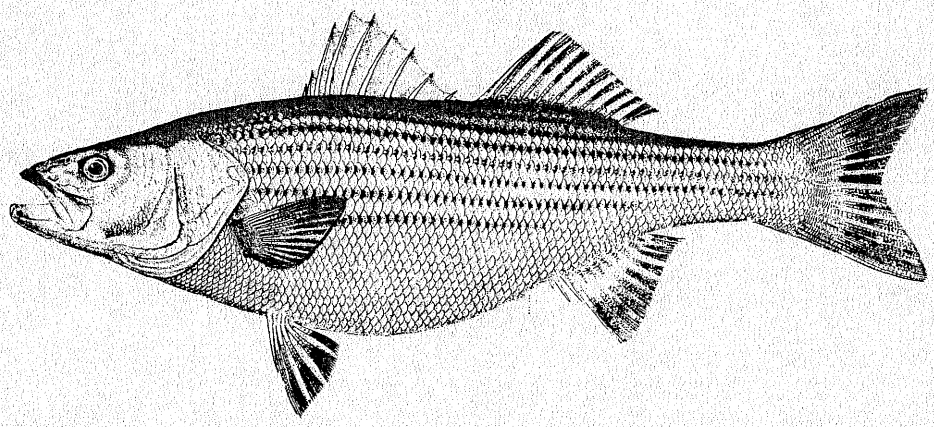

BIOLOGICAL & FISHERIES DATA
ON
STRIPED BASS, *Morone saxatilis* (WALBAUM)

MAY 1977

Biological and Fisheries Data

on

striped bass, *Morone saxatilis* (Walbaum)

by

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U. S. Department of Commerce

Highlands, N. J.

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PREFACE: This report was compiled from existing literature and in many cases paraphrases the writing of other investigators. It does not contain the results of any original research.

1. IDENTITY

1.1 Nomenclature

Perca rock-fish vel Striped bass, Schopf, Schrift. der Gesseils. Nat. Freunde, VIII, 160, 1788, New York.

Perca saxatilis, Walbaum, Artedi Genera Piscium, 330, 1788, New York; after Schopf.

Sciaena lineata, Bloch, Ichthyologia, lx, 53, pl. 305, 1792 Mediterranean Sea; figure incorrect, but probably from American specimen.

Perca septentrionalis, Bloch and Schneider, Systema Ichthyol., 90, pl. 70, 1801, New York.

Roccus striatus, Mitchill, Rep. Fishes N. Y., 25, 1814, specimens from New York; Bean, Proc. U. S. Nat. Mus., 1884, 243, specimens from Montgomery, Ala.

Perca mitchilli, Mitchilli, Trans. Lit. and Phil. Soc. N. Y., I, 413, pl. 3, fig. 4, 1815, New York.

Perca mitchilli alternata, Mitchill, l.c., 415, 1815, New York.

Perca mitchilli interrupta, Mitchill, Trans. Lit. and Phil. Soc. N. Y. 415, 1815, New York.

Lepibema lineatum, Steindachner, Verh. Zool. Bot. Ges. Wien., XII, 1862, 504.

Labrax lineatus, Cuver and Valenciennes, Hist. Nat. des Poissons, II, 79, 1828.

Roccus lineatus, Gill, Ichth. Rep. Capt. Simpson's Explor. Great Basin Utah, 391, 1876; Goode, Nat. Hist. Aquat. Anim., 425, 1884.

Roccus saxatilis, Jordan and Gilbert, Proc. U. S. Nat. Mus., 1882, 599.

Roccus lineatus, Jordan and Eigenmann, l.c., 423, 1890.

Morone lineata, Boulenger, Cat., I, 129.

Roccus saxatilis (Walbaum) 1940.

Morone saxatilis (Walbaum) Whitehead and Wheeler 1966. Ann. Mus. Civ. Stor. Nat. Genova, 76: 23-41.

Until recently, the striped bass was considered a member of the family Serranidae. Gosline (1966) split it and several other members from the Serranidae and placed them in a new family, the Percichthyidae. It is most widely known as striper and in some areas, especially from Chesapeake Bay southward, as rock or rockfish.

1.2 Taxonomy

Phylum: Chordata
Subphylum: Vertebrata
Class: Osteichthys
Subclass: Actinopterygii
Order: Perciformes
Family: Percichthyidae
Genus: Morone
Species: saxatilis

1.3 Morphology

There is little chance of confusing the striped bass, or striper, with other coastal fishes (Figure 1). Its color, longitudinal stripes, morphology and dorsal fin structure distinguish the bass from other fishes found within its natural range. Dorsally, its color may be olive green to almost black, the sides silver and the belly white. The 7 or 8 longitudinal stripes on each side usually follow scale rows. The body is elongate, slightly compressed and has a deep caudal peduncle (Nichols, 1966). The two dorsal fins are about equal in length and separated at the base. The first consists of 9 or 10 spines, the second of 12 or 13 soft rays. The anal fin (III, 11) is about the length of the second dorsal fin. The bass is the largest member of the family, achieving a weight in excess of 100 pounds and a length of more than 6 feet (Bigelow and Schroeder, 1953).

Of the coastal fishes, the white perch, Morone americana, most closely resembles the striped bass in general appearance but the two dorsal fins of the perch are continuous, those of the bass separated. The perch lacks the prominent longitudinal stripes found on the bass. The striper also closely resembles two of its fresh water relatives, the yellow bass, M. mississippiensis, and the white bass, M. chrysops, as well as some recently derived hybrid crosses (see 2.4 Hybridization).

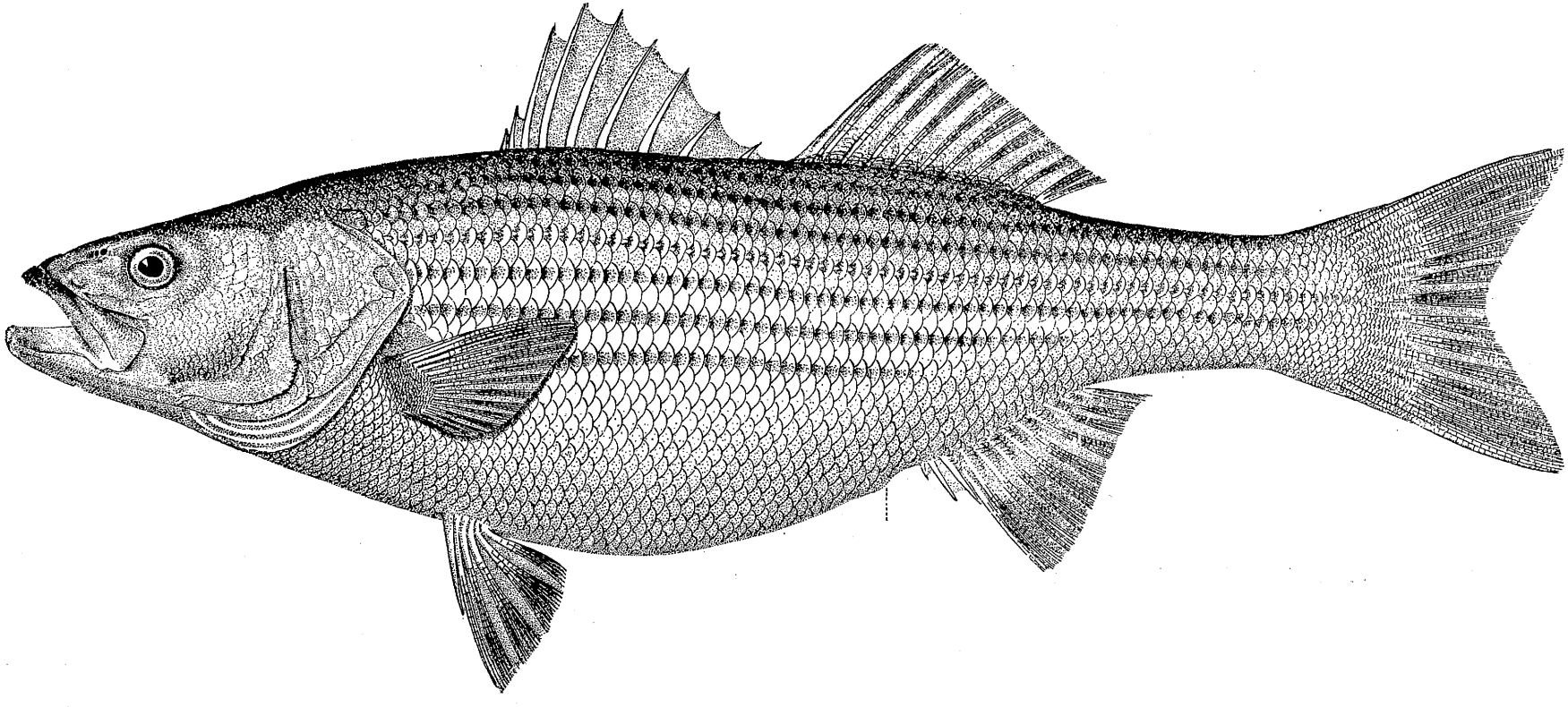

Figure 1. Striped bass, Morone saxatilis (from: Bigelow and Schroeder, 1953).

2. DISTRIBUTION

2.1 Total Areas

The striped bass occurs naturally along the Atlantic coast from the St. Lawrence River in Canada to the St. Johns River, Florida, and in some river systems along the Gulf of Mexico from western Florida to Lake Pontchartrain, Louisiana. It is a coastal fish, inhabiting nearshore ocean waters as well as adjacent bays, sound and tidal rivers.

It occurs along our Pacific coast from southern California to Washington as a result of a stocking program during the late 1800's. In 1879 and 1882 yearling bass from the Navesink and Shrewsbury rivers of New Jersey were planted in San Francisco Bay near Martinez, California. Within 10 years of the first plant a prosperous fishery was developing in central California (Nichols, 1966). Annual commercial landings fluctuated between 500,000 and 1 million pounds from World War I to the early 1930's. They dropped sharply after 1931, when commercial fishing was prohibited and the striper declared a sport fish. Today, the largest concentrations are found in the San Francisco Bay drainage system and in Coos Bay, Oregon, with smaller populations in the Russian and Columbia rivers.

Although the striper is a hardy fish, capable of living in both fresh and salt water (see tolerance experiments by Tagatz, 1961), only limited success has been achieved in establishing naturally reproducing stocks in fresh water rivers, lakes and reservoirs. They appear to thrive in landlocked bodies of water if food supplies and spawning habitat are adequate. Otherwise, populations can be maintained only by restocking. Reproducing populations have been established in the Santee Cooper River System of South Carolina; in Kerr Reservoir, located on the headwaters of the Roanoke River of North Carolina and Virginia; in Millerton Lake, California; and possibly in Kentucky Lake of Kentucky and Tennessee.

2.2 Differential Distribution

Although the population structure along the middle Atlantic coast is unclear, evidence suggests the existence of separate populations. In the southern part of the stripers range, where the distribution is not continuous, substantial populations occur in the St. Johns River System in Florida; the Savannah, Altamaha, Ogeechee, and St. Marys rivers in Georgia; the Santee and Cooper rivers of South Carolina; and in the Roanoke River of North Carolina. Bass are seldom caught in offshore coastal waters south of North Carolina and apparently, there is little or no movement of the fish out of their home river system at any stage of their life cycle (Raney and Woolcott, 1955). From Chesapeake Bay to New England, where the population structure is most confused, seasonal migrations take

place along the coast to as far north as Maine. Like those fish south of Cape Hatteras, bass of the Gulf of St. Lawrence and the lower St. Lawrence River do not migrate, although some irregular back and forth movements probably occur between the bays and rivers of the area (Bigelow and Schroeder, 1953).

On the Pacific coast, little exchange occurs between bass populations of the various river systems from California to Washington (Nicholson and Lewis, 1973).

