ORIGINAL

Guide to Otoliths of Some Northwest Atlantic Fishes

by

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INTRODUCTION

The value of otoliths for determining the age of fish has long been recognized by fishery biologists. It is only recently, however, that the possible taxonomic uses of otoliths have been investigated. Otoliths have been used to delineate fish faunas of recent geological ages and as such have become an important paleobiological tool. Several works (Campbell 1929, Frizzel and Dante 1965, Schwarzhans 1978) include illustrations of both recent and extinct fish otoliths. Wigley and Stinton (1973) examined sediments from the Northwest Atlantic and found high densities of otoliths which they were able to assign to at least 26 species.

Otoliths have also been used to identify the prey of fish, sharks and cetaceans (Perrin et al. 1973, Talent 1976). Fitch and Brownell (1968) give a synopsis of reports dealing with otoliths found in cetacean stomachs. Otoliths are often all the remains as evidence of fish predation. Fish prey, whose salient identification features have been digested away, may often be identified by the otoliths (Personal observation).

Another more widely accepted approach has been the use of otoliths as identification aids to differentiate between closely allied species. Several papers have dealt with differentiation of species of similar morpholgical appearance using otoliths (Schmidt 1969, Casteel 1974, Price 1978, and Chao 1978). Minute but constant intraspecific variations in otolith structure have been used to identify stocks or races within a fish population (Parrish and Sharman 1958, Kotthaus 1961, Messieh 1972, and Rojo 1977).

To date, few attempts have been made to provide a complete guide to otoliths likely to be found in a specified geographic area. Frost (1925 -

1930) provided complete descriptions of many Neopterygian fish but the figures lack detail and are of questionable quality for identification purposes. Eziuzo (1963) gave descriptions and figures of otoliths for fishes occurring off West Africa and Morrow (1979) published a key to adult fish from Alaska. The purpose of the present paper is to provide a guide to the common fishes of the Northwest Atlantic. The area covered by this study includes the Gulf of Maine, Georges Bank and southern New England.

METHODS

Otoliths were removed from fresh or frozen fish caught primarily on NMFS bottom trawl surveys.[1] Other methods of capture included baited traps, hook and line, and scuba diving. Care was taken to insure that only otoliths from adult fish were used for this study as some morphological changes in otolith structure do occur during maturation. Some of the more delicate otoliths were stored in a solution of 40% alcohol/60% glycerin while the others were simply stored dry in labeled vials. No otoliths were taken from fish preserved in formaldehyde as preservation in this solution, for even a short period of time, dissolves away the distinguishing features. The illustrations were drawn with the aid of a binocular dissecting scope, and measurements were made using an ocular micrometer. All otoliths illustrated have been placed in a reference collection at the National Marine Fisheries Service Laboratory, Woods Hole, Massachusetts.

OTOLITH STRUCTURE

The labyrinth system of the teleostean skull actually contains three pairs of otoliths but one pair, the sagittae found within the sacculi, are

[1]A detailed description of NMFS botton trawl surveys is provided by: Grosslein, M. D., 1969. Groundfish Survey Methods. NMFS, Woods Hole, Mass., Lab. Ref. No. 69-2, 34p.

