nantucket, R. I., Norfolk, Va., Beaufort, N. C. (Wilson, 1932), Miami, Fla. (Pearse, 1951), and Mazatlan, Sinaloa (Causey, 1960).

FAMILY DICHELESTHIDAE

5. Lernanthropus pomatomi Rathbun, 1888

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Palm Beach, Miami, Marathon, and St. Petersburg, Fla.

SITE.--Gills.

Previously reported hosts and localities.--Bluefish from Vineyard Sound, Mass. (Rathbun, 1888), Beaufort, N.eC. (Linton, 1905; Wilson, 1922), and Woods Hole, Mass. (Wilson, 1932), and two other host species frome Sinaloa and Nayarit (Causey, 1960).e

PHYLUM ACANTHOCEPHALA
ORDER PALAECANTHOCEPHALA
FAMILY RHADINORHYNCHIDAE

6.e Telosentis tenuicornis (Linton, 1891)

LOCALITY.--Hatteras and Cape Lookout, N. C., and Fort Pierce and Marathon, Fla.

SITE.--Intestinal wall.

APPENDIX TABLE 1. (continued)

Previously reported hosts and localities.--Bluefish from Beaufort, N. C. (Linton, 1905), and 17 other host species from Woods Hole, Mass. (Linton, 1892), Newport, R. I., Beaufort, N. C. (Linton, 1905), Bermuda (Linton,1908a), Tortugas (Linton, 1908b), and Galveston Bay, Tex. (Chandler, 1935).

FAMILY GORGORHYNCHIDAE

7.s Serrasentis socialis (Leidy, 1851)s

LOCALITY.--Sandy Hook, N. J., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Palm Beach, Miami, Marathon, and St. Petersburg, Fla.

SITE.--Body cavity and mesenteries.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton 1901b), and 16 other host species from Woods Hole (Linton, 1889, 1901b), Beaufort, N. C. (Linton, 1905), Miami, Fla. (Ward, 1954), and Galveston and Port Isabel, Tex. (Bullock, 1957).

FAMILY POMPHORHYNCHIDAE

8.s Pomphorphynchus proteus (Westrumb, 1821)s

LOCALITY.--Sandy Hook, N. J., Hatteras, N. C., and Palm Beach, Fla.

SITE.--Intestinal wall.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1901b), and seven other host species from Woods Hole (Linton, 1901b), and from Beaufort, N. C. (Linton, 1905).

FAMILY POLYMORPHIDAE

9.s Corynosoma incrassatus (Linton, 1891)s

LOCALITY.--Marathon and St. Petersburg, Fla.

SITE.--Intestinal wall.

APPENDIX TABLE 1. (continued)

Previously reported hosts and localities.--Bluefish and two other host species from Woods Hole, Mass. (Linton, 1891).

PHYLUM PLATYHELMINTHES
CLASS CESTODA
ORDER TETRAPHYLLIDAE

10.d Scolex pleuronectis Muller, 1788d

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Marathon, and St. Petersburg, Fla.d

SITE.--Cystic duct, gall bladder and intestine.d

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1901b, 1925), and Beaufort, N. C. (Linton, 1905), and over 60 other host species from Woods Hole (Linton 1901b,d 1925), Beaufort, N. C. (Linton, 1905), Bermuda (Linton, 1908a), and Galveston Bay, Tex. (Chandler, 1935).d

ORDER TRYPANORHYNCHAd
FAMILY LACISTORHYNCHIDAEd

11.d Lacistorhynchus bulbifer (Linton, 1889)d

LOCALITY.--Not found in bluefish during the present study.

SITE.--Viscera and intestinal wall.

Previously reported hosts and localities.--Bluefish and 30 other host species from Woods Hole, Mass. (Linton, 1891, 1925).

12.d Nybelinia bisulcata (Linton, 1889)d

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras, N. C., and Fort Pierce and Seabastian, Fla.

SITE.--Viscera.