2.3 Determinants of Distribution

The striper is strictly a coastal fish, seldom caught more than 4 or 5 miles offshore, although it probably ranges farther seaward off coastal indentations during seasonal migrations. Small bass are most often found in bays or river systems but most fish in excess of 20 pounds are found along the coast, except during the spawning season, when they move inland to fresh water. They are usually found wherever food is available, frequenting sandy beaches, rocky areas or the mouths of estuaries, where tidal currents are strongest. Stripers are strong swimmers and are often seen feeding in the surf zone. The depths at which they are found are usually dictated by tides and in shallow bays they frequently feed in areas that are exposed during low water (Bigelow and Schroeder, 1953).

Bass are active at temperatures between 7 and 21°C. When coastal water cools to temperatures below 7° they either move to warmer water or become dormant. Prolonged exposure to temperatures above 27°C is probably lethal. They can withstand both fresh and salt water but their normal migrations do not expose them to salinities much in excess of 30 to 33 o/oo (Bigelow and Schroeder, 1953).

2.4 Hybridization

Hybridization experiments were an offshoot of several frustrated attempts to artifically propagate stripers. The experiments were initiated to create a fish that possessed the size, longevity, food habits, fighting ability and food quality of the striped bass, as well as the adaptive qualities and more relaxed spawning requirements of one of its fresh water relatives.

The experiment first succeeded in 1966. It involved eggs from a female striped bass and milt from a male white bass, *M. chrysops*. Since then, viable young have been hatched from crosses involving striped bass eggs and milt from the other three American species of the genus *Morone*. To date, however, only progeny from the striped bass and white bass cross have produced a successful fishery. Although the hybrid is viable, there is no evidence of natural reproduction.

With the exception of a 3 to 6 hour longer incubation period, development of eggs from the striper and white bass cross closely follows that of striper eggs. During their first 18 months the young hybrids grow faster than either parent. Thereafter, striped bass growth begins to surpass that of the hybrid (Bayless, 1972). In Cherokee Reservoir, Tennessee, both stripers and their hybrid offspring weighed about 4 pounds at 27 months of age (Bishop, 1968).

The hybrid is not difficult to distinguish from either parent (Figure 2). Gross morphological differences, such as the body length-body depth ratio, permit identification by anyone even slightly familiar with the hybrid and its parent species (Bishop, 1968). The number of scale rows above the lateral line is the most reliable character for distinguishing between parent and offspring (Table 1).

Young hybrids have a better survival rate than striped bass, both in hatcheries and when stocked in fresh water lakes and reservoirs but like both parents, to be successful, it appears that the hybrids need a clupeid fish, such as the threadfin shad, Dorosoma petenense, to forage upon.

The current state record in South Carolina and Tennessee serves as a worthy testament of the hybrid's potential as a sportfish. Four years after stocking, the state record in South Carolina is 7.5 pounds. Unofficial reports indicate that fish over 9 pounds have been taken. In Tennessee, the state record is 14 pounds 12 ounces (Bayless, 1972).

3. BIONOMICS AND LIFE HISTORY

3.1 Reproduction

Stripers are anadromous. The spawning grounds, although usually in fresh water, may vary from low salinity estuarine rivers or streams, like those along the eastern shore of Chesapeake Bay, to a rocky, fresh water habitat such as the Roanoke River of North Carolina. Tributaries of Chesapeake Bay, most notably the Potomac River, and also the James, York, and most of the smaller rivers on the eastern shore of Maryland, are collectively considered the major spawning grounds of striped bass, but other rivers make substantial contributions to the population along the middle Atlantic coast. Significant spawning occurs in tributaries of Albemarle Sound, the Chesapeake-Delaware Canal, and the Hudson River. Occasionally other smaller rivers contribute (Bigelow and Schroeder, 1953; Merriman, 1941; Freeman, pers. comm.). On the west coast, bass utilize flooded deltas on the Sacramento-San Joaquin River System for spawning (Nicholson and Lewis, 1973). It is thought that a principal requirement for successful spawning is a current turbulent enough to prevent the eggs from settling to the bottom

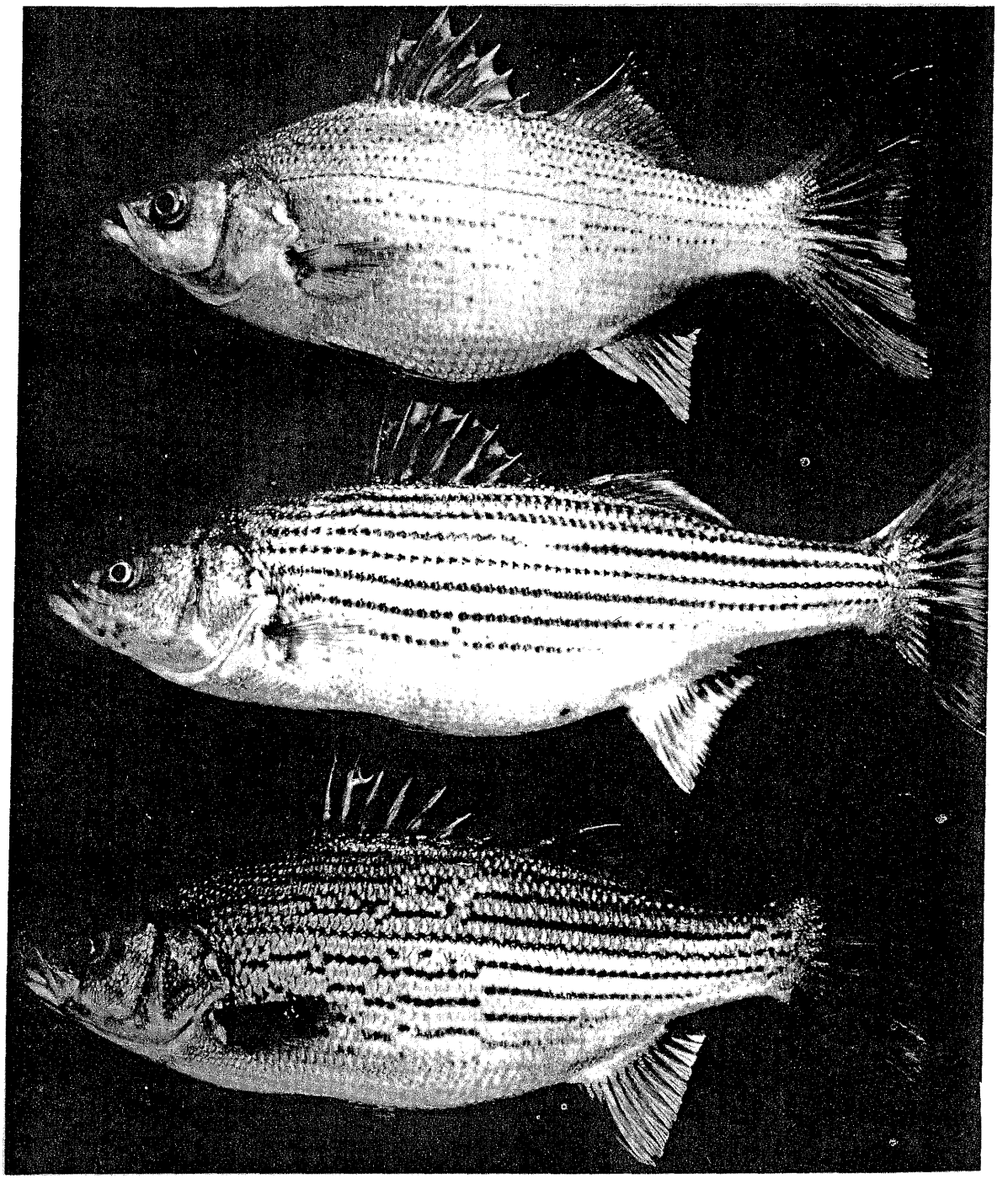

Figure 2. Top - White bass: Middle - Striped bass: Bottom - Hybrid: (Photo. Courtesy, Tennessee Game and Fish Commission. From: Bishop, 1967).

TABLE 1. Description of meristic characters for Morone spp. and hybrids (from Bayless, 1972)

Species	Fork Length/ Body Depth	Lateral Line Scales	Scale Rows Above Lateral Line	Scale Rows Below Lateral Line	Soft Anal Rays	2nd Dorsal Count	2nd Anal Spine Length/ 3rd Anal Spine Length	Head Length 2nd Anal Spine Length	Dorsal Fins	Arch of Back	Stripes
Striped Bass	3.7-4.2 usually 3.9	58-67	7-9 usually 8	11-12 usually 11	10-11	I-12	0.73-0.83 mean 0.74	4.4-5.2 mean 4.5	Separated	Slight	Distinct (occasionally broken)
White Bass	2.4-2.8 usually 2.6	53-61*	7-9 usually 9	15*	11-12	I-13-14	0.68-0.75 mean 0.72	2.4-3.1 mean 2.9	Separated	Moderate	Indistinct Faint
Original White Bass Hybrid	2.6-3.4 usually 2.7	54-58 usually 56	10-12 usually 10	15-17 usually 16	12-13	I-12-14	0.89-0.96 mean 0.92	3.4-4.03 mean 4.01	Separated	Moderate	Distinct (frequently broken)
F_2	3.8-4.3 usually 4.1	55-62	9-11	12-14	11	I-12	0.58-0.90	3.8-5.7	Separated	Slight to Moderate	Distinct (occasionally broken)
Original Backcross	3.8-4.2	52-58	9-11	12-14	11-12	I-12-13	0.77-0.89	3.5-5.4	Separated	Slight	Distinct
Reciprocal Backcross	3.7-4.1	52-58	8-10	12-14	8-11	I-12-13	0.26-0.83	4.0-14.3	Separated	Slight to Acute	Distinct (occasionally broken)
White Perch Hybrid	3.8-4.2 usually 3.9	53-56	8-9	11-13 usually 12	10	I-12-13	0.81-1.0	3.4-3.8	Connected	Slight	Distinct

* Source: Jordan and Evermann (1896).

where they may be silted over and smothered (Bigelow and Schroeder, 1953). Although the eggs require some circulation to survive, a recent study showed that shear stress, caused by water movement, also can be lethal to both eggs and larvae. Exposure of bass eggs to a shear level of 350 dynes/cm^2 killed 36% of the eggs in 1 min., 69% in 2 min., and 88% in 4 min. Larvae exposed to the same shear levels suffered mortalities of 9% in 1 min., 30% in 2 min., and 68% in 4 min. (Morgan et al., 1976).

The extent of the stripers spawning run varies, depending on the river in question. Bass ascend the Roanoke a distance of more than 100 miles above Albemarle Sound and the Potomac more than 75 miles above Chesapeake Bay (Nichols, 1966). The spawning population is made up of males 2 years or older and females 4 or more years old.

The sex ratio of bass collected in North Carolina's Roanoke River after a fish kill was 82% males upstream and 75% males downstream, the difference attributed to later arrivals of females on upstream spawning grounds (Trent and Hassler, 1968). The sex ratio from gill net collections on the same river is shown in Table 2. The large difference during the 3 years of sampling was attributed to differences in recruitment, and the subsequent age at which bass join in the upriver spawning migration. Males migrate when 2 or 3 years old, females not until 4 years old. From 1959-62 abundance estimates of young-of-the-year bass caught in Albemarle Sound were 1.70, 0.44, 0.79, and 0.52 fish/trawling minute.

The spawning season along the Atlantic coast usually extends from April to June, but it begins as early as January or February in Florida, and is governed largely by water temperature. Stripers spawn at temperatures between 10 and 23°C, but seldom at temperatures below 13 to 14°C. Peak spawning activity occurs at about 18°C and declines rapidly thereafter. Extreme water temperature fluctuations during the spawning season are detrimental to egg development. Temperatures below 12°C and above 22°C are usually lethal (Barkaloo, 1967). In the Sacramento and San Joaquin Rivers in California spawning is heaviest from April 23 to June 12 at water temperatures from 17.2 to 20.0°C. Spawning occurs earlier in the San Joaquin River than in the Sacramento. The time difference is greatest during years of high run-off (Turner, 1976).

