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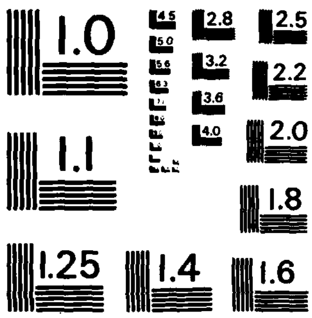


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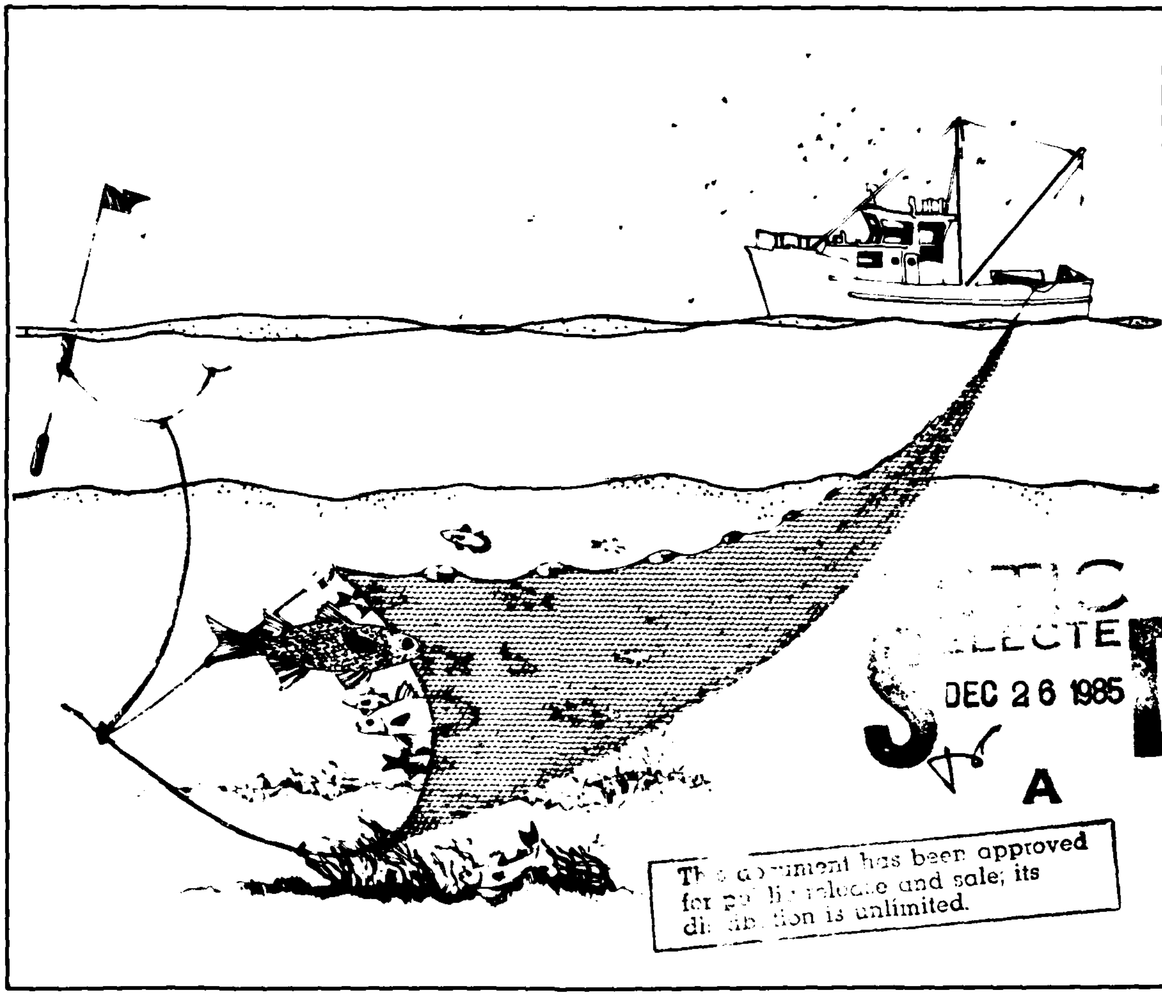
Biological Report 82 (11.34)
April 1985