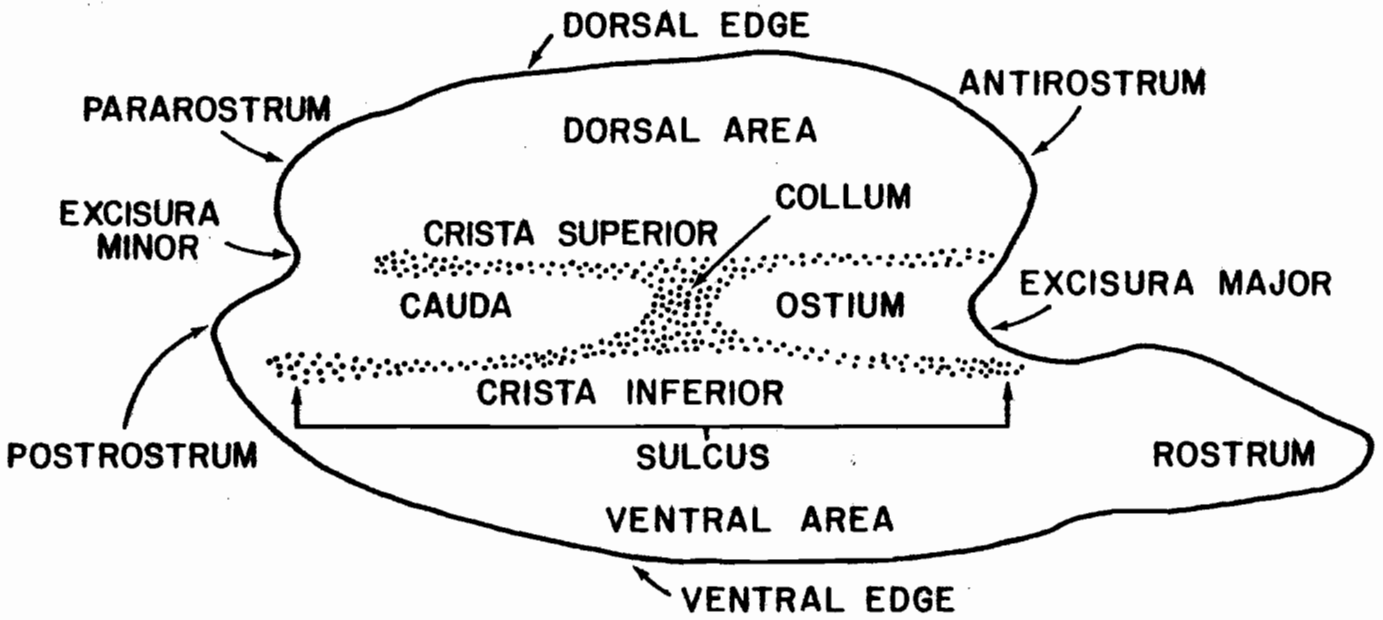

Figure 1. Diagram of inner face of left sagitta showing important characters (Modified from Messieh, 1972 & Morrow, 1979)

by far the largest in most species and are referred to when the general term otolith is used. The sagitta is suspended in lymph fluid obliquely in the sacculus with the concave surface facing mesially. The sagitta pair are easily exposed by making a lateral cut through the posterior section of the fish brain. The main function of the sagitta is as a sound receptor. Blacker (1974) gives a more complete description of otolith structure and studies related to it.

There is much variation in otolith size when comparing fish species. In this study, for example, an ocean pout (Macrozoarces americanus) and a tilefish (Lopholatilus chamaeleonticeps) of identical length (58 cm) yielded otoliths of 4.0 mm and 58.2 mm respectively. Intraspecific variation in otolith size, however, is minimal for fish of the same year class and size range.

Surface structure and general outline of the otolith are also species specific. Minor variations and gradations do occur in the transition from juvenile to adult stages and the fact that only adult otoliths are pictured here should be taken into consideration when using this guide. Figure 1 is of a typical otolith and shows some of the key morphological characters used for the identification or differentiation of species. Some of the more important features are: general outline and size of otolith, depth of the excisura, length and shape of the rostrum and antirostrum, depth and shape of the sulcus, location and size of surface concretions and ridges. Often several of these characters must be examined simultaneously for closely allied species. Morrow (1979) should be consulted for more detailed definitions of the structures labeled in Figure 1.

LIST OF SPECIES

The species listed in the following table are considered important within the study area and are likely to be potential prey of Northwest

Atlantic piscivores. Included in the list are 23 of the most important fish in terms of biomass (Edwards and Bowman 1979) as well as other fish that are commonly caught in bottom trawls. Southern demersal species which stray into the study area during the warmer months of the year have been excluded. Inshore, anadromous, and pelagic species may be incompletely represented due to sampling methodology employed.

Systematic classification including general and species names are for the most part taken from Bailey et al. (1970). Distributions of the individual species are taken from Bigelow and Schroeder (1953, 1955) and Ursin (1977) and include only the species range within the Northwest Atlantic.

A C K N O W L E D G M E N T

I wish to thank the following from National Marine Fisheries Service, Woods Hole, for their assistance in this project: Louise Dery and Paul Andrews for collecting and sorting otoliths, Roland L. Wigley for financial support and Richard W. Langton for moral support and critical review of the manuscript. I would especially like to thank Betsey Pratt for her painstaking attention to detail in drawing the otoliths.