The number of mature ova in female striped bass varies by age, weight and fork length. Morgan and Gerlach (1950) reported that bass captured in Oregon produced about 100,000 eggs/pound of body weight. Jackson and Tiller (1952) found that fish from Chesapeake Bay produced from 62,000 to 112,000 eggs/pound of body weight, with older fish producing more eggs than younger fish. Lewis and Bonner (1966) reported about 80,000 eggs/pound of body weight from bass collected in North Carolina (Table 3). When ripe, the ovaries are greenish-yellow in color (Scofield, 1931).

TABLE 2. Sex ratio (% males) of bass caught in gill nets set in Roanoke River, N. C. (from Trent and Hassler, 1968).

Age Group	1963	1964	1965
II	100.0	100.0	
III	98.9	100.0	99.7
IV	43.2	67.6	61.6
V	30.9	25.0	40.8
VI	15.4	0.0	0.0
VII	0.0		
VIII	0.0		
IX	0.0		
All Age Groups (weighted average)	69.7	85.1	76.9

TABLE 3. Estimated mean number of mature ova (thousands) by body weight and fork length in striped bass from the Roanoke River, North Carolina. Values in parentheses are the numbers of specimens upon which the mean values are based (from: Lewis and Bonner, 1966).

Fork Length (inches)	Body Weight (pounds)													
	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.0	15.0-15.9
17.0-17.9	-	282(1)	-	-	-	-	-	-	-	-	-	-	-	-
18.0-18.9	163(3)	239(4)	339(1)	-	-	-	-	-	-	-	-	-	-	-
19.0-19.9	-	244(4)	372(6)	-	-	-	-	-	-	-	-	-	-	-
20.0-20.9	-	-	320(23)	411(10)	-	-	-	-	-	-	-	-	-	-
21.0-21.9	-	-	298(2)	400(15)	401(1)	-	-	-	-	-	-	-	-	-
22.0-22.9	-	-	-	446(3)	454(8)	490(3)	-	-	-	-	-	-	-	-
23.0-23.9	-	-	-	-	570(1)	517(4)	-	524(1)	-	-	-	-	-	-
24.0-24.9	-	-	-	-	-	-	664(6)	839(2)	-	-	-	-	-	-
25.0-25.9	-	-	-	-	-	-	-	792(7)	864(7)	-	-	-	-	-
26.0-26.9	-	-	-	-	-	-	577(1)	903(1)	851(8)	898(1)	-	-	-	-
27.0-27.9	-	-	-	-	-	-	-	-	923(3)	862(4)	960(5)	-	-	-
28.0-28.9	-	-	-	-	-	-	-	-	-	-	-	959(2)	1,090(2)	-
29.0-29.9	-	-	-	-	-	-	-	-	-	-	-	-	1,012(2)	1,055(1)
30.0-30.9	-	-	-	-	-	-	-	-	-	-	-	-	-	1,029(1)

3.2 Preadult Phase

Eggs are non-adhesive and slightly heavier than fresh water. Eggs collected in the Sacramento River of California had a specific gravity ranging from 1.0003 to 1.00065 with a $\bar{x}$ of about 1.0005. When unfertilized they are about 1.3 mm in diameter (Albrecht, 1964). After fertilization and water hardening, their diameter increases to 2.4 to 3.9 mm. They average 3.4 mm. Bass eggs are spherical, with a single large oil globule (0.40 to 0.85 mm) lightly granulated york mass and an exceptionally wide perivitelline space, which comprises as much as 65% of the egg diameter (Mansueti, 1958).

After fertilization the semi-buoyant eggs of striped bass are transported downstream or, if spawned in slightly brackish water, back and forth by tidal circulation. Although generally considered to drift near bottom, eggs have been collected at various depths, depending on water velocity. At velocities exceeding 2.3 ft/sec they are usually more concentrated near the surface (Albrecht, 1964). Hatching occurs in about 70 to 74 h at 14 to 15°C; in 48 h at 18 to 19°C; and in about 30 h at 21 to 22°C (Bigelow and Schroeder, 1953).

The following rate of development (taken from Mansueti, 1958) is based on eggs held at 16 to 17°C.

2 h after fertilization: Egg development has advanced to the 16 to 32 blastomere stage. During early development the oil globule is located at the vegetal pole, opposite the blastoderm. In final stages of egg development, it is situated just beneath the head of the embryo (Fig. 3B, F).

12 h after fertilization: The blastoderm covers half of the yolk mass (Fig. 3C).

20 h after fertilization: Neural ridges and eyes are visible on the developing embryo. Pigment occurs around the embryo and on the oil globule (Fig. 3D, E).

36 h after fertilization: The embryo is well developed and some eggs are nearly ready to hatch. Eyes lack pigment (Fig. 3F).

48 h after fertilization: 48 h hatching occurs. Larvae are 2.0 to 3.7 mm at hatching. The mouth is not formed and eyes remain unpigmented (Fig. 4A).

2 to 5 days after hatching: Larvae are about 5 mm long. The yolk is noticably reduced in size. Melanophores occur along ventral body surface. Eyes are pigmented and jaws differentiated. Myotomes are easily counted. Fan-shaped pectoral fins are forming (Fig. 4C, D).

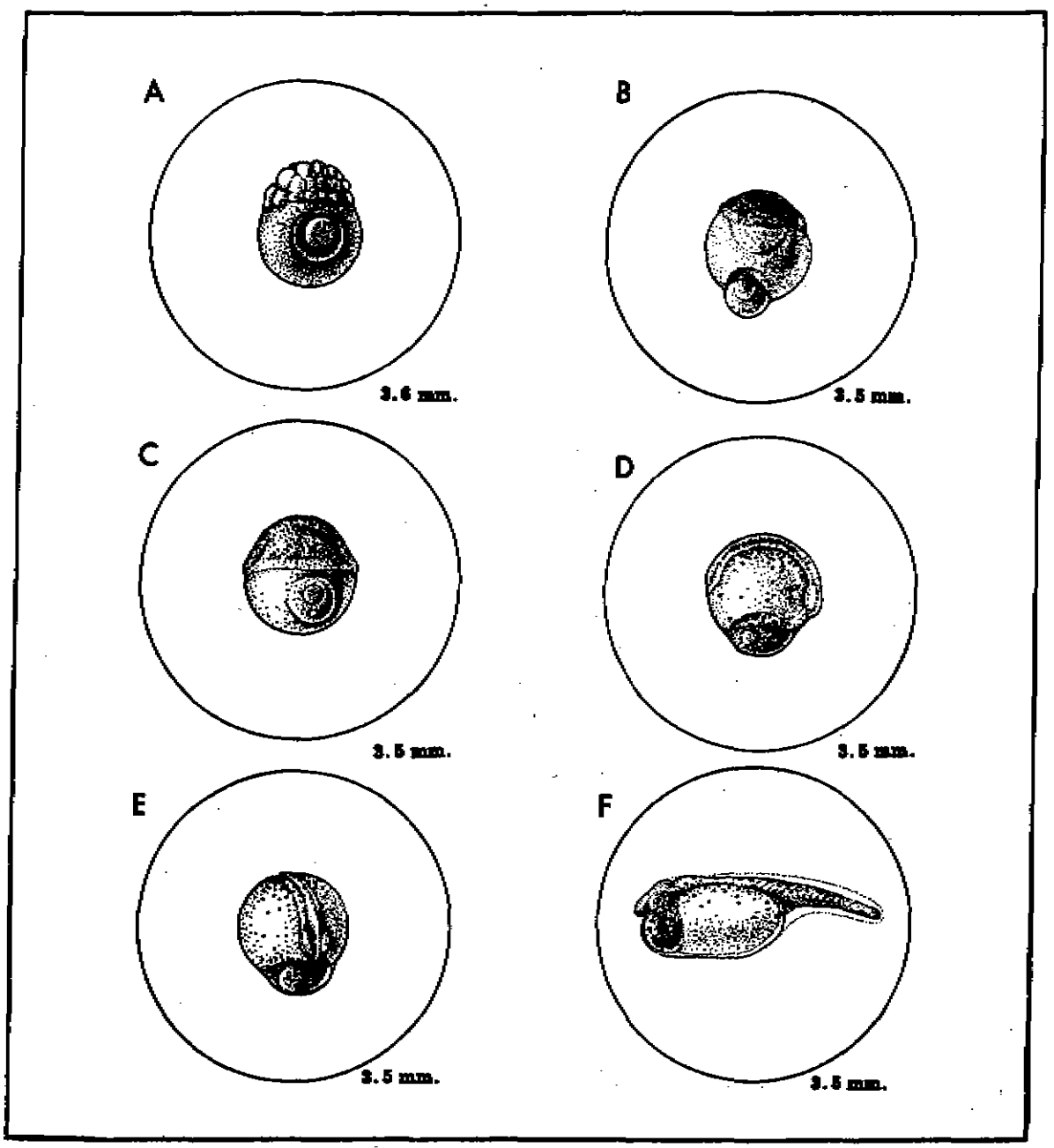

Figure 3. Striped bass eggs. A. fertilized egg, showing 32-cell stage; B. fertilized egg, many-celled stage or early blastoderm; C. fertilized egg, germ ring and embryonic shield stage; D. fertilized egg, early embryonic stage (lateral view); E. fertilized egg, early embryonic stage (dorsal view); F. fertilized egg, fully developed embryo, chorion-3.5 mm, embryo-2.5 mm (from: Mansueti, 1958).

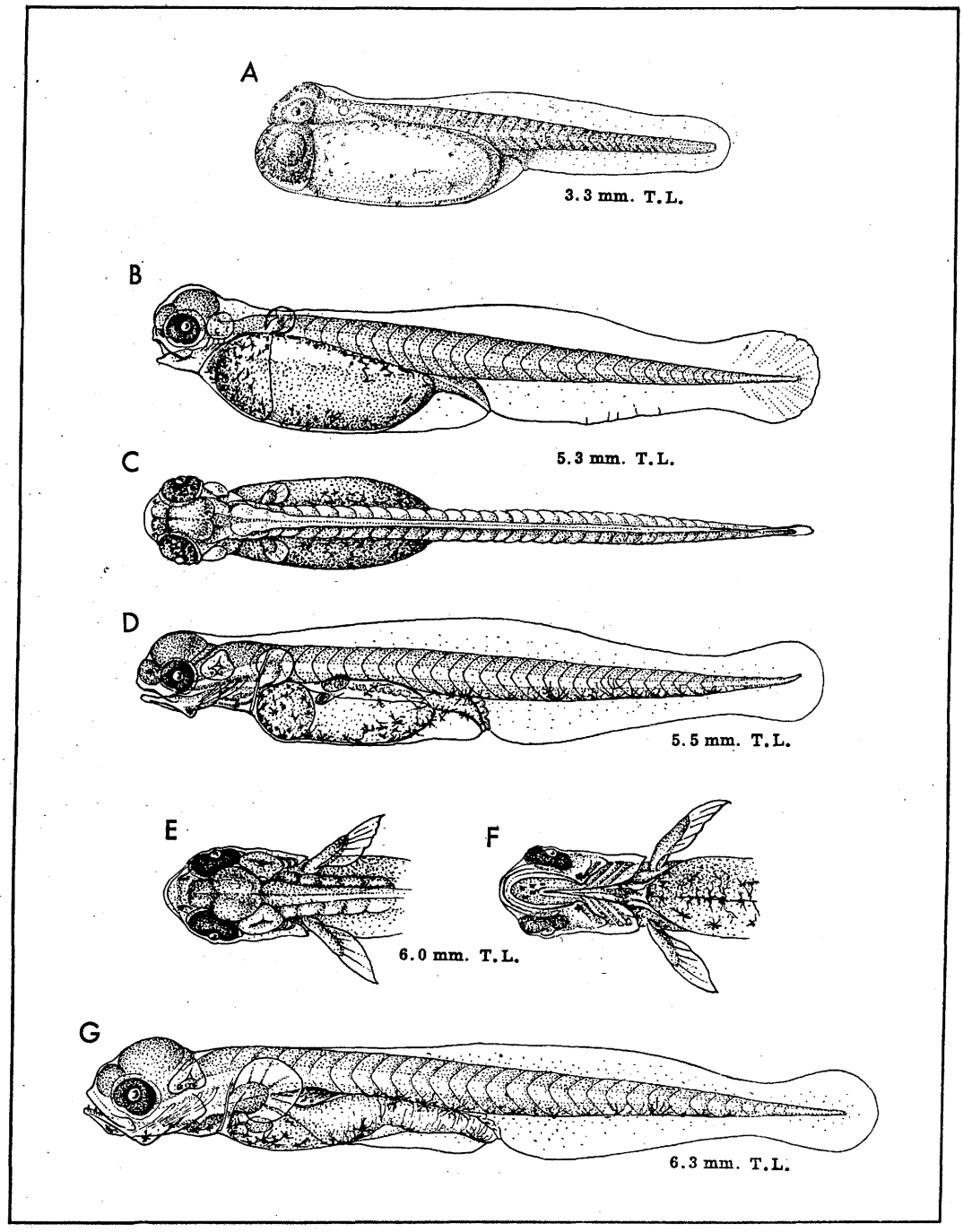

Figure 4. Striped bass prolarvae. A. prolarva, soon after hatching. B. prolarva, lateral view; C. prolarva, dorsal view; D. prolarva, 5.5 mm; E. prolarva, dorsal view; F. prolarva, ventral view; G. prolarva, almost indistinguishable from early postlarva (from: R. Mansueti, 1958).