TR EL-82-4

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

# STRIPED MULLET







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

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

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

## STRIPED MULLET

by

Mark R. Collins
Department of Zoology
University of Florida
Gainesville, FL 32611

Project Manager
Larry Shanks
Project Officer
John Parsons
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458

Performed for
Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers
Vicksburg, MS 39180

and

National Coastal Ecosystems Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

# PREFACE

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

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

*Information Transfer Specialist*
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
NASA-Slidell Computer Complex
1010 Gause Boulevard
Slidell, LA 70458

or

U.S. Army Engineer Waterways Experiment Station
Attention: WESER-C
Post Office Box 631
Vicksburg, MS 39180

# CONVERSION TABLE

## Metric to U.S. Customary

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

## U.S. Customary to Metric

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

CONTENTS

ACKNOWLEDGMENTS

I am grateful for the review of the manuscript by J. Shireman of the University of Florida.

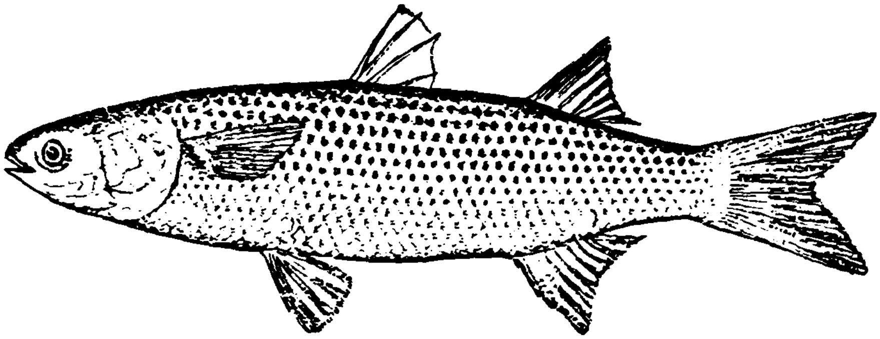

Figure 1. Striped mullet.

# STRIPED MULLET

## NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . *Mugil cephalus* Linnaeus 1758
Preferred common name . . . striped mullet (Figure 1)
Other common names . . . grey mullet, black mullet
Class . . . . . . . . . . . Osteichthyes
Order . . . . . . . . . . . Perciformes
Family . . . . . . . . . . . Mugilidae

Geographic Range: Coastal waters of all seas, roughly between 42° N and 42° S. In the western Atlantic from Brazil to Nova Scotia (Hoese and Moore 1977). Abundant along the south Florida coast (Figure 2).

## MORPHOLOGY/IDENTIFICATION AIDS

Dorsal fin IV + I spines, 8 soft rays; anal fin III spines, 8 rays (II, 9 in juveniles); pectoral fin 16-17 rays; caudal fin 18-20 rays; lateral scale count 38-42. Anal and second dorsal fins almost scaleless; origin of second dorsal behind origin of anal fin; pectoral fin shorter than distance from last spine of first dorsal to origin of second dorsal fin; head somewhat wider than deep; mouth terminal and small, teeth inconspicuous; no lateral line visible, but longitudinal dark stripes on the sides of elongate body; body bluish-gray dorsally and white ventrally; scales cycloid in young, feebly ctenoid in adults; distinct axillary scale at pectoral fin; gill raker number increasing with size; prominent adipose eyelid with only a narrow slit over the pupil, covering the preorbital anteriorly and running twice as far behind the eye as in front (Hoese and Moore 1977). The six *Mugil* species reported from south Florida sometimes are difficult to separate taxonomically; however Rivas (1980) constructed a key that is useful for tentative identification. The two species most often encountered, striped mullet and white mullet, may be separated by anal fin ray counts of 8 and 9, respectively.