APPENDIX TABLE 1. (continued)

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1925), and Beaufort, N. C. (Linton, 1905), and 51 other host species from Woods Hole (Linton, 1925), Beaufort (Linton, 1905), Miami, Fla. (Ward, 1954), Bermuda (Linton, 1908a), and Japan (Yamaguti, 1959).

FAMILY DASYRHYNCHIDAE

13.a Callitetrarhynchus gracilis (Rudolphi, 1819)a

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Palm Beach, Miami, Marathon, and St. Petersburg, Fla.

SITE.--Viscera.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton 1901b, 1925), and Beaufort, N. C. (Linton, 1905), and 24 other host species from Woods Hole (Linton, 1901b, 1925), Beaufort (Linton, 1905), Florida (Schuler, 1938), Miami, Fla. (Ward, 1954), Bermuda (Linton, 1908a), and Galveston Bay, Tex. (Chandler, 1935).

FAMILY OTOBOTHRIIDAE

14.a Otobothrium dipsacum Linton, 1897a

LOCALITY.--Marathon, Fla.

SITE.--Viscera.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1897, 1901b, 1925), and 11 other host species from Woods Hole (Linton, 1925), Pensacola, Fla. (Linton, 1905), and Miami, Fla. (Ward, 1954).

15.a Otobothrium crenacolle Linton, 1890a

LOCALITY.--Sandy Hook, N. J., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Marathon, and St. Petersburg, Fla.

APPENDIX TABLE 1. (continued)

SITE.--Stomach mucosa, mesenteries, and viscera.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1925), and Beaufort, N. C. (Linton, 1905), and 35 other host species from Woods Hole (Linton, 1891, 1925), Beaufort (Linton, 1905), Tortugas (Linton, 1908b), and Bermuda (Linton, 1908a).

FAMILY PTEROBOTHRIIDAE

16.a Pterobothrium fillicolle (Linton, 1889)a

LOCALITY.--Hatteras, N. C., and Fort Pierce, Sebastian, Palm Beach, Marathon, and St. Petersburg, Fla.

SITE.--Viscera.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1897, 1901b, 1925), New York (Linton, 1897), and Beaufort, N. C. (Linton, 1905), and at least 25 other host species from Woods Hole (Linton, 1901b, 1925), Beaufort (Linton, 1905), Tortugas (Linton, 1908b), and India (Yamaguti, 1959).

17.a Pterbothrium malleum (Linton, 1924)a

LOCALITY.--Was not found in bluefish during the present study.

SITE.--Mesenteries and viscera.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1897, 1901b), and Beaufort, N. C. (Linton, 1905), and at least six other host species from Woods Hole (Linton, 1897, 1901b, 1925), Beaufort (Linton, 1905), Galveston Bay, Tex. (Chandler, 1935), and the Indian Ocean (Southwell, 1929).

ORDER PSEUDOPHYLLIDAE
FAMILY PTYCHOBOTHRIIDAE

18.a Clestobothrium crassiceps (Rudolphi, 1819)a

LOCALITY.--Was not found in bluefish during the present study.

APPENDIX TABLE 1. (continued)

SITE.--Intestine.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1941), and nine other host species from Woods Hole (Linton, 1941). Yamaguti (1959) reported it in nine genera, including Pomatomus, from North America.

FAMILY BOTHRIOCEPHALIDAE

19.- Bothriocephalus sp. Linton, 1941-

LOCALITY.--This parasite was not found in bluefish during the present study.

SITE.--Viscera.

Previously reported hosts and localities.--Bluefish and 26 other host species from Woods Hole, Mass. (Linton, 1941).

CLASS TREMATODA
ORDER MONOGENEA
FAMILY MICROCOTYHLIDAE

20.- Microcotyle pomatomi Goto, 1900-

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Palm Beach, Miami, Marathon, and St. Petersburg, Fla.

SITE.--Gills.