10 to 15 days after hatching: Larvae are about 7.5 mm long. Yolk sac is fully absorbed and larvae appear slender. The pectoral fins are the only ones visible. Finfold is lost except in dorsal and caudal region. Pigment occurs ventrally along body; over the air bladder and visceral mass; laterally along tail, posterior to anus; and on the side of the head and lower jaw. Teeth are visible (Fig. 5A, B).

20 to 30 days after hatching: Larvae are about 10 mm long. Dorsal, anal and caudal fin rays are differentiated but first dorsal elements are lacking. Pelvic fin not yet visible. The notochord curves dorsally in area of the urostyle. Pigment is heavier but in the same regions as noted above. Some fish resemble juveniles in shape (Fig. 5C).

50 to 70 days after hatching: Larvae are about 20 mm long. The spinous first dorsal fin is evident and most fish have three anal spines. Other fins, except the pelvic, are fully developed. Pigment is heavier on entire body. The fins are also pigmented (Fig. 5E, F).

60 to 80 days after hatching: Larvae are about 25 mm long. Scale formation and other meristic characters are complete. Fish are well pigmented but longitudinal stripes are not evident. The body is covered with small melanophores that produce a diffuse spotting effect (Fig. 5G).

Newly hatched bass larvae remain in fresh or slightly brackish water until they are about 12 to 15 mm long. At that time, they move in small schools toward shallow protected shorelines, where they remain until fall. In the winter, they concentrate in deep water of rivers. These nursery grounds appear to include that part of the estuarine zone with salinities <3.2 o/oo (Smith, 1970). During their second summer, or when a year old, the young bass move down river from their parent stream to low salinity bays or sounds.

3.3 Adult Phase

Stripers are hardy, adaptable fish, able to make the transition from salt to fresh water and, apparently, tolerant of relatively high levels of domestic and industrial pollution. Mansueti (1961) suggested that bass populations and civilization are compatible and increased enrichment and turbidity might have contributed to the strong year classes in Chesapeake Bay.

Until 2 years old, stripers live mostly in small groups. Thereafter, and until they reach a size of about 10 pounds, they often congregate in large schools. Fish up to 20 pounds may also school, but the

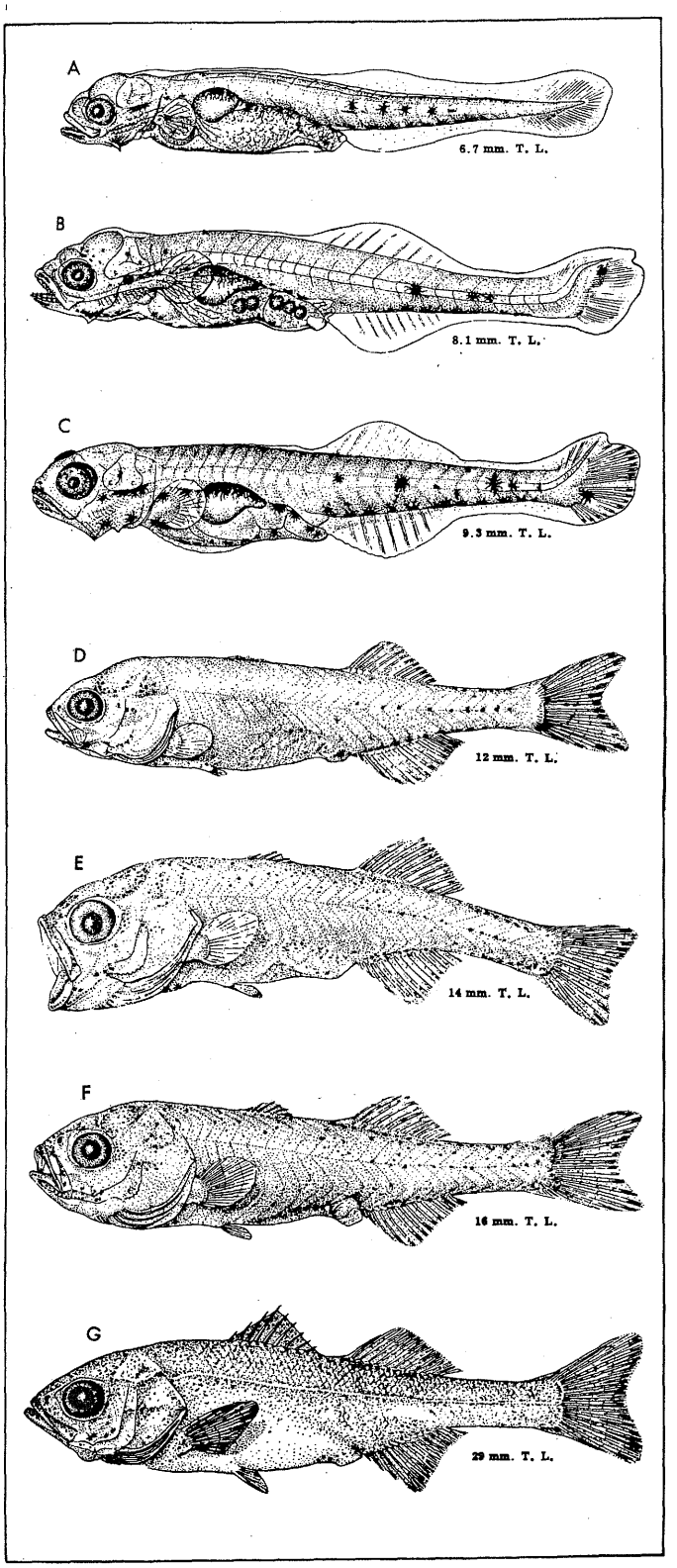

Figure 5. Striped bass postlarvae and young. A. postlarva, stage; B. postlarva, early metamorphosis. Brin. shrimp eggs can be observed in the intestine. C. postlarva metamorphosing; D. young, largely metamorphosed; E,F, and G. striped bass young (from: R. Mansueti, 1958).

large fish, those over 30 pounds, are usually found alone or in small groups except when mating, when they too may be schooled (Bigelow and Schroeder, 1953).

3.4 Nutrition and Growth

Because of their anadromous habits, striped bass are exposed to a broad spectrum of habitats, and have a highly variable diet. Heubach et al. (1963) determined that stomachs of bass up to 110 mm long in the Sacramento-San Joaquin River System contained opossum shrimp, copepods and cladocerans. Fish did not enter their diets in significant numbers until the young bass were 150 to 250 mm long (Stevens, 1966). According to Harper et al. (1969), young bass 10 to 110 mm long that were taken from culture ponds in Oklahoma contained copepods, cladocerans and insects. Although forage fish were available, they did not occur in the diet until the young fish were 60-69 mm long and did not become an important food item until the bass were 100 mm long. Markle and Grant (1970) reported that the diet of young bass ($\leq$70 mm) varied between river systems in Virginia. In the Rappahannock River they fed predominately on fishes, polychaetes and amphipods; in the York River on mysids and fishes; and in the James River, insects. They attributed the difference in diet to the size of the young bass and salinity. The smallest piscivorous bass in their collections were 46 mm long.

Lists of stomach contents from adult stripers include: alewife, herring, menhaden, mummichogs, mullet, rock eels, sculpin, shad, silver hake, silversides, smelt, tomcod, weakfish, white perch, lobsters, crabs, shrimp, isopods, gammarid crustaceans, worms, squid, clams and mussels. When feeding on any particular prey, they usually ignore other sorts of food. It appears that when food is plentiful, bass gorge themselves, then cease feeding to digest, afterwhich, they again gorge themselves (Bigelow and Schroeder, 1953). Clupeid fishes constitute the principal food item in land locked fresh water areas. In the Santee-Cooper River System in South Carolina, Stevens (1958) found that shad and herring supported the bass population throughout the year, except for a brief period in the spring when the mayfly nymph became the dominant food item.

Stripers grow to great size. They are the largest member of the family. Several fish in excess of 100 lbs., and estimated to have been at least 6 feet long, have been caught in North Carolina and Massachusetts. Both sexes grow at the same rate until 3 years old. Beginning at age 4, females grow faster than males. They also grow larger (Fig. 6). Most bass over 30 pounds are females (Bigelow and Schroeder, 1953).

Growth occurs during the 7-month period between April and October. Within this time frame, bass stop feeding for a brief period just before and during spawning, but feeding continues during the upriver spawning migration and begins again soon after spawning (Trent and Hassler, 1966). From November through March, growth is negligible.

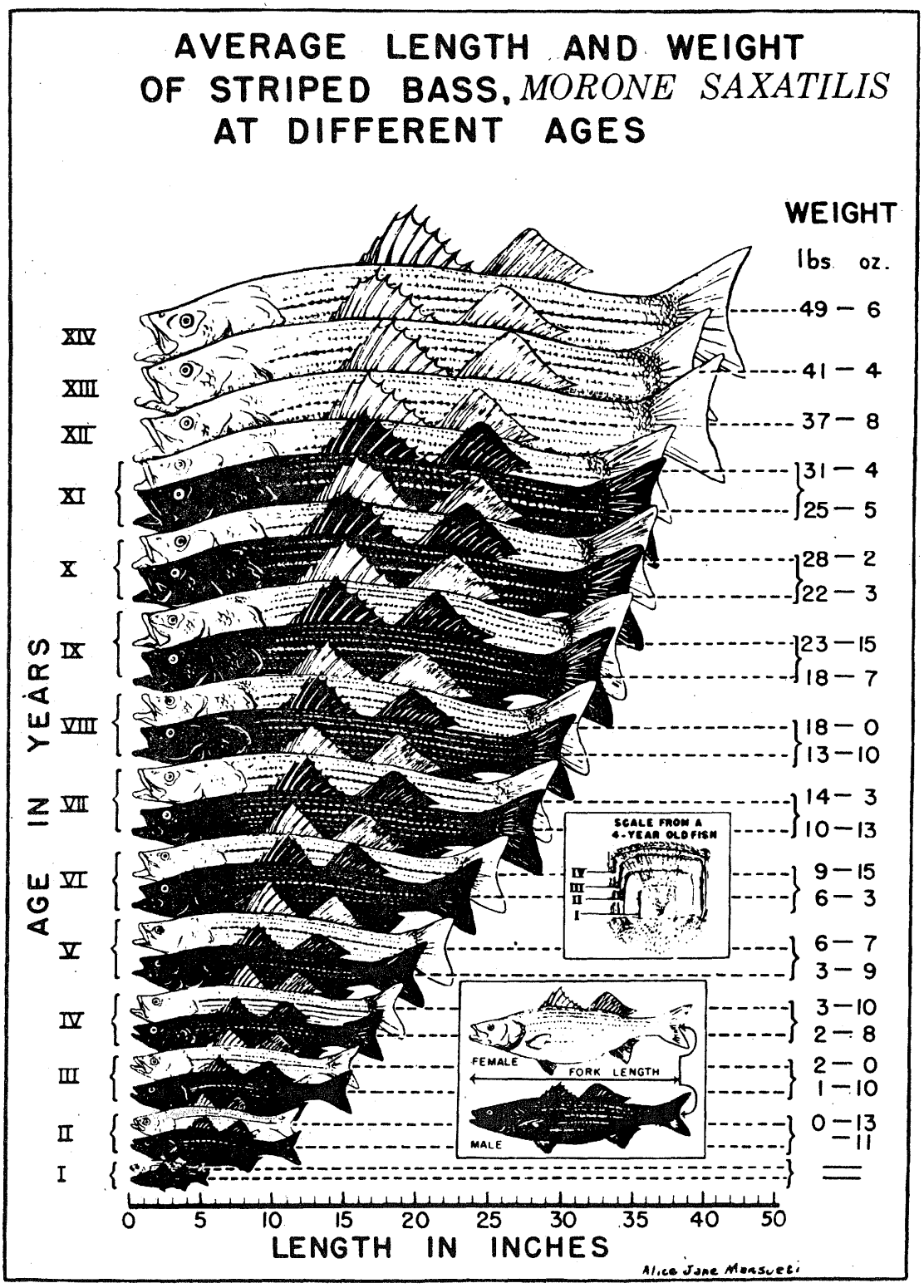

Figure 6. Average length and weight of striped bass at different ages (from: Mansueti, 1961).