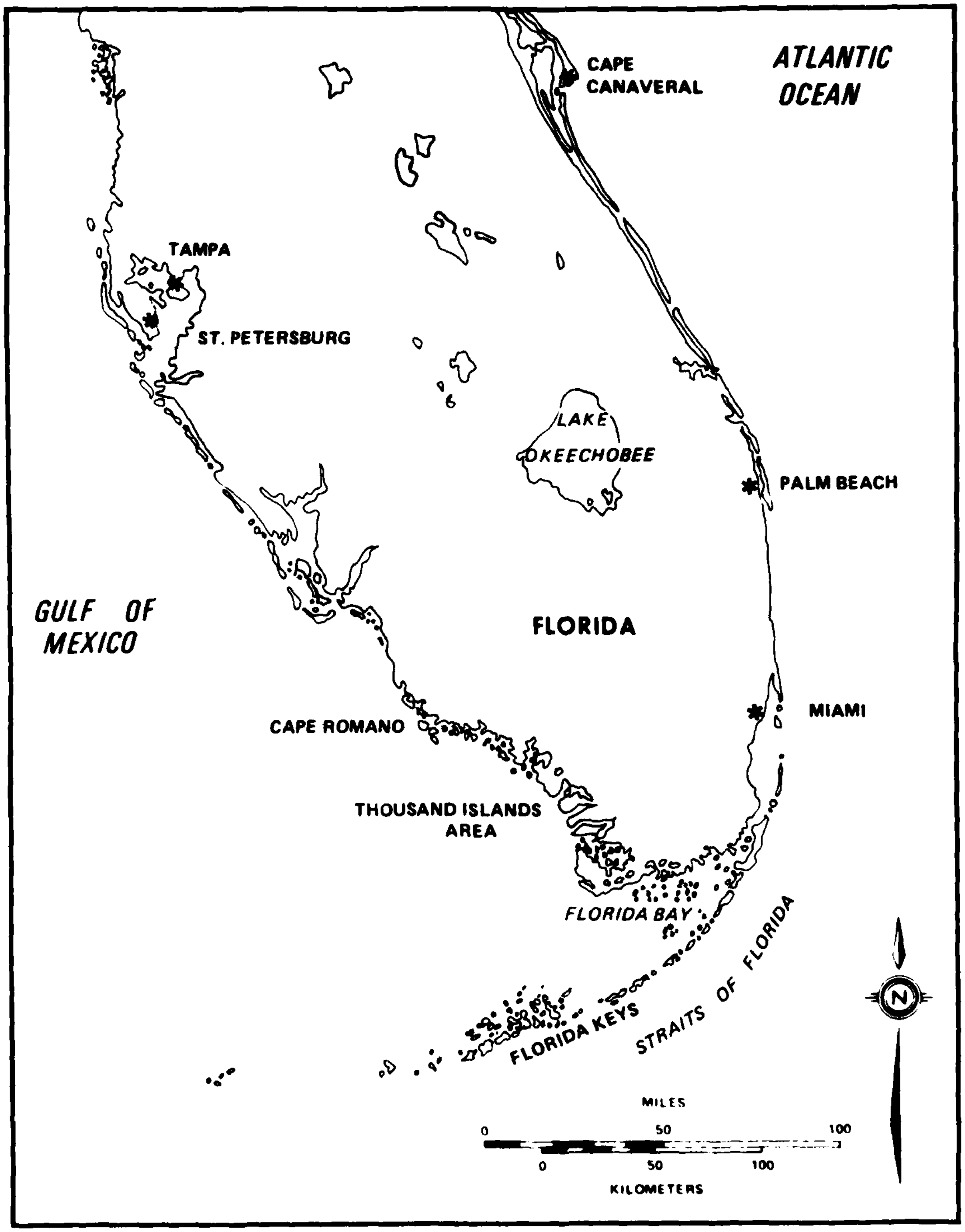


Figure 2. Striped mullet are distributed along the entire coast of the Southern Florida Region.

