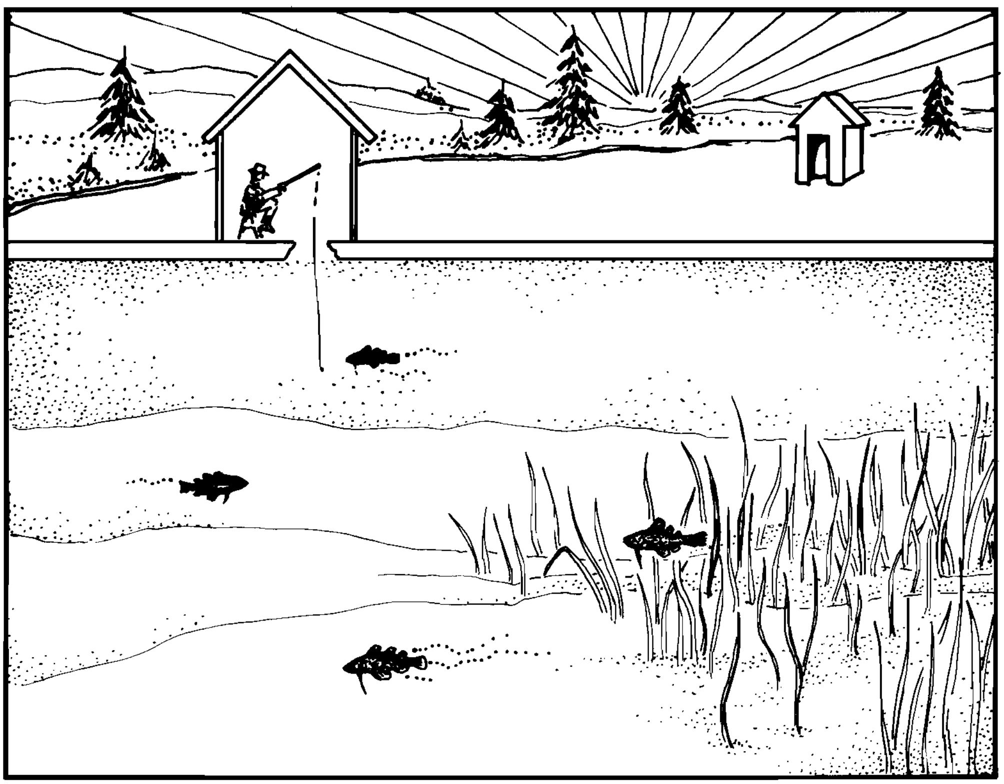
Biological Report 82 (11.76)
August 1987

TR EL-82-4

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

ATLANTIC TOMCOD



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 (North Atlantic)

ATLANTIC TOMCOD

by

Lance L. Stewart and Peter J. Auster
NOAA's National Undersea Research Program
The University of Connecticut at Avery Point
Groton, CT 06340

Project Manager
Carroll Cordes
Project Officer
David Moran
U.S. Fish and Wildlife Service
National Wetlands Research Center
1010 Gause Boulevard
Slidell, LA 70458

Performed for
Coastal Ecology Group
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National Wetlands Research Center
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PREFACE

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

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

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

U.S. Customary to Metric

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

CONTENTS

ACKNOWLEDGMENTS

We are grateful for the review by W. Smith and T. Pacheco of the National Marine Fisheries Service, Sandy Hook, New Jersey. We also thank Constance Fontaine and Andrew Shepard for patiently dealing with drafts and the computer. Mary Jane Spring expertly prepared figure 1.