Annulus formation on scales of bass collected in North Carolina occurs from late October or early January, with the peak occurring in early December. Annuli form on scales of bass caught in Virginia between April and June, or during the spawning season (Grant, 1974).

3.5 Behavior

Along the Atlantic coast most bass migrate into fresh water rivers to spawn in the spring. Along the southeast Atlantic coast and the Gulf of Mexico, bass do not leave their home rivers but, after spawning, return to the lower parts of the river or estuary for the summer and winter months. Along the middle Atlantic coast from North Carolina to southern New England, part of the population leaves the estuaries after spawning and migrates along the coast. Despite extensive research, these coastal migrations are understood only in broad outline. Although what portion of the total population undertakes seasonal migrations remains unknown, it is generally agreed that young stripers do not stray far from their home bay or river system until they are 2 or 3 years old. Thereafter, those fish that migrate move out of their respective estuaries and follow the coastline northward as far as New England in the spring and summer and southward again in the fall (Merriman, 1941). Some return to their home river or estuary, while others may choose a different estuarine environment for the winter (Fig. 7). A group of large bass, mostly in excess of 15 pounds, overwinters nearshore off the coast from southern New Jersey to North Carolina (Freeman and Cox, in press).

As noted in Section 2.2, bass native to the St. Lawrence River area do not make extended coastal migrations, nor do those found in west coast tributaries.

See also Section 2.3, Determinants of Distribution.

4. POPULATION

4.1 Structure

The population structure for the total bass population has not been defined. It is generally assumed that river systems along the southeast Atlantic coast, the Gulf of Mexico, the St. Lawrence River System of Canada, and west coast rivers from California to Washington, each contain their own population of striped bass. Along the middle Atlantic coast, where seasonal migrations occur, the population structure remains unresolved.

4.2 Abundance and Density

Stripers were in short supply along the middle Atlantic coast from about 1900 to 1933. Although records of landings from 1887 to 1929 are incomplete, they show the broad downward trend which the fishery

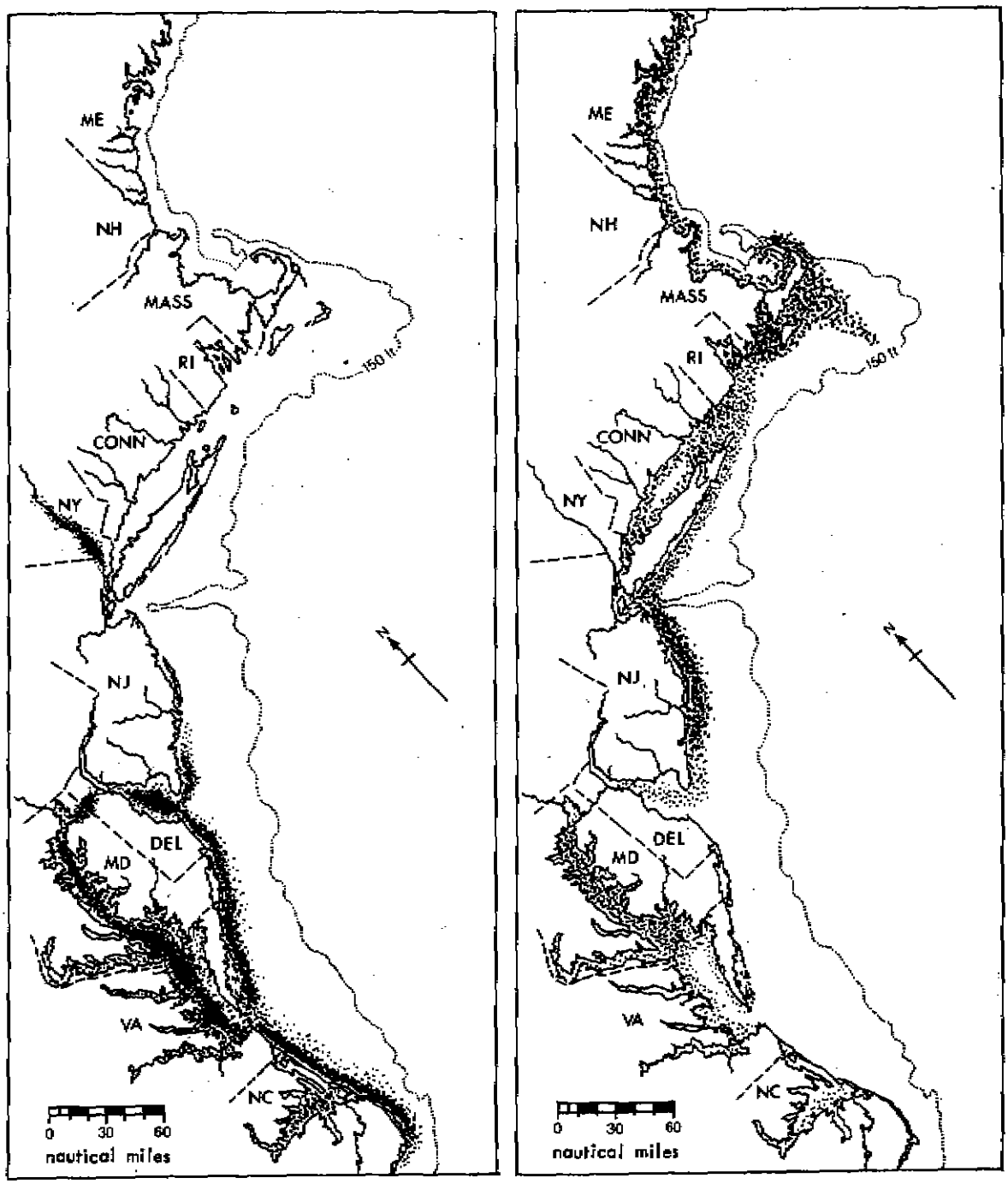

Figure 7. Distribution of striped bass along the Middle Atlantic and New England coast during winter (left) and summer (right). From: Freeman and Cox (in press).

suffered at about the turn of the century. In the late 1800's, landings along the Atlantic coast approached 4 million pounds. By 1929, they had declined to just over 1 million pounds (Table 4).

The decline was more severe in some areas than in others. For example, changes in fishing regulations in Connecticut probably accounted for some of the decline in New England landings during the early 1900's. A precipitous decline in New Jersey landings, and the total loss of Pennsylvania landings due to the construction of dams on the Susquehanna River, resulted in the Middle Atlantic Region suffering the most drastic reduction in catch. Whereas landings had dipped and rebounded in the Chesapeake Region by 1929, they did not show a serious downward trend in North Carolina until 1929.

In 1934, a large year class reversed the ominous trend in landings and, although catches indicate fluctuations in abundance, the supply has been adequate to support large commercial and recreational fisheries since the late 1930's. In the absence of large scale surveys that encompass the entire range of striped bass, the relative strength of year classes for the total population cannot be evaluated. However, the 1958, 1961 and 1970 year classes appeared to be exceptionally large. Catch statistics from Maryland show a distinct pattern of high and low landings occurring at about 6-year intervals. Highs occurred in 1936, 1942, 1948, 1954, 1960, 1966 and, except for 1954, each of the above was followed by one or more relatively productive seasons. Most of these fish, of course, were spawned 2 to 3 years before the given year of high landings; thus large year classes occurred in Maryland in 1934, 1940, 1946, 1952, 1958, 1961 and 1964 (Koo, 1970).

In recent years, bass populations on the west coast appear to be as plentiful as the habitat can support (Nicholson and Lewis, 1973).

4.3 Mortality and Morbidity

Short term mortality estimates are avilable for some segments of the population. For example, overall exploitation rates for striped bass in Albemarle Sound, North Carolina, were estimated at 26.0 and 24.5% for the years 1965-1966 (Hassler et al., 1966, 1967). For those bass that winter off North Carolina, the estimated total mortality (fishing and natural mortality)/month for the years 1968 through 1971 was 24.3%. Chadwick (1968) reported that mortality rates varied for bass in Sacramento-San Joaquin River System in California (Table 5).

Striped bass are infected by a number of diseases and parasites common to both fresh and saltwater fishes. For example, lymphocystis, a nonlethal viral infection, has been reported on stripers caught in

TABLE 4. Striped bass landings, earlier records (in thousands of pounds) (from Koo, T. S. 1970)

Year	New England Region						Middle Atlantic Region					Chesapeake Region			South Atlantic Region				COMBINED TOTAL
Year	ME	NH	MA	RI	CT	TOTAL	NY	NJ	PA	DE	TOTAL	MD	VA	TOTAL	NC	SC	GA	TOTAL	
1887	-	-	20	11	46	77	115	615	15	116	861	1,140	505	1,645	500	182	11	693	3,276
1888	-	-	32	13	50	95	98	739	59	116	1,012	1,123	779	1,902	560	251	11	822	3,831
1889	-	-	25	80	39	144	212	306	24	110	652	-	-	-	526	11	13	550	-
1890	-	-	-	-	-	-	208	328	23	107	666	1,366	529	1,895	568	12	9	589	-
1891	-	-	-	-	-	-	205	298	25	95	625	1,265	483	1,748	-	-	-	-	-
1897	-	-	-	-	-	-	116	287	10	129	542	935	576	1,511	845	10	9	864	-
1898	25	1	13	102	14	155	82	274	-	-	-	-	-	-	-	-	-	-	-
1901	-	-	-	-	-	-	72	354	13	48	487	824	528	1,352	-	-	-	-	-
1902	16	2	28	50	40	136	-	-	-	-	-	-	-	-	1,175	10	3	1,188	-
1904	-	-	-	-	-	-	53	66	6	40	165	721	451	1,172	-	-	-	-	-
1905	4	-	21	32	19	76	-	-	-	-	-	-	-	-	-	-	-	-	-
1908	2	1	5	34	2	44	45	53	7	53	158	640	504	1,144	510	5	9	524	1,870
1920	-	-	-	-	-	-	-	-	-	-	-	1,040	380	1,420	-	-	-	-	-
1921	-	-	-	-	-	-	95	70	-	5	170	-	-	-	-	-	-	-	-
1923	-	-	-	-	-	-	-	-	-	-	-	-	-	-	447	-	-	447	-
1925	-	-	-	-	5	-	-	-	-	-	-	1,414	821	2,235	-	-	-	-	-
1926	-	-	-	-	5	-	87	64	-	46	197	-	-	-	-	-	-	-	-
1927	-	-	-	-	4	-	-	-	-	-	-	-	-	-	507	-	1	508	-
1928	-	-	8	44	4	56	-	-	-	-	-	-	-	-	-	-	-	-	-
1929	-	-	19	23	2	44	156	41	-	10	207	1,292	290	1,582	246	-	-	246	2,079

TABLE 5. (A) Instantaneous and monthly mortality rates calculated from striped bass tagging data, offshore North Carolina 1968-1971 (from: Holland and Yelverton, 1973). (B) Mortality rates calculated from tagging data, Sacramento-San Joaquin River System (from: Chadwick, 1968.