## REASON FOR INCLUSION IN SERIES

Striped mullet, perhaps the most widespread and abundant inshore teleost (Odum 1970), supports a valuable commercial fishery along the gulf coast of Florida (Rivas 1980). Mullet are primary consumers that feed largely on relatively minute living and dead vegetable matter. They are an ecologically important component in the flow of energy through estuarine communities. In many parts of the world striped mullet are important in fish culture.

## LIFE HISTORY

### Spawning

Because of the scarcity of data on striped mullet spawning, speculations on the locations of spawning grounds are based largely on the appearance of larvae. Mullet have been reported to spawn inshore (Breder 1940), along beaches (Gunter 1945), 8 to 32 km offshore (Broadhead 1953), and in water deeper than 40 m (Anderson 1958). In the Gulf of Mexico, mullet were observed spawning 65 to 80 km offshore in water 1,000 to 1,800 m deep (Arnold and Thompson 1958). These observations indicate that mullet spawn over a wide range of coastal waters but the current consensus is that most spawn offshore.

The spawning season of striped mullet usually begins in October, peaks in November-December, and ends in February (Anderson 1958; Rivas 1980). Along Florida's west coast, striped mullet spawn from October through May at Cedar Key and from December through July at Bayport (Kilby 1949). In Australia some females spawn only in alternate years (Thomson 1955), and evidence from Louisiana (Shireman 1975) suggests this may also be true for mullet in U.S. waters. The estimated fecundity of striped mullet is 0.5 to 2.0 million eggs per female, depending on the size of the female (Broadhead 1953). A fecundity value of 648 ± 62 eggs/g body weight was calculated by Shehadeh et al. (1973).

Eggs are transparent, straw-colored, non-adhesive, spherical, and without external marking. The eggs average 0.72 mm in diameter, contain an oil globule 0.28 mm in diameter, are positively buoyant, and hatch about 48 h after fertilization (Thomson 1963).

### Larvae and Juveniles

Larvae average 2.4 mm long (all lengths in this report are total lengths unless indicated otherwise) at hatching and have no mouth, paired fins, or branchial skeleton. After 5 days they are about 2.8 mm long, the jaws are well-defined, the internal organs become organized, and fin buds have started developing (Thomson 1963). Morphological and meristic development and growth continue until the larvae are about 16-20 mm standard length (SL), at which time they migrate to inshore waters and estuaries (Kilby 1949; Anderson 1958). The migrant larvae have two spines and nine rays in the anal fin (the "Querimana" stage) until they reach 35-45 mm SL, at which time the first ray fuses into a third spine and the adipose eyelid becomes apparent. The mullet is then considered a juvenile (Anderson 1958).

Juvenile striped mullet 40 to 69 mm SL reach a "definitive state" of osmoregulatory capability. For example, they tolerate salinities of 0 to 35 ppt, whereas they could not have previously survived in freshwater. Juveniles spend the rest of their first year of life in coastal waters, salt marshes, and estuaries, and often move to deeper water in the fall when the adults migrate offshore to spawn, yet large numbers of immature mullet overwinter in estuaries. After the first year, mullet inhabit the sea, salt marshes, estuaries, or freshwater rivers (Nordlie et al. 1982). Apparently in some instances, females greatly outnumber the males in brackish and freshwater habitats (Shireman 1975; Collins 1981).

## Adults

The length at which mullet mature ranges from about 200 to 300 mm SL; the females mature at a slightly larger size than the males. Although some mature in their second year of life, most mature in their third year (Broadhead 1953, 1958; Rivas 1980). On the northern gulf coast of Florida, the growth rate and size at maturity of striped mullet increased progressively from west to east. Mullet may live 4 years or more (Rivas 1980); the maximum age reported is 13 years (Thomson 1963).