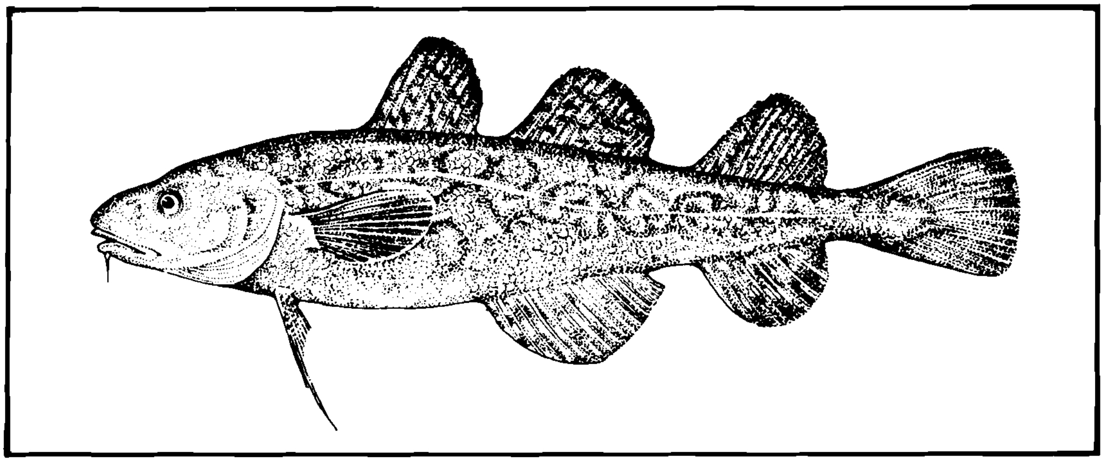

Figure 1. Atlantic tomcod (Microgadus tomcod).

NOMENCLATURE/TAXONOMY/RANGE

Scientific name .... Microgadus tomcod (Walbaum)
Preferred common name .... Atlantic tomcod (Figure 1)
Other common name .... Frostfish
Class .... Osteichthyes
Order .... Gadiformes
Family .... Gadidae

Geographic range: Coastal waters of the northwest Atlantic from southern Labrador and northern Newfoundland to Virginia (Figure 2). Generally occurring in brackish water but occasionally in freshwater (Bigelow and Schroeder 1953; Leim and Scott 1966).

MORPHOLOGY/IDENTIFICATION AIDS

Bigelow and Schroeder (1953) and Leim and Scott (1966) provided complete descriptions of the Atlantic tomcod and guides for its differentiation from other species. Atlantic tomcod generally have the same body plan as the much larger Atlantic cod (Gadus morhua). The body is elongated, and the upper jaw projects past the lower jaw. There is a barbel on the chin. Differences in several key external characters allow easy differentiation: The second rays of the ventral fins of the tomcod are long, narrow, and tapering (the tapered portion is as long as the rest of the fin), whereas those of the cod are shorter, broad, and rounded (the filament is one-quarter the length of the fin). The caudal fin of the tomcod is rounded, in contrast to the squarish fin of the cod. Coloration of the tomcod is olive, olive-brown, or muddy green, with some yellow on the dorsal surface; lower lateral surfaces have a more yellowish cast, especially in larger fish; dorsal fins are mottled with dark spots or blotches; and the belly is gray or yellow-white and the margin of the anal fin is olive.

Booth (1967) and Hardy (1978) provided descriptions of the development of eggs and larvae, which can be distinguished from other species on the basis of morphology.