Previously reported hosts and localities.--Bluefish from Newport, R. I. (Goto, 1900), Woods Hole, Mass. (Goto, 1900; Linton, 1901b), Beaufort, N. C. (Linton, 1905; Pearse, 1949), Chesapeake Bay, Md. (McMahon, 1964), "off Port Aransas, Texas" (Koratha, 1955), Alligator Harbor, Fla. (Hargis, 1956), and the Black Sea (Bychowsky, 1961).

Note.--In a recent paper "Studies on Larval Monogenea of fishes from the Chesapeake Bay Area, Part I, "by N. Kingston, W. A. Dillon, and W. J. Hargis, Jr., 1969 (Journal of Parasitology, vol. 55, no. 3, p.-544-558), the authors reported two genera found in autopsied bluefish. Besides Microcotyle pomatomi

APPENDIX TABLE 1. (continued)

Goto listed herein, they also found Gotocotyla acanthophallus (MacCallum and MacCallum, 1913) Yamaguti, 1963. Gotocotyla was not found or reported in the present study.

ORDER DIGENEA
FAMILY ALLOCEADIIDAE

21.. Opecoeloides vitellosus (Linton, 1901a).

LOCALITY.--Sandy Hook, N. J., Hatteras and Cape Lookout, N. C., and Fort Pierce, Fla.

SITE.--Stomach and intestinal chyme.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1901a, 1901b), and Beaufort, N. C. (Linton, 1905), and 37 other host species from Woods Hole (Linton, 1901a, 1901b), Beaufort (Linton, 1905), and Bermuda (Linton, 1908a).

22.. Lepocreadium pyriforme (Linton, 1889).

LOCALITY.--Sandy Hook, N. J.

SITE.--Intestine.

Previously reported hosts and localities.--Bluefish and eight other host species from Woods Hole, Mass. (Linton, 1901b, 1940).

FAMILY HEMIURIDAE

23.. Brachyphallus crenatus (Rudolphi, 1802).

LOCALITY.--Annapolis, Md., and Sebastian, Marathon, and St. Petersburg, Fla.

SITE.--Liver.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1898, 1940), and at least 17 other host species from Woods Hole (Linton, 1940), Barents Sea, Boreal Atlantic, Boreal Pacific (Polyanski, 1961), Berling Sea, Okhotsk Sea, and Sea of Japan (Strelkov, 1956).

APPENDIX TABLE 1. (continued)

24.o Sterrhurus monticellii (Linton, 1899)o

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Marathon, and St. Petersburg, Fla.

SITE.--Stomach chyme.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1901b, 1940), and Beaufort, N. C. (Linton, 1905), and 32 other host species from Woods Hole (Linton 1901b, 1940), Beaufort (Linton, 1905), Bermuda (Linton, 1908a), and Tortugas (Linton, 1908b).

FAMILY BUCEPHALIDAE

25.o Rhipidocotyle transversale Chandler, 1935o

LOCALITY.--This parasite was not found in bluefish during the present study.

SITE.--Viscera.

Previously reported hosts and localities.--Bluefish from Beaufort, N. C. (Linton, 1905), and at least 13 other host species from Woods Hole, Mass. (Linton, 1901b, 1940), Beaufort, N. C. (Linton, 1905), Galveston Bay, Tex. (Chandler, 1935), Grand Isle, La., Rockport and Port Aransas, Tex., and York River, Va. (Sparks, 1957).

26.o Bucephaloides arcuatus (Linton, 1901a)o

LOCALITY.--Sebastian, Palm Beach, Miami, Marathon, and St. Petersburg, Fla.

SITE.--Intestinal caeca.

Previously reported hosts and localities.--At least eight host species but not bluefish, from Woods Hole, Mass. (Linton, 1901a, 1940), Beaufort, N. C. (Linton, 1905), Miami, Fla. (Ward, 1954), Tortugas (Manter, 1940), and the Red Sea (Sparks, 1957).