Mature mullet migrate offshore to spawn in the fall and winter, often in large schools. Mullet that mature in freshwater either migrate to the sea to spawn or resorb their gonads (Shireman 1975). Swimming speed during migration is much greater than that predicted to be energetically optimal, probably because of the increased hydromechanical efficiency provided by schooling and the selective force of heavy predation during spawning migrations (Peterson 1976). Fishing for mullet is heaviest during spawning migrations when schools are large, the condition of the fish is excellent, and the prized roe (gonads) are largest.

In a mullet tagging study, 2,779 recoveries from 12,647 tagged mullet revealed that 91% were recovered within 32 km of the release point; only 2% were recovered more than 160 km away. These results together with other tagging studies and meristic analyses (Broadhead 1953; Broadhead and Mefford 1956; De Sylva et al. 1956), indicate that Florida gulf coast mullet are divided into three loosely knit populations, the south Florida population extending northward to the Steinhatchee area. East coast mullet commonly migrate much further (up to 560 km), usually in a southerly direction, and are considered a single population. Fish returning from spawning migrations on the gulf coast usually have less fat reserves and more eroded fins and lesions on the body than do premigratory mullet (M.R. Collins, University of Florida, Gainesville; unpublished data).

## GROWTH CHARACTERISTICS

Growth rates of striped mullet along the gulf coast of Florida increase from west to east along the panhandle and to the south along the peninsula, possibly due to a slight increase in coastal water temperatures (Broadhead 1958). In a tagging study, Broadhead (1953) found that growth during spring and summer is twice that of fall and winter: 7.3 ± 1.8 mm/quarter for the first and fourth quarters of the year, 16.4 ± 2.7 mm/quarter for the second, and 19.1 ± 2.7 mm/quarter for the third. The mean fork lengths of mullet from four gulf coast areas for each year of life are given in Table 1.

Table 1. Mean fork lengths (mm) of striped mullet at various ages from four gulf coast areas of Florida as calculated from scale analysis (Broadhead 1958).

| Area | Year of life | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Pensacola | 142 | 207 | 263 | -- |
| Apalachicola | 134 | 207 | 271 | -- |
| Cedar Key | 175 | 258 | 307 | -- |
| Homosassa | 178 | 269 | 319 | 366 |

Females are larger and grow slightly faster than males of the same age (Broadhead 1958). In the Cedar Key and Crystal River areas, mullet longer than 28 cm SL are predominantly females (Collins 1981). In the Gulf of Mexico, the growth in length of mullet gradually slows as the fish become larger, and reaches an asymptote at an average length of 600 mm TL, at probably 5-6 years of age (Rivas 1980). Length-weight relationships for striped mullet in the gulf are given in Figure 3.

## FISHERIES

### Sport

Striped mullet along the Florida gulf coast are used as bait for a wide variety of fishes and are regarded as an excellent food fish. In fresh and brackish waters, mullet are sometimes caught with hook and line. Earthworms may be used for bait, but oatmeal and chicken laying mash are more popular. Mullet from freshwater often have a muddy or hydrogen sulfide-like taste. In brackish and saltwater areas, mullet are sometimes snagged with treble hooks, but most often some type of net is used. Sport fishermen usually use a cast net or seine, but some use short lengths of gill nets or trammel nets.

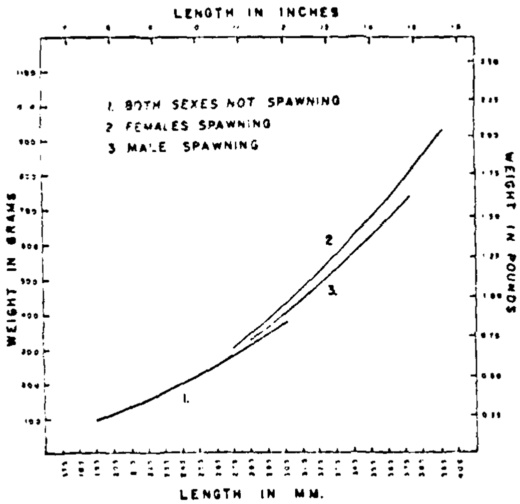


Figure 3. Length-weight relationships of striped mullet from Florida's gulf coast in 1951 (Broadhead 1953).