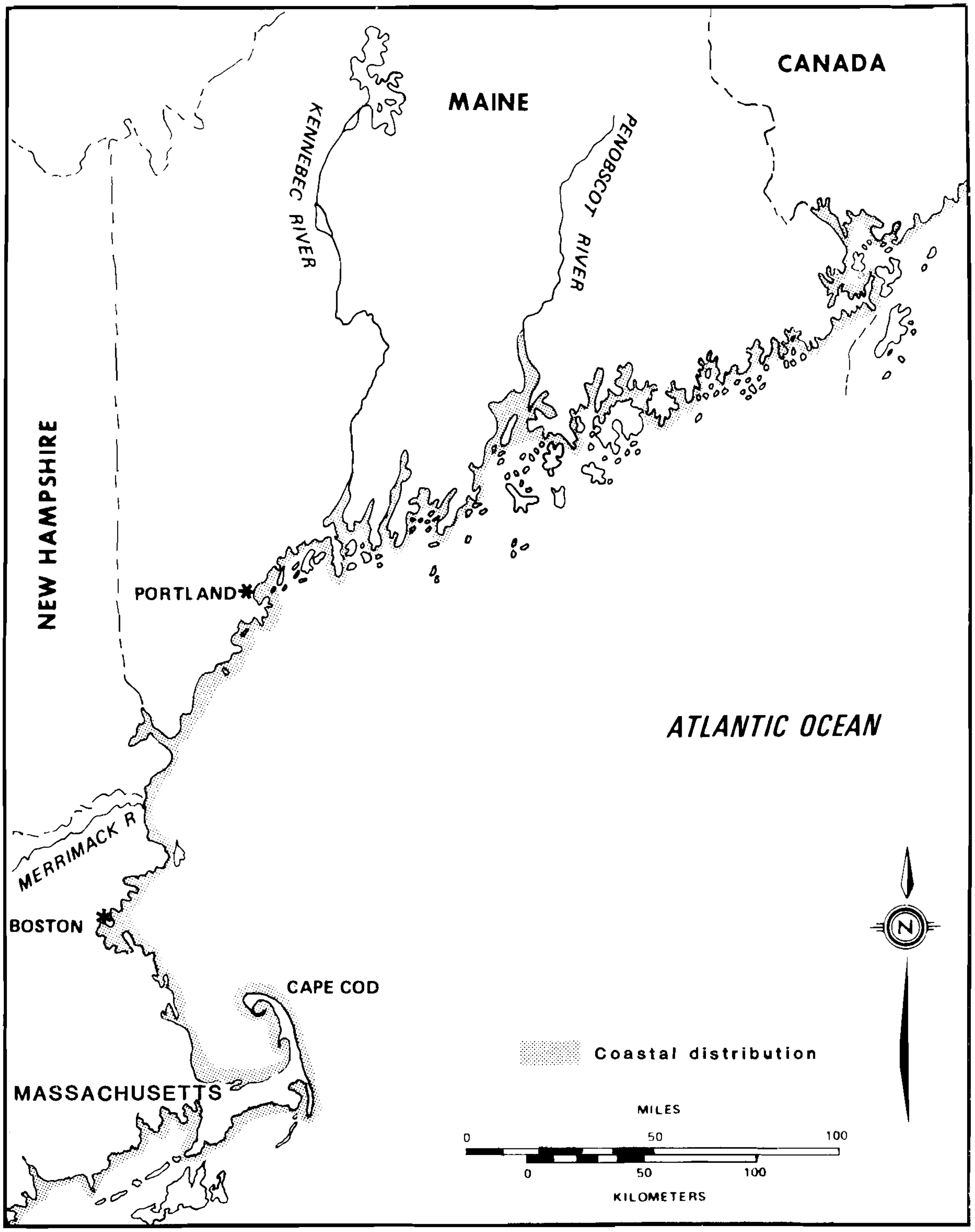

Figure 2. Coastal distribution of the Atlantic tomcod (Microgadus tomcod) in the North Atlantic region.

REASON FOR INCLUSION IN SERIES

Altantic tomcod are widespread along coastal regions of the north-eastern coast of the U.S. They are abundant in estuarine habitats such as river mouths and salt marshes. These same habitats are subject to a wide variety of human sources of disturbance.

LIFE HISTORY

Spawning

Although the range of the tomcod extends south to Virginia, no spawning has been reported in estuaries south of the Hudson River (DeSylva et al. 1962; Schwartz 1964; Massmann 1975); however, spawning occurs in many estuaries in the northern part of the range. North of the Hudson River, tomcod spawn from November to February with a peak in January (Vladykov 1955; Pearcy and Richards 1962; Howe 1971; Dew and Hecht 1976; Able 1978). Spawning occurs in shallow waters of estuaries or stream mouths, in salt, brackish, or freshwater (Nichols and Breder 1926; Bigelow and Schroeder 1953).

Fecundity and Eggs

Females 170 to 340 mm long produce an average of 20,000 eggs within a range of 6,000 to 30,000 (Schaner and Sherman 1960). Nichols and Breder (1926) reported that average fecundity was 25,000 eggs (maximum 44,000).

The eggs of Atlantic tomcod are large, approximately 1.5 mm in diameter, and have a large oil globule. They sink to the bottom after spawning and adhere in masses to available substrate (Bigelow and Shroeder 1953; Dew and Hecht 1976).

Salinity affects fertilization, development, and subsequent hatching success. Sperm motility is greatest at low salinities (Booth 1967); hence fertilization success is also highest at low salinity. Eggs generally occur and develop mostly in freshwater, due to stream flow characteristics at the heads of estuaries; seawater intrusion occurs only at extreme high tides. Normal development does not occur when eggs are continuously exposed to salinities of 30 ppt or higher (Peterson et al. 1980). Booth (1967) found that the percentage of eggs that developed to the blastula stage was highest when salinities ranged from 0 to 15 ppt.

Incubation time is approximately 30 days at 6.1 °C and 24 days at 4.4 °C (Bigelow and Schroeder 1953). Peterson et al. (1980) demonstrated that time to hatching decreases as salinity increases (up to 30 ppt). For example, at temperatures between approximately 4 and 9 °C, median times of hatching were reduced from 53 days at 0 ppt to 38 days at 30 ppt (at 30 ppt development was abnormal).