(A)

Year Period	Months Released	Total (Z)	Fishing (F)	Other (X)	Total $(1-e^{-Z})$	Fishing $(1-e^{-X})$	Other $(1-e^{-X})$
1968-1969	December-March	0.347	0.070	0.276	29.5	6.8	24.4
1969-1970	December-February	0.294	0.028	0.276	25.2	3.0	24.4
1970-1971	November-March	0.186	0.009	0.178	17.3	1.0	16.5
Monthly Means		0.278	0.036	0.243	24.3	3.6	21.8

(B) *

Year	Survival Rate	Rate of Exploitation	Expectation of Death from Natural Causes	Instantaneous Total Mortality Rate	Instantaneous Fishing Mortality Rate	Instantaneous Natural Mortality Rate
1958	0.319	0.372	0.309	1.14	0.62	0.52
1959	0.534	0.247	0.219	0.63	0.33	0.30
1960	0.601	0.243	0.156	0.51	0.31	0.20
1961	0.662	0.190	0.148	0.41	0.23	0.18
1962	0.592	0.200	0.208	0.52	0.25	0.27
1963	0.511	0.281	0.208	0.67	0.39	0.28
1964	0.557	0.235	0.208	0.67	0.36	0.31

* Includes only striped bass tagged in spring of 1958 through 1961. Estimates below line are approximations based on the assumption that ratio of 1961 to 1962 returns is valid estimate of 1961 survival, and that the annual expected death rate from natural causes from 1962 through 1964 was equal to the 1958 through 1961 mean.

Maryland (Krantz, 1970). Mahoney et al. (1973) found striped bass in New Jersey estuaries infected with a fin rot disease. Several efforts to raise bass in freshwater impoundments have been frustrated by large scale mortalities that resulted from parasites. Gaines and Rogers (1972) reported heavy poststocking mortalities in some Florida lakes. The cause was traced to nematodes. Major losses have been caused by bacterial infections of skin and kidneys and infestation of gills by protozoans (Reeves, 1972). Parasites found in striped bass from lower Chesapeake Bay are listed in Table 6.

Although not a disease, and not necessarily fatal, pugheadedness is not unusual in striped bass. This deformity, which affects a variety of teleosts, may result from a germinal defect in the embryo. Its course may be directed by adverse conditions, especially an oxygen deficiency during early stages of development. Pugheadedness, which usually results in retarded growth rates, has been found among siblings hatched from normal parents, suggesting that both environmental and genetic factors are involved (Mansueti, 1960).

5. EXPLOITATION

5.1 Fishing Equipment

A. Recreational: Striped bass are a highly prized catch to both recreational and commercial fishermen. They are voracious feeders and strike almost any type of bait or lure, although when they are feeding on a particular prey, it is common knowledge among fishermen that they usually ignore other kinds of food (Bigelow and Schroeder, 1953).

In the middle Atlantic area where bass are most plentiful, they are caught by casting, trolling or bait fishing, one method being more popular than the others, depending on the season and region. Surf casting is popular during summer and fall in New England, mostly during the fall off New York and New Jersey and during late fall and early winter off North Carolina. Except for surf fishing off the outer banks of North Carolina, most bass caught in and south of Chesapeake Bay are taken by trolling (Nicholson and Lewis, 1973).

B. Commercial: The commercial fishery employs a variety of gears, their effectiveness varies and depends on geographic area. In North Carolina, stake and gill nets are most popular in inland waters, the haul seine is used exclusively along the outer banks. In Chesapeake Bay more than half of the catch is taken by gill nets and haul seines. In Maryland drift gill nets are most popular while in Virginia staked gill nets are used almost exclusively. Pound nets are the most productive gear in New Jersey where it is illegal to fish exclusively for striped bass. The haul seine is the most productive gear in New York. In New England the largest catches are made in Massachusetts waters with rod and reel (Nicholson and Lewis, 1973).

TABLE 6. Parasites and diseases of striped bass from the lower Chesapeake Bay (from: Paperna and Zwerner, 1976).

Parasite	Host age	% infected	Locality* range	Organ(s) affected	Heaviest infection found	Hosts other than striped bass found (*sobis*) to harbour this parasite (locality range)
Virus						
Lymphocystis	2+	1	M	Skin	Skin entirely covered	
Chlamydia						
Epitheliocystis—small type	2+	<1	O.M.	Gills	Over 20 per gill filament	*Morone americana* (Gmelin) (O.M.)
Epitheliocystis—large cysts	0+	3	O.M.E.	Gills	Over 50 per gill arch	
	2+	6				
Bacteria						
Pasteurella piscicida Janssen & Surgalla, 1968	1+	2	M	Viscera systemic	Mass mortality	*M. americana* (M)
	2+	2				
Protozoa						
Trichodina davisi, Wellborn 1967	0+	45	O.M.E.	Gills	10 per field†	*Cynoscion regalis* (Bloch and Schneider)
	1+	33				*Leiostomus xanthurus* Lacépède (M)
	2+	20				*M. americana* (O.M.)
	3+	33				*Mugil* sp. (M)
						Sphoeroides maculatus (Bloch and Schneider)
						Bairdiella chrysura (Lacépède) (M)
Trichodinella sp.	0+	<1	O.M.	Skin and gills	2 per field†	*L. xanthurus* (M)
	1+	<1				
Epistylis sp.	1+	12	O.M.	Gills	All gills densely covered	None found in York River
	2+	10				
Glossatella sp.	0+	40	O.M.E.	Gills	All gills densely covered	*Perca flavescens* (Mitchill) (O)
	1+	2				
	2+	2				
Scyphidia sp.	0+	7	O	gills	All gills densely covered	
	1+ (rare)	<1				
Colpoma sp. (*C. n.* sp.?)	0+	63	O.M.E.	Gills	10 per field‡	*Morone americana* (O.M.)
	1+	3				*Leiostomus xanthurus* (M)
						Ictalurus catus (L.) (O)
						Micropogon undulatus (L.) (M)
						Perca flavescens (O)
Trichophrya sp. (*T. ictaluri* Davis, 1942?)	0+	11	O.M.	Gills	2 per field	*P. flavescens* (O)
	1+ (rare)	<1				
Myxosoma morone n. sp. Johnson & Paperna (in prep.)	0+	55	O	Cartilage, bones	86 cysts per fish	*M. americana* (rare)
Kudoa cerebralis Paperna & Zwerner, 1974	1+	15	M.E.	Meninges of the brain and the spinal cord	80 cysts per fish	
	2+	9				
Neoxenia sp.	1+	<1	M	Gills	1 cyst per fish (rare)	*Morone americana* (M) (very prevalent)
Oodinium sp.	1+	<1	M	Gills	1 per fish	*Fundulus* sp. (M)
	2+	<1				
Metazoa						
Monogenea:						
Gyrodactylus sp.	0+	<1	O	Gills	1 seen	
Amycrocephalinae—unidentified	0+	<1	O	Gills	1 seen	
Microcotyle macrura McCallum & McCallum, 1913	1+	2	M.E.	Gills	6 per fish	
	2+	3				
Digenea						
Lepocreadium setiferoides (Miller & Northup, 1926) Martin, 1938	2+	10	M.E.	Intestine	10 per fish	*Bairdiella chrysura* (M.)
						Leiostomus xanthurus (M.)
Lepocreadium arcolatum (Linton, 1900) Stunkard, 1969§	2+	14	M.E.	Intestine	10 per fish	*M. americana* (M)
Stephanostomum tenue (Linton, 1898) Linton, 1934	2+	14	M.E.	Intestine	10 per fish	*M. americana* (M)
Immature opecoelids§	2+	9	E	Intestine	3 per fish	
Digenea sp. 1§	0+	<1	O	Intestine	1 per fish (rare)	
Digenea sp. 2§	1+	<1	M.E.	Intestine	1 per fish (rare)	
	2+	3				

Parasite	Host age	% infected	Locality* range	Organ(s) affected	Heaviest infection found	Hosts other than striped bass found (*sobis*) to harbour this parasite (locality range)
Metacercariae						
Neascus sp.	0+	3	O	Skin	105 per fish	Occurs in many freshwater fishes
Diplostomulum sp.	0+	<1	O	Spleen	Rare	Common in *M. americana* (O.M.) and *Lepomis gibbosus* (L.) (O) liver, spleen.
Ascocotylid type sp.	0+	<1	O	Viscera	Rare	Common in *M. americana* (O.M.) causes severe pathological changes in liver, spleen, truncus arteriosus, etc.
Clinostomum marginatum (Rud., 1819)	0+	2	O.M.	Connective tissue and muscle	Rare (10 per fish)	Occurs in many freshwater fishes
	1+	<1				
Cestodes						
Proteocephalid larvae—type A	0+	76	O	Mesenteries	40 per fish	*Morone americana* (O)
Proteocephalid larvae—type B	0+	46	O	Mesenteries and liver	9 per fish	
Scolex pleuronectis Rudolphi, 1819	0+	79	O.M.E.	Intestine	5 per fish	Occurs in many different marine fishes
	1+	<1				
	2+	1				
Trypanorhynchid pleurocercoid	1+	<1	M	Mesenteries	3 per fish	Occurs in many different marine fishes
	2+	<1				
Acanthocephala						
Pomphorhynchus rocci Cordonnier & Ward, 1967 (adult worms)	0+	14	O.M.	Intestine	130 per fish (1+)	
	1+	25			42 per fish (0+)	
	2+	29				
	3+	67				
P. rocci (larvae)	0+	34	O. (M-rare)	Viscera	45 per fish (0+)	*M. americana* (O)
						Ethreostoma olmstedi (Storer) (few) (O)
						Ictalurus catus (few) (O)
						Lepomis gibbosus (O)
Nematoda						
Philometra rubra (Leidy, 1856)	0+	39	O.M.E.	Visceral cavity and mesenteries	11 per fish (1+)	
	1+	64			14 per fish (0+)	
	2+	77				
	3+	100				
Cucullanus sp. (*C.* sp. of Meyer 1954?)	0+	8	O.M.	Intestine	5 per fish	
	1+	<1				
Spinitectus sp. (larva)	1+	<1	M.E.	Intestine wall	4 per fish	
Goezia sp. (larva)	1+	<1	M	Intestine wall	1 per fish	
Crustacea parasitica						
Ergasilus labracis Krøyer, 1863	0+	19	O.M.E.	Gills	2757 per fish (1+)	*M. americana*
	1+	80				Rarely found in Potomac River; abundant in other areas.
	2+	83				
	3+	100				
Ergasilus cf. *lizae* Krøyer, 1863	0+	<1	O.M.	Gills	2 per fish (rare)	*M. americana* (O) (common)
Argulus bicolor Bere, 1936	1+	5	M	Skin and gills	19 per fish	
	2+	5				
Caligus sp.	1+	<1	M	Gills	1 per fish	
Livonecs ovalis (Say, 1818)	1+	4	M	4th gill arch	4 per fish	
	2+	3			(usually only 1 per fish)	
Argulus cf. *oculatus* (Say, 1818)	2+	<1	M	Skin	1 per fish (rare)	
Hirudinea						
Myzobdella lugubris, Leidy, 1851	2+	<1	M	Skin	1 per fish (rare)	
Mollusca						
Glochidia	0+	1	O	Gills	12 per fish	*Morone americana* (O)
						Lepomis gibbosus (O)

* Locality range key (Venice system). E = subaline (40–30‰), Atlantic Ocean; M = mesohaline (18–5‰), Bay and lower rivers; O = oligohaline (5–0·5‰), upper reaches of rivers.