### Commercial

In general, sport and commercial mullet fishermen employ the same types of nets, but commercial seines, gill nets, and trammel nets are usually much longer. Seines are now used more on the east coast than on the west coast because of the abundance of smooth bottoms near sandy beaches on the east coast. Nets with largest meshes are used in the fall when mullet are gravid and fat. Many gill nets and trammel nets are longer than 500 m and are usually set from a boat. When mullet are in open water either net is set to completely encircle the school; when the school is near a shoreline the net is set in a half-circle from shore to shore; and in intertidal coves or creeks the nets are used to completely block off an area, catching the mullet as they leave with the ebb tide. Fishing may be carried out day or night, and sometimes two boats work together, combining their nets and encircling a school from opposite directions. When seines or nets are used, many mullet escape by jumping over the float line and, in the case of gill and trammel nets, they may avoid the net. Small mullet escape through the mesh.

The commercial landings of mullet were not reported by species until 1958. Since then, Florida has produced 80% to 90% of the U.S. striped mullet catch from the Gulf of Mexico (Rivas 1980). The annual Florida catch of striped mullet in 1958-1981 fluctuated from a high of 35 million lb in 1964 to a low of 16.8 million lb in 1976 (Table 2). Gulf coast landings contributed about 80% of the catch. Mullet also are important baitfish, especially in the sport

Table 2. Annual catch of striped mullet (millions of pounds) in Florida, 1958-81. Data compiled from annual catch statistics, National Marine Fisheries Service, Washington, D.C.

| Year | Catch | Year | Catch | Year | Catch |
|---|---|---|---|---|---|
| 1958 | 32.3 | 1966 | 27.0 | 1974 | 25.1 |
| 1959 | 30.6 | 1967 | 23.3 | 1975 | 23.2 |
| 1960 | 30.9 | 1968 | 20.4 | 1976 | 16.8 |
| 1961 | 33.0 | 1969 | 25.5 | 1977 | 18.8 |
| 1962 | 32.8 | 1970 | 23.1 | 1978 | 22.0 |
| 1963 | 32.6 | 1971 | 23.8 | 1979 | 25.7 |
| 1964 | 35.0 | 1972 | 26.9 | 1980 | 29.6 |
| 1965 | 31.4 | 1973 | 26.7 | 1981 | 31.0 |

fishery for billfish. They commonly bring a higher price as bait than as food fish.

Most (65%) striped mullet are marketed in the Southeast United States. The remainder are marketed in large northeastern, midwestern, and California cities. Of the total catch, about 25% is marketed fresh, 63% frozen in the round, 6% smoked, and 6% as roe. Marketing in other forms has been attempted, but failed because mullet turn rancid within 60 days and consumer acceptance is poor outside of the southeast (Cato et al. 1976; Rivas 1980).

## Management

Closed seasons and other regulations have been used to manage the Florida mullet in the past, but most have since been eliminated. Currently, minimum lengths of 9 to 11 inches FL (depending on local ordinances) are the only regulations (Rivas 1980). Although landings and fishing intensity for striped mullet declined from 1964 to 1977, catch-per-unit-of-effort and the average size of the fish remained unchanged. This relationship suggests that the lack of demand rather than a scarcity of mullet limits the fishing (Rivas 1980).