Larvae

Atlantic tomcod larvae became photopositive within 24 h after hatching, and swim to the surface to inflate the swim bladder by gulping air. Larvae are transported seaward as water temperatures begin to increase (Peterson et al. 1980).

Larvae are most abundant in the water column in early March in southern New England (Booth 1967; Howe 1971). They are generally found near bottom in the (low salinity) upper reaches of estuaries (Pearcy and Richards 1962; Howe 1971). This distribution pattern would facilitate retention of larvae in the estuary, since downstream movement is reduced near bottom and upstream tidal movement is enhanced in this area. No pelagic larvae more than 12 mm in total length (TL) have been collected (Booth 1967), reflecting the change to benthic habits. All fins are formed when the larvae reach about 10 mm TL (Booth 1967); the resulting greater motility allows increased directional movement.

Juveniles and Adults

Young-of-the-year remain in the estuary where they were hatched during the succeeding summer months (Bigelow and Schroeder 1953), and are restricted by water of relatively low salinity. For example, no juveniles were found in water of less than 10 ppt salinity or at temperatures above 26 °C in the Weweantic River Estuary, Massachusetts (Howe 1971).

The diet of juvenile tomcod in the Hudson River, New York, shifted as size increased (Grabe 1978). Primary prey items of young-of-the-year in May and June were copepods and small amphipods. As total length reached 80-90 mm, prey shifted toward larger individuals and species of amphipods and mysids. The shift was probably not due to shifts in densities of prey species, as the copepod population increased and amphipod population decreased during this period (Table 1).

Conversely, Howe (1971) found that tomcod in the Weweantic River Estuary preyed on species in direct proportion to their availability. They fed principally on crustaceans, primarily the shrimp *Crangon septemspinosa* (68% of total items) and amphipods. Other prey included polychaete worms, small mollusks, and fish.

Table 1. Importance values (importance = (% composition x % occurrence)$^{1/2}$) of copepods, amphipods, and the mysid *Neomysis americana* in stomachs of June and July Atlantic tomcod pooled by 10-mm length intervals (adapted from Grabe 1978).

Length interval (mm)	No. of fish	Copepods	Amphipods	Neomysis americana
40-49	3	36	48	0
50-59	48	66	30	4
60-69	65	75	27	6
70-79	80	60	30	7
80-89	40	40	39	5
90-99	38	0	84	17
>100	5	9	76	0

GROWTH CHARACTERISTICS

Howe (1971) determined growth characteristics of tomcod in the Weweantic River Estuary, Massachusetts. Age was determined from both scales and otoliths. The relation between scale radius and total body length for both sexes was described by the model:

$$L = 27.8 \text{ mm} + 3.86\ R$$

where L = total length (mm) and R = scale radius (mm) when magnified 43 times. Maximum total length was 317 mm and maximum age was 3 years. Table 2 describes the age-length relation in the population. Growth of young-of-the-year was rapid from June to mid-July, and then decreased. Fish were about 90 mm by their first September, and the larger juveniles were more than 100 mm long by early fall.

Warfel and Merriman (1944) reported young-of-the-year tomcod from New Haven, Connecticut, to be 35-47 mm on June 25. Nichols and Breder (1926) and Bigelow and Schroeder (1953) reported young-of-the-year tomcod in

Table 2. Age composition by total lengths of Atlantic tomcod collected from Weweantic River, 1966-67 (from Howe 1971).

Total length (mm)	Total no. of fish	Age group (entire sample included) 0	I	II	III
45-99	347	347			
100-119	36	31	5		
120-204	117		117		
205-244	36		10	26	
245-279	20			20	
280-319	7			3	4
Total	563	378 (67%)	132 (23%)	49 (9%)	4 (1%)

southern New England were 63-77 mm long in fall. These values agree with the growth found in the more northern populations in Massachusetts by Howe (1971).

Tomcod may grow larger during their first year in southern New England than those in the Canadian Maritimes. Leim and Scott (1966) reported that young-of-the-year fish reached only 57 mm by August, although they also reported the longest tomcod at 330 mm.

The model describing the relation between length and weight follows:

$$\log W(g) = 5.1087 + 3.032 \log L(mm)$$

where r = 0.995 for both sexes (Howe 1971). No statistically significant differences between sexes were found.