APPENDIX TABLE 1. (continued)

FAMILY ACANTHOCOLPIDAE

27.a Stephanostomum dentatum (Linton, 1901a)a

LOCALITY.--Was not found in bluefish during the present study.

SITE.--Kidneys.

Previously reported hosts and localities.--Bluefish from Beaufort, N. C. (Linton, 1905), and nine other host species from Woods Hole, Mass. (Linton, 1901a, 1940), Beaufort, N. C. (Linton, 1905), and Tortugas (Manter, 1947).

28.a Stephanostomum tenue (Linton, 1898)a

LOCALITY.--Sandy Hook, N. J., Hatteras, N. C., and Sebastian, and Marathon, Fla.

SITE.--Kidneys.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1940), and Beaufort, N. C. (Linton, 1905), and 17 other host species from Woods Hole (Linton, 1898, 1940), Beaufort (Linton, 1905), and Sandy Hook Bay, N. J. (Nigrelli and Atz, 1943).

FAMILY UNKNOWN

29.a Distoma fenestratum Linton, 1905a

LOCALITY.--Fort Pierce and Marathon, Fla.

SITE.--Heart and kidneys.

Previously reported hosts and localities.--At least 20 host species, but not bluefish, from Woods Hole, Mass. (Linton, 1940), Beaufort, N. C. (Linton, 1905), Bermuda (Linton, 1908a), Tortugas (Linton, 1910), Bahamas, "off the Mississippi River," and Grand Isle, La. (Sparks, 1957).

APPENDIX TABLE 1. (continued)

PHYLUM ASCHELMINTHES
CLASS NEMATODA

Four forms of immature nematodes were described from bluefish at Woods Hole and three at Beaufort. Two forms were found in both regions. All were collectively identified by Linton (1901b, 1905) as Ascaris sp.

ORDER DRACUNCULOIDAE
FAMILY PHILOMETRIDAE

30.o Philometra globiceps (Rudolphi, 1819)o

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras, N. C., and Sebastian, Palm Beach, Miami, and St. Petersburg, Fla.

SITE.--Ovaries.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1901b), Beaufort, N.oC. (Linton, 1905), and North Carolina coast (Lassiter, 1962), and seven other host species fromo Woods Hole (Linton, 1901b), Beaufort (Linton, 1905), Bermuda (Linton, 1908a), and Naples, Italy (Yamaguti, 1961).o

31. ORDER ASCARIDDIDEA

LOCALITY.--Sandy Hook, N. J., Annapolis, Md., Hatteras and Cape Lookout, N. C., and Fort Pierce, Sebastian, Palm Beach, Miami, Marathon, and St. Petersburg, Fla.

SITE.--Viscera.

Previously reported hosts and localities.--Bluefish from Woods Hole, Mass. (Linton, 1901b), and Beaufort, N. C. (Linton, 1905), and at least 31 other host species from Beaufort, N. C. (Linton, 1905).

APPENDIX TABLE 1. (continued)

PHYLUM PROTOZOA
CLASS MASTIGOPHORA
ORDER DINOFLAGELLATA
FAMILY GYMODINIIDAE

32.0 Oodinium ocellatum Brown, 1931O

LOCALITY.--This parasite was not found in bluefish during the present study.

SITE.--Gills and skin.

Previously reported hosts and localities.--Bluefish at the New York Aquarium (Nigrelli, 1936), and numerous other host species from the East Indies, the West Indies (Brown, 1934), North American waters (Nigrelli, 1936), the New York Aquarium (Nigrelli, 1936), and the Aquarium of the Zoological Society of London (Brown, 1931).

PHYLUM PLATYHELMINTHES
CLASS TREMATODA
FAMILY CAPSALIDAE

33.0 Benedenia melleni MacCallum, 1927O

LOCALITY.--This parasite was not found in bluefish during the present study.

SITE.--Skin.

Previously reported hosts and localities.--Bluefish and numerous other host species from the New York Aquarium (MacCallum, 1927), and Europe (Bychowsky, 1961).