## ECOLOGICAL ROLE

There has been some discrepancy concerning the diet of juvenile striped mullet but most authors now agree that larval mullet primarily eat microcrustaceans (De Silva 1980). The fact that larvae, successfully reared to 20 mm SL, were fed entirely on animal material illustrates the dependence of larval and postlarval mullet on zooplankton (Nash et al. 1974). In Florida's Indian River lagoon the stomach contents of nearly 400 striped mullet larvae up to 35 mm SL were examined. Larvae up to 15 mm SL fed almost entirely on copepods (70%) and mosquito larvae (30%); those from 15 to 25 mm SL fed on copepods (50%), mosquito larvae (15%), and plant debris (35%); and larvae from 25 to 35 mm SL fed primarily on plant debris (80%) and copepods (10%) (Harrington and Harrington 1961). The proportion of sand and detritus in the gut of juveniles increases with length, indicating that they tend to take more food from the bottom as they grow older (De Silva and Wijeyaratne 1977). The exceptions are juveniles that feed from the water column or surface when suitable foods are plentiful there. For example, in one study mullet 35-80 mm long fed on a bloom of the dinoflagellate *Kryptoperidinium* sp. (Odum 1968). The rate of digestion or retention time of food in juveniles varies with both salinity and body weight. In Sri Lanka, a study of juvenile mullet 10 to 50 mm long showed that digestion rate increases with body weight and that both digestion and ingestion rates increased with salinity from 1 ppt to 30 ppt (Perera and De Silva 1978). Food evacuation times ranged from about three to six hours.

Adult striped mullet have been described as herbivorous, detritivorous, and "interface" feeders. The diet and feeding behavior of mullet may vary by location, but their major food is either epiphytic and benthic microalgae, macrophyte detritus, or inorganic sediment particles. Although sediment particles function as a grinding paste in the gizzard-like pyloric portion of the stomach, some small particles are rich in adsorbed micro-organisms and are selectively ingested for their food value (Odum 1970).

Mullet commonly feed by sucking up the top layer of sediment, which is rich in detritus and microalgae, primarily diatoms in the Cedar Key area (Collins 1981), and by grazing on epiphytes and epifauna from seagrasses and other substrates. They also ingest surface scum when large concentrations of microalgae are present at the air-water interface (Odum 1970), and feed on swarming polychaetes (Nereis succinea) in the water column (Bishop and Miglarese 1978). In some freshwater habitats striped mullet feed primarily on the epiphytes and epifauna of aquatic macrophytes and on benthic filamentous green algae (Collins 1981), but they also ingest sediment for trituration (grinding). The time of most intense feeding apparently varies with location. In all Florida habitats studied by Odum (1970) feeding varied with the height of the tide, whereas in saltwater (Cedar Key) and freshwater (Crystal River) sites studied by Collins (1981) feeding was strictly diurnal and unrelated to tidal stage.

The major predators of juvenile and adult mullet are fishes and birds (Thomson 1963). In Florida, sharks sometimes feed heavily on large mullet. Mullet up to 35 cm long are fed on by spotted seatrout (Cynoscion nebulosus) (Breuer 1957). Although the diet of striped mullet overlaps those of a variety of aquatic species, competition has not been documented.

Parasitic infections and infestations are common in mullet. Of nearly 300 adult mullet from freshwater and saltwater sites on Florida's gulf coast, no individuals were found without parasites on either the gills or body surface (M. R. Collins, Univ. of Fla., Gainesville; unpublished data). Striped mullet serve as definitive or intermediate hosts for many parasites including flagellates, ciliates, myxosporidians, monogenean and digenean trematodes, nematodes, acanthocephalans, leeches, argulids, copepods, and isopods (Paperna 1975; Overstreet 1978; Paperna and Overstreet 1981). Extensive parasite-induced mortalities of mullet in the wild have not apparently been reported.

## ENVIRONMENTAL REQUIREMENTS

### Temperature

An analysis of the worldwide distribution of striped mullet suggests that mullet are not permanent residents in waters with temperatures below 16°C or where water temperatures fail to reach 18°C. On Florida's gulf coast, young striped mullet live in salt marsh pools at temperatures from 13°C to 34.5°C (Kilby 1949). Water temperatures probably regulate the length of time that young mullet stay in estuaries. Mullet less than 50 mm SL prefer temperatures from 30.0° to 32.5°C and mullet from 50 to 130 mm SL prefer temperatures from 19.5° to 20.0°C. For all sizes of fish the temperature selected tends to decrease as salinity increases. In experiments with Hawaiian striped mullet 78-122 mm SL, the upper lethal temperature was between 27.0° and 29.6°C for fish acclimated at 21°C in freshwater and the lower lethal temperature was between 10.2° and 15.0°C (Sylvester et al. 1974). The upper lethal temperature for mullet acclimated at 26°C in saltwater (32 ppt) ranged from 29.0° to 33.0°C, and the lower lethal temperature ranged from 10.4° to 14.0°C. The critical thermal maximum (CTM) of Hawaiian mullet (70 to 125 mm SL) is affected both by acclimation temperature and by time of day (Sylvester 1975). Mean CTM increased from 38.5° to 41.3°C for fish acclimated at 20.0° and 29.0°C, respectively, and mean CTM is about 0.5°C higher at midday than in morning or evening. Critical thermal maxima and minima were not available for adult mullet.