† counts made at 100×.

‡ counts made at 970×.

§ identification impossible or tentative due to either state of systematics or poor quality of material submitted for identification.

5.2 Fishing Areas (from Nicholson and Lewis, 1973).

Wherever it occurs, the striped bass is caught by recreational fishermen, but some areas are more heavily fished than others. The most popular areas include:

ATLANTIC COAST

Florida
- St. Johns River

Georgia
- Savannah River
- Ogeechee River
- Altamaha River

South Carolina
- Santee River
- Cooper River
- Lake Marion
- Lake Moultrie

North Carolina
- Albemarle Sound and tributaries
- Pamlico Sound and tributaries
- Roanoke River
- Outer Banks
- Kerr Lake

Virginia
- Chesapeake Bay and tributaries

Maryland
- Chesapeake Bay and tributaries

Delaware
- Delaware Bay
- Rehobeth Bay
- Indian River
- Chesapeake and Delaware Canal

New Jersey
- Coastline
- All major rivers and bays

GULF COAST

Alabama
- Mobile Bay
- Alabama Bay

Florida
- Rivers West of Apalachicola

PACIFIC COAST

California
- San Francisco Bay and tributaries

Oregon
- Umpqua River
- Coos Bay

ATLANTIC COAST	GULF COAST	PACIFIC COAST
Connecticut, Rhode Island, Massachusetts Coastline All major rivers and bays		
New Hampshire, Maine Most major rivers		
New Brunswick, Nova Scotia, Quebec Coastal rivers north to St. Lawrence River		

5.3 Fishing Seasons

Only three Atlantic states have seasonal restrictions on their striped bass fishery. The season is closed to sportfishing in New Jersey during January and February and New York's Hudson River is closed to both recreational and commercial fishing from December 1 to March 15. Bass may be taken by fish traps in Rhode Island from September 1 to October 14. Although Maryland authorities are authorized to restrict or close known spawning grounds to fishing during the spawning seasons, normally there is no closed season in Maryland. Despite the lack of restrictions, fishing off most middle Atlantic and New England states is seasonal and dictated by migrations of the fish.

5.4 Fishing Operations and Results

The healthy status of the striped bass populations along the Atlantic coast is reflected in commercial landings by state or geographic area (Table 7). Between 1967 and 1973, landings exceeded 10 million pounds/year, for which fishermen were paid $1.7 to $3.7 million (Table 8). Maryland and Virginia landings comprise about 2/3 of the total catch. Fluctuations in Chesapeake landings are paralleled by those from the middle Atlantic and New England Regions, but with a 2-year lag, probably because most of the bass landed from New Jersey to New England originate in Chesapeake Bay. See Koo (1970) for a detailed analysis of the catch from 1888 to 1966.

In addition to commercial landings, recreational fishermen along the Atlantic coast caught an estimated 37.5 million pounds in 1960 (Clark, 1962); 56.7 million pounds in 1965 (Deuel and Clark, 1968); and 73.2 million pounds in 1970 (Deuel, 1973). On the Pacific coast, where commercial fishing for bass is illegal, sport catches for the same three years were estimated at 19.7, 14.1 and 10.4 million pounds/year, respectively.

TABLE 7. Landings of striped bass for North Carolina, by gear.

Year	Haul Seines	Purse Seines	Pound Nets	Gill Nets	Miscellaneous	Total
	Thousands of Pounds					
1930	203.5	10.0	106.4	118.7	2.0	440.6
1935*	--	--	--	--	--	--
1940	49.3	--	248.6	231.0	11.0	539.9
1945	41.7	--	238.2	267.3	61.3	608.5
1949	--	--	--	--	--	--
1950	191.7	112.8	310.0	137.2	45.1	796.8
1951	143.2	155.0	233.6	127.3	42.9	702.0
1952	118.6	138.1	206.2	161.7	22.4	647.0
1953	189.1	112.5	274.7	150.9	29.8	759.0
1954	74.8	101.6	696.5	242.7	6.1	1,121.7
1955	54.3	36.0	334.8	307.6	3.3	736.0
1956	64.9	22.5	362.6	312.7	.8	763.5
1957	27.8	22.7	208.7	337.8	--	597.0
1958	193.1	82.8	211.5	601.8	6.8	1,096.0
1959	201.4	65.0	121.8	483.3	--	871.5
1960	196.7	89.8	195.3	300.5	--	782.3
1961	123.0	47.7	133.6	245.1	--	549.4
1962	182.4	70.0	163.1	331.8	--	747.3
1963	100.6	10.0	180.4	444.8	--	735.8
1964	131.6	--	154.4	428.5	--	714.5
1965	96.0	--	131.4	256.0	--	483.4
1966	66.0	--	47.7	524.5	13.8	652.0
1967	285.6	50.1	52.7	1,369.7	59.1	1,817.2
1968	460.7	24.6	92.6	1,302.9	31.1	1,911.9
1969	367.9	166.7	54.2	859.6	119.6	1,568.0
1970	558.6	246.2	198.6	618.0	666.1	2,287.5
1971*						1,448.7
1972*						1,261.1
1973*						1,751.9
1974*						1,016.2

* Incomplete Data

TABLE 7. Landings of striped bass for Maryland and Virginia, by gear.

Year	Haul Seines	Pound Nets	Gill Nets	Hand Lines	Otter Trawls	Fyke Net	Miscel-laneous	Total
	Thousands of Pounds							
1930	285.8	591.9	404.2	--	--	60.8	310.6	1,653.3
1935	200.8	708.6	188.4	--	--	34.1	--	1,131.9
1940	375.4	683.5	726.8	--	--	47.3	5.8	1,838.8
1945	1,001.5	1,200.5	1,230.6	19.8	63.7	160.4	--	3,676.5
1949	1,819.3	1,203.4	1,305.1	23.3	14.2	178.4	--	4,542.7
1950	2,786.5	1,300.9	1.473.0	6.4	6.3	260.8	--	5,833.9
1951	1,535.2	792.3	1,579.1	7.6	1.5	223.9	--	4,139.6
1952	1,072.1	765.8	1,364.1	25.4	.8	185.1	--	3,413.3
1953	952.9	896.3	1,118.7	11.4	1.5	125.4	--	3,106.2
1954	852.2	559.7	1,486.1	--	.6	152.1	8.5	3,059.2
1955	902.3	371.8	2,057.3	--	.6	134.1	--	3,466.1
1956	670.0	399.4	1,967.6	--	.4	106.1	1.3	3,144.8
1957	607.1	326.2	1,697.8	--	.9	147.2	9.2	2,788.4
1958	542.2	820.6	2,846.0	20.7	.1	182.8	10.0	4,422.4
1959	1,181.8	823.9	4,197.2	5.6	6.8	230.8	--	6,446.1
1960	2,112.0	1,368.2	3,017.5	6.7	.2	170.7	11.0	6,686.3
1961	1,370.7	813.8	4,939.2	.8	21.9	103.1	11.6	7,261.1
1962	1,034.4	581.7	4,061.8	--	.6	225.5	18.9	5,922.9
1963	1,462.4	1,229.2	3,663.3	.1	7.4	133.1	--	6,495.3
1964	913.4	690.3	3,202.2	196.9	1.1	186.9	--	5,190.8
1965	567.9	842.5	3,334.9	259.0	10.6	134.1	12.6	5,161.6
1966	952.4	1,233.6	3,517.6	182.5	80.9	180.9	.4	6,148.3
1967	586.2	870.0	3,680.3	113.5	472.1	104.2	--	5,826.3
1968	827.4	902.6	3,719.4	--	423.1	117.5	--	5,990.0
1969	417.8	1,066.7	4,707.9	324.3	1101.7	139.3	1.3	7,759.0
1970	256.2	558.3	3,904.5	33.8	864.0	57.4	--	5,674.2
1971*								3,964.3
1972*								5,779.8
1973*								7,080.4
1974*								2,564.1

* Incomplete Data

TABLE 7. Landings of striped bass for New Jersey and Delaware, by gear.

Year	Haul Seines	Pound Nets	Gill Nets	Hand Lines	Otter Trawls	Purse Seines	Miscel-laneous	Total
	Thousands of Pounds							
1930	33.1	6.5	78.6	16.8	--	--	5.6	140.6
1935	10.7	2.0	5.5	--	--	--	6.2	24.4
1940	41.4	1.0	102.8	.1	.3	--	62.1	207.7
1945	81.1	1.1	98.0	55.4	181.8	--	63.5	480.9
1949	201.5	.2	17.5	.2	37.8	--	19.0	276.2
1950	155.1	--	145.3	46.2	.5	19.5	13.2	379.8
1951	106.0	--	178.5	4.0	52.9	--	13.7	355.1
1952	21.6	.6	587.4	8.7	35.7	--	1.4	655.4
1953	36.4	--	479.3	3.7	3.0	9.2	9.0	540.6
1954	1.4	--	160.9	2.8	31.8	--	.1	197.0
1955	7.3	.2	77.5	2.0	32.8	1.1	2.4	123.3
1956	7.8	1.7	54.3	1.4	7.5	4.8	1.3	78.8
1957	124.1	.3	19.4	.1	1.3	--	2.7	157.9
1958	5.5	.4	30.6	--	.6	.4	3.2	80.7
1959	53.9	.1	143.4	--	.4	--	10.2	208.0
1960	25.6	1.4	89.7	--	13.5	.2	8.6	139.0
1961	19.1	1.3	79.2	--	189.6	4.9	57.5	341.6
1962	57.4	5.1	256.9	--	258.6	18.4	5.9	602.3
1963	14.1	3.1	92.9	2.1	645.2	11.7	31.9	801.0
1964	17.4	21.9	93.8	8.8	865.2	14.3	5.2	1,026.6
1965	7.3	3.7	196.0	5.3	573.5	5.3	1.8	792.9
1966	10.0	40.7	96.2	2.1	222.5	3.7	2.6	377.8
1967	7.5	52.7	171.9	5.7	144.4	--	.4	382.6
1968	7.5	25.3	101.4	2.4	192.4	--	.1	342.4
1969	20.8	8.6	121.5	.6	201.3	7.7	1.4	352.2
1970	11.1	6.3	59.0	6.8	156.4		0.8	234.0
1971*	4.7							283.2
1972*								361.8
1973*								766.1
1974*								713.6

* Incomplete Data

TABLE 7. Landing of striped bass in New York, by gear.

Year	Haul Seines	Pound Nets	Gill Nets	Hand Lines	Otter Trawls	Miscel-laneous	Total
	---------- Thousands of Pound ----------						
1930	41.3	13.9	3.3	7.4	.2	.2	66.3
1935	8.3	12.9	15.6	--	--	--	168.6
1940	110.3	9.6	42.9	5.8	--	.3	301.1
1945	116.7	7.8	22.5	95.1	58.5	--	626.0
1949	592.1	4.3	2.3	17.5	9.8	.5	517.1
1950	483.9	4.4	10.5	6.2	12.1	--	626.2
1951	566.4	9.2	13.9	35.0	1.7		485.7
1952	431.2	3.3	30.4	17.5	3.3	--	481.7
1953	409.6	5.9	54.7	11.0	.5	--	438.9
1954	382.0	1.1	49.2	--	6.5	--	506.1
1955	408.4	1.3	74.8	17.3	4.3	.1	395.2
1956	289.9	1.5	91.9	11.7	.2	--	553.0
1957	446.5	.8	85.1	18.3	3.3	--	397.9
1958	318.0	1.0	77.1	--	1.7	--	538.0
1959	379.7	1.5	133.1	15.1	8.6	.1	730.8
1960	531.9	4.2	132.8	15.0	46.9	--	909.8
1961	651.1	9.8	84.3	30.7	133.9	--	656.6
1962	492.7	3.2	88.1	29.5	83.1	--	672.8
1963	374.1	5.0	50.7	66.0	177.0	--	995.0
1964	687.1	17.3	55.3	42.0	193.3	--	739.6
1965	576.8	3.7	81.4	28.5	49.2	--	1,050.3
1966	747.5	109.5	80.3	27.9	85.1	--	1.630.1
1967	1,042.2	86.9	268.9	85.7	146.4	--	1,550.5
1968	901.2	76.5	376.9	144.8	51.1	--	1.535.1
1969	873.0	104.6	267.4	66.8	223.3	--	1.338.3
1970	906.3	38.3	176.2	143.1	74.4	--	1.158.3
1971	688.2	101.3	87.6	176.7	105.2	--	818.1
1972	407.3	148.2	77.4	53.0	132.3	--	1,673.9
1973*							1,378.7
1974*							

* Incomplete Data

TABLE 7. Landings of striped bass for New England states, by gear.