Growth rates of tomcod are highest from January, February, or March (according to region) through July. Feeding is heaviest after the fish spawn, as water temperatures increase (Howe 1971).

FISHERY

Tomcod were a locally important commercial target species in northern estuaries during the 1800's. Storer (1839) reported that they were locally abundant near Boston, where 2,000 bu were landed annually at Watertown. Goode (1888) reported that 10,000 lb were landed annually from the Charles River, where they were marketed as "London trout" and considered a delicacy. The importance of the commercial tomcod fishery declined along the New England coast during the past century. There have been no catch statistics for this species in New England since small amounts were landed at Point Judith in 1957 and reported by Edwards (1958). Leim and Scott (1966) reported that tomcod are taken incidentally in the smelt trap fishery in Canada, and are sometimes caught by hand line and hoop net. They are also taken in a winter ice fishery in the St. Lawrence River. One million pounds, worth $26,000, were landed in the Canadian Atlantic area in 1962. Tomcod are now the target of a winter sport fishery along the New England coast.

ECOLOGICAL ROLE

Atlantic tomcod feed principally on small crustaceans and to a lesser extent on polychaete worms, mollusks, and fish (Bigelow and Schroeder 1953; Howe 1971; Grabe 1978, 1980).

Little is known about predation on tomcod by piscivorous fishes. A study by Dew and Hecht (1976) in the Hudson River, New York, suggested that yearling striped bass, *Morone saxatilis*, selectively prey on tomcod during summer, when other prey species of suitable size (i.e., juvenile herrings) are not available. Tomcod may serve as an alternate prey species for striped bass during years when their primary prey, the bay anchovy (*Anchoa mitchilli*), is scarce. In some river-estuarine systems, the tomcod may be an alternate prey resource critical to the continuous production of striped bass.

ENVIRONMENTAL REQUIREMENTS

Temperature

Coastal, estuarine, and riverine water temperatures along the northeast coast vary over a wide range. Howe (1971) found no fish at water temperatures higher than 26 °C. Kellogg et al. (1978) determined that the upper lethal temperature of tomcod eggs was 6.6 °C. Tomcod have been found at temperatures as low as -1.2 °C (Gordon et al. 1962); glycoproteins that depress the freezing point enable the fish to avoid freezing (Fletcher et al. 1982).

Salinity

In the Hudson River, Dew and Hecht (1976) found the densities of larvae and juveniles to be highest within a salinity range of 4.5 to 8.7 ppt; the total range was 1.5 to 10.0 ppt. Howe (1971) found young-of-the-year in areas with salinity higher than 10.0 ppt. Juveniles and adults have been found at all salinities from full-strength seawater to freshwater, in bays and estuaries (Bigelow and Schroeder 1953; Leim and Scott 1966).

Habitat

Tomcod are found at the high tide mark of saltmarshes and mudflats (Dutil et al. 1982), in eelgrass beds (Howe 1971), and to an approximate maximum depth of 6 m in bays, estuaries, and coastal waters within about 1.6 km of shore (Bigelow and Schroeder 1953). Tomcod are also reported to ascend rivers well beyond the furthest point of seawater intrusion (Bigelow and Schroeder 1953; Leim and Scott 1966).

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15. Supplementary Notes

*U. S. Army Corps of Engineers Report No. TR EL-82-4.

16. Abstract (Limit: 200 words)

Species profiles are literature summaries on taxonomy, morphology, range, life history, and environmental requirements of coastal finfishes and shellfishes. They are designed to assist in environmental impact assessment. The Atlantic tomcod (Microgadus tomcod) is of regional importance in a winter recreational sport fishery. Tomcod are widespread along coastal regions of the northeast coast of the United States. They are abundant in estuarine habitats such as river mouths and saltmarshes, and thus are subject to a wide variety of anthropogenic sources of disturbance. Tomcod spawn from November to March. Young-of-the-year remain in the estuary where they were spawned during succeeding summer months. Adults live in full-strength seawater to freshwater, but eggs and larvae have narrower salinity requirements.

17. Document Analysis a. Descriptors

Estuaries	Feeding habits
Fishes	Life cycles
Fisheries	Growth
Salinity	Temperature

b. Identifiers/Open-Ended Terms

Atlantic tomcod
Microgadus tomcod

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
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National Wetlands Research Center
NASA-Slidell Computer Complex
1010 Gause Boulevard
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