Salinity

Adult mullet have been reported from waters with a salinity ranging from 0 ppt (Collins 1981) to 75 ppt (Simmons 1957). Using fish induced to spawn in the laboratory, Sylvester et al. (1975) found that egg survival was highest at a salinity of 32 ppt (the highest salinity tested), whereas the greatest survival of larvae was at 26 ppt in tests from 24 to 36 ppt. When juvenile mullet are 40-70 mm SL they reach a definitive state of osmoregulatory capability and can tolerate salinities from freshwater to full seawater (Nordlie et al. 1982).

Dissolved Oxygen

Mullet larvae apparently cannot survive in dissolved oxygen (DO) concentrations below 4 ppm (Sylvester et al. 1975). Over a range of 1.0 to 8.0 ppm DO, eggs incubated in the laboratory for 48 h had a survival rate of 0%-3% at concentrations 4.5 ppm and below, and 85%-90% for 5.0 ppm and above. Larvae were held from one to four days in concentrations of 4.0-7.9 ppm DO, and those held for 4 days had a mean survival of 0-8% at 4.0-5.4 ppm, 21% at 6.4 ppm, and 84% at 7.9 ppm. Although 7.9 ppm in this instance is 146% saturation, there was no evidence of gas bubble disease. No specific data on oxygen requirements were found for adult mullet, but preliminary experiments with caged fish show that they survive at an oxygen concentration of 4.4 ppm DO at 29°C and a salinity of 28 ppt (M. R. Collins, Univ. of Fla., Gainesville; unpublished data). In a study of schools of migrating mullet, DO was 29% lower at the trailing than the leading edges, suggesting that the continual breaking up and reforming of the school and changing of position within the school allow fish at the center and trailing edge access to water higher in DO (McFarland and Moss 1967).

Depth

Mullet live in a wide range of habitats and depths and spawn primarily in relatively deep cool coastal waters. The larvae move inshore to shallow waters along beaches and in salt marshes. In Hawaii, schools of mullet less than 50 mm SL were always found in waters of minimal depth, including the swash zone and tide pools, despite near-lethal temperatures (Major 1978). Juveniles greater than 50 mm SL prefer slightly deeper waters beyond the swash zone, but during flood tides they may move into shallow waters vacated by smaller mullet. The preference of fish less than 50 mm SL for extremely shallow water apparently permits them to escape most predators and to feed without serious competition (Major 1978).

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16. Abstract (Limit: 200 words)


Species profiles are literature summaries of the taxonomy, morphology, distribution, life history, biological and physical environments, and environmental requirements of coastal species of fishes and aquatic invertebrates. They are designed to assist in environmental impact assessment and permit review. The striped mullet (Mugil cephalus) is a valuable food fish and baitfish. About 31 million pounds were landed in Florida in 1981. Striped mullet are caught with hook and line, trammel nets, gill nets, and seines, and by snagging. Some striped mullet spawn along beaches, but they usually spawn offshore in relatively deep (to 1,800 m) cool waters. Juveniles spend their first year in salt marshes, estuaries, and coastal waters. Striped mullet usually avoid water colder than 16° C.


17. Document Analysis a. Descriptors

Fishes
Estuaries
Feeding
Growth

b. Identifiers/Open Ended Terms

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Mugil cephalus
Salinity requirements
Temperature requirements
Life history
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