Year	Haul Seines	Pound Nets	Floating Traps	Otter Trawls	Hand Lines	Miscel-laneous	Total
	Thousands of Pounds						
1930	48.0	8.5	24.8	--	5.0	2.6	88.9
1935	1.5	1.3	15.9	--	3.0	--	21.7
1940	23.4	32.4	39.4	--	52.2	--	147.4
1945	90.5	13.3	25.9	1.6	184.1	1.4	316.8
1949	15.3	15.4	41.9	6.2	78.9	4.7	162.4
1950	15.9	19.6	68.3	4.9	51.6	6.5	166.8
1951	41.0	--	60.4	23.4	132.7	7.5	265.0
1952	3.3	9.4	33.0	4.3	120.3	8.8	179.1
1953	1.2	12.1	65.8	1.4	109.6	3.0	193.1
1954	8.0	3.9	101.3	.4	65.5	6.0	185.1
1955	--	--	24.2	.1	81.4	--	105.7
1956	1.9	2.4	16.7	2.4	75.3	.2	98.9
1957	2.2	1.7	6.0	1.4	68.2	--	79.5
1958	.1	--	27.2	.2	62.9	.1	90.5
1959	--	4.8	22.3	1.3	91.4	.4	120.2
1960	--	4.9	68.2	.6	137.2	.2	211.1
1961	10.6	40.6	127.5	6.2	207.8	4.1	396.8
1962	.6	56.9	25.0	3.1	595.7	1.6	682.9
1963	11.4	33.4	32.1	5.8	496.3	2.9	581.9
1964	.4	21.2	20.6	8.2	565.7	15.8	631.9
1965	--	22.4	21.1	4.4	479.2	.9	528.0
1966	--	24.9	197.8	12.6	603.8	1.8	840.9
1967	--	33.6	70.0	22.1	664.1	4.2	794.0
1968	4.0	18.7	30.8	20.6	864.4	4.6	943.1
1969	4.7	29.1	54.6	8.5	1,076.1	9.7	1,182.7
1970	--	91.7	36.7	11.4	1,299.3	3.2	1,442.3
1971*							291.3
1972*							456.5
1973*							752.6
1974*							469.0

* Incomplete Data

TABLE 8. Landings of striped bass for the Atlantic coast, by gear

Year	Haul Seines	Purse Seines	Pound Nets	Floating Trap	Stake Gill	Drift Gill	Hand Lines	Otter Trawl	Miscel-laneous	Total	Value Thousands $
	Thousands of Pounds										
1930	611.7	320.6	727.2	24.8	374.4	230.4	29.2	.2	71.2	2,389.7	389
1935*	--	--	--	15.9	--	--	--	--	--	--	165
1940	599.8	66.7	975.1	39.4	947.0	156.5	58.1	.3	59.5	2,902.4	307
1945	1,311.5	27.0	1,460.9	25.9	1,364.7	253.8	354.4	305.6	260.0	5,383.8	1,084
1949*	--	--	--	41.9	--	--	--	--	--	--	1,034
1950	3,633.1	132.3	1,634.9	68.3	1,209.1	556.9	110.4	23.9	325.5	7,694.4	1,367
1951	2,391.8	155.0	1,035.1	60.4	1,268.5	630.3	179.3	79.5	288.0	6,087.9	1,298
1952	1,646.8	138.1	985.3	33.0	1,651.8	491.8	182.1	44.1	207.5	5,380.5	1,172
1953	1,589.2	121.7	1,189.0	65.8	1,471.7	331.9	135.7	6.4	169.2	5,080.6	1,118
1954	1,318.4	101.6	1,261.2	101.3	1,429.7	509.2	68.3	39.3	172.9	5,001.9	1,058
1955	1,372.3	37.1	708.1	24.2	1,750.3	766.9	100.7	37.8	139.8	4,937.2	1,112
1956	1,034.5	27.3	767.6	16.7	1,916.3	510.2	88.4	10.3	109.9	4,481.2	973
1957	1,206.7	22.7	537.7	6.0	1,654.7	485.5	86.6	6.9	159.0	4,165.8	901
1958	1,098.9	83.2	1,033.5	27.2	2,882.4	673.2	83.6	2.6	202.9	6,087.5	1,286
1959	1,816.8	65.0	952.1	22.3	4,038.1	919.1	105.3	17.1	248.0	8,183.8	1,436
1960	2,866.2	90.0	1,574.0	68.2	2,722.4	818.1	158.9	61.2	190.5	8,549.5	1,338
1961	2,174.5	52.6	999.1	127.5	3,712.2	1,635.6	239.3	351.6	166.3	9,458.7	1,270
1962	1,767.5	88.4	810.0	25.0	3,441.5	1,258.1	625.2	345.4	250.9	8,612.0	1,345
1963	1,962.6	21.7	1,451.1	32.1	3,324.3	928.5	564.5	835.4	166.8	9,287.0	1,314
1964	1,749.9	14.3	905.1	20.6	2,974.7	811.0	813.4	1,067.8	202.0	8,558.8	1,380
1965	1,248.0	5.3	1,003.7	21.1	2,965.3	903.0	772.0	637.7	149.4	7,705.5	1,461
1966	1,775.9	3.7	1,456.4	197.8	3,254.2	964.4	816.3	401.1	199.5	9.069.3	1,654
1967	1,921.5	51.6	1,095.9	70.0	4,514.3	976.5	869.0	841.7	109.7	10,450.2	1,729
1968	2,214.1	24.6	1,115.7	30.8	4,265.4	1,239.8	1,011.6	717.4	118.5	10,737.9	2,283
1969	1,674.5	174.4	1,263.2	54.6	5,495.8	460.6	1,467.8	1,534.8	271.3	12,397.0	2,493
1970*	1,725.8	246.2	893.2	212.9	4,581.5	--	1,483.0	1,106.2	727.5	10,976.3	2,520
1971*										7,146.4	1,961
1972*										8,677.4	2,371
1973*										12,061.1	3,743

* Incomplete

6. PROTECTION AND MANAGEMENT

6.1 Regulatory Measures

See Tables 9 and 10. State regulations are subject to change annually. Fishermen are advised to familiarize themselves with the latest regulations before fishing for striped bass.

6.2 Control or Alteration of Physical Features of the Environment

Estuaries along the Atlantic coast are, for the most part, an important but maligned resource. In many coastal areas more than 50% of the original marshland and other shallow areas important to striped bass have been altered or destroyed through dredging, filling or polluting. For example, in the 10-year period between 1955-64, 45,000 acres of tidal marshland were destroyed between Maine and Delaware. Of the total acreage lost, 34% was destroyed by dredging; 27% for housing development; 15% to parks, beaches and marinas; 10% to bridges, roads, etc.; 7% to industrial development; 6% to dumping sites; and 1% to other causes (Clark, 1967). See Clark (1967) for more information on what states along the Atlantic coast are doing to protect their remaining marshes. In recent years the effects of heated effluence from nuclear power plants constructed along coastal estuaries has caused concern among those interested in the well being of striped bass. Fish kills attributed to thermal shock have become an all too frequent occurrence. Although biologists are concerned about these fish kills, they are more alarmed about the permanent ecological changes that could result from excessive thermal loading (Jensen, 1970).

6.3 Control or Alteration of Chemical Features of the Environment

Many Atlantic coast estuaries are heavily maligned by inadequately treated industrial and domestic effluence. Because striped bass spend their entire life cycle in estuaries and nearshore ocean waters, the fish and the fishery are affected by chemical loading of the coastal marine and brackish water environment. Two recent cases of chemical pollution clearly demonstrate this point. Commercial fishing was closed in the James River, Virginia, in December 1965 and in the Hudson River, New York in spring of 1976. These are two of the major rivers utilized by striped bass. The James was contaminated with kepone and the Hudson with polychlorinated biphenyls (PCB's), both chlorinated hydrocarbons (Frye, 1976). Tissue from striped bass netted in the lower Hudson River contained PCB's at levels ranging from 3.70 to 49.63 ppm, with an average level of 15.61 ppm (Natural Resources Defense Council, 1975). To put these contamination levels in perspective, the Japanese Government, which severely restricts the use of PCB's in Japan, has established contamination limits for fish and shellfish of 3 ppm for nearshore varieties and 0.5 ppm for ocean varieties (Schweitzer, 1975).

6.4 Artificial Stocking

See 2.1 Distribution - Total Areas.

TABLE 9. Summary of regulations on commercial harvesting of striped bass in states where netting is legal (from Nicholson and Lewis, 1973)

State	Type of Gear	Season	Illegal Areas	Minimum Size	Maximum Size
Rhode Island	Fish trap only	September 1 - October 16		16 in. FL	None
New York	No restriction	No restriction	Hudson and Delaware Rivers	16 in. FL	None
Delaware	Haul seines and gill nets only	November 1 - April 30	All areas except Delaware Bay and River	12 in. FL	20 lb.
Maryland	All gear except purse seines and otter trawls	No restriction	None	12 in. FL	15 lb.
Virginia	No restriction	No restriction	None	14 in. TL	None
North Carolina	No restriction	No restriction	New Hanover County	12 in. FL 1/	None
Oregon	Gill net only; no monofilament		Not known	16 in. FL	None

1/ No more than 5% of catch may be less than 12 inches.

Table 9 (continued)

State	Minimum Size	Daily Creel Limit	Sale of Fish	Remarks
South Carolina	None	10	Not permitted	Creel limit 5, or 2 per day in some lakes
Georgia	15 in. FL	5	Not permitted	
Florida	15 in. FL	6	Not permitted	
Alabama	None	5	Not permitted	No creel limit in salt water
Mississippi	15 in. FL	3	Not permitted	No creel limit in salt water
Louisiana	None	2	Not permitted	
Texas	None	2	Not permitted	Not present in coastal waters; land locked only.
California	16 in. TL	3	Not permitted	Spear, harpoon, bow and arrow illegal in San Francisco Bay. One line with maximum of 3 hooks.
Oregon	16 in. TL	5	Not permitted	
Washington	None	None	No restriction	No regulations

TABLE 10. Summary of state regulations on fish size, creel limits and disposition of striped bass caught by hook and line and spear gun (from Nicholson and Lewis, 1973)

State	Minimum Size	Daily Creel Limit	Sale of Fish	Remarks
Maine	None	None	No restriction	
New Hampshire	16 in. FL	None	No restriction	
Massachusetts	16 in. FL	None	No restriction	Rod and reel license required to sell daily catch over 100 lbs.
Rhode Island	16 in. FL	None	No restriction	
Connecticut	16 in. FL	None	Not permitted	
New York	16 in. FL	None	No restriction	
New Jersey	18 in. TL	10	No restriction	
Delaware	None	None	No restriction	
Maryland	12 in. TL	None	No restriction	Maximum size limit is 15 lbs., except between March 1 and June 15, 1 fish 15 lbs. may be taken per day.
Virginia	14 in. TL	None	No restriction	No more than 2 fish per day over 40 inches.
North Carolina	12 in. FL	None	No restriction	Creel limit 25 per day in Neuse River

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