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LIST OF SPECIES

Order Anguilliformes

Family Anguillidae

Anguilla rostrata (Lesueur) - American eel - Nova Scotia to Gulf of Mexico

Order Clupeiformes

Family Clupeidae

Alosa aestivalis (Mitchill) - Blueback herring - Nova Scotia to Florida
Alosa pseudoharengus (Wilson) - Alewife - Labrador to Florida
Alosa sapidissima (Wilson) - American shad - Nova Scotia to Florida
Brevoortia tyrannus (Latrobe) - Atlantic menhaden - Nova Scotia to Florida
Clupea harengus harengus Linnaeus - Atlantic herring - Labrador to Long Island
Etrumeus teres (DeKay) - Round herring - Cape Cod to Florida

Order Salmoniformes

Family Argentinidae

Argentina silus Ascanius - Atlantic argentine - Nova Scotia to Long Island

Order Batrachoidiformes

Family Batrachoididae

Opsanus tau (Linnaeus) - Oyster toadfish - Cape Cod to Gulf of Mexico

Order Lophiiformes

Family Lophiidae

Lophius americanus Valenciennes - Goosefish - Newfoundland to North Carolina

Order Gadiformes

Family Gadidae

Brosme brosme (Müller) - Cusk - Newfoundland to Long Island
Enchelyopus cimbrius (Linnaeus) - Fourbeard rockling - Nova Scotia to Florida
Gadus morhua Linnaeus - Atlantic cod - Greenland to New Jersey
Melanogrammus aeglefinus (Linnaeus) - Haddock - Newfoundland to New Jersey
Merluccius albidus (Mitchill) - Offshore hake - Georges Bank to Florida
Merluccius bilinearis (Mitchill) - Silver hake - Newfoundland to South Carolina
Phycis chesteri Goode and Bean - Longfin hake - Newfoundland to North Carolina
Pollachius virens (Linnaeus) - Pollock - Nova Scotia to Long Island
Urophycis chuss (Walbaum) - Red hake - Newfoundland to North Carolina
Urophycis regius (Walbaum) - Spotted hake - Cape Cod to Florida
Urophycis tenuis (Mitchill) - White hake - Newfoundland to Cape Cod

Family Zoarcidae

Macrozoarces americanus (Bloch and Schneider) - Ocean pout - Newfoundland to New Jersey

Family Macrouridae

Nezumia bairdi (Goode and Bean) - Marlin-spike - Newfoundland to Cape Cod

Order Perciformes

Family Percichthyidae

Morone saxatilis (Walbaum) - Striped bass - Gulf of St. Lawrence to Florida

Family Serranidae

Centropristis striata (Linnaeus) - Black sea bass - Cape Cod to Florida

Family Branchiostegidae

Lopholatilus chamaeleonticeps Goode and Bean - Tilefish - Nova Scotia to Chesapeake Bay

Family Pomatomidae

Pomatomus saltatrix (Linnaeus) - Bluefish - Nova Scotia to Florida

Order Perciformes, continued

Family Sparidae

Stenotomus chrysops (Linnaeus) - Scup - Cape Cod to Florida

Family Sciaenidae

Cynoscion regalis (Bloch and Schneider) - Weakfish - Nova Scotia to Florida

Family Labridae

Tautoga onitis (Linnaeus) - Tautog - Nova Scotia to South Carolina
Tautogolabrus adspersus (Walbaum) - Cunner - Newfoundland to Chesapeake Bay

Family Anarhichadidae

Anarhichas lupus Linnaeus - Atlantic wolffish - Newfoundland to Long Island

Family Cryptacanthodidae

Cryptacanthodes maculatus Storer - Wrymouth - Newfoundland to New Jersey

Family Ammodytidae

Ammodytes americanus (DeKay) - American sand lance - Labrador to Cape Hatteras

Family Scombridae

Scomber scombrus Linnaeus - Atlantic mackerel - Labrador to South Carolina

Family Stromateidae

Peprilus triacanthus (Peck) - Butterfish - Nova Scotia to South Carolina

Family Scorpaenidae

Helicolenus dactylopterus (De la Roche) - Blackbelly rosefish - Georges Bank to Florida
Sebastes marinus (Linnaeus) - Redfish - Newfoundland to New Jersey

Family Triglidae

Peristedion miniatum Goode - Armored Sea Robin - Cape Cod to South Carolina
Prionotus carolinus (Linnaeus) - Northern searobin - Cape Cod to South Carolina

Family Triglidae, continued

Prionotus evolans (Linnaeus) - Striped searobin - Cape Cod to South Carolina

Family Cottidae

Hemitripterus americanus (Gmelin) - Sea raven - Gulf of St. Lawrence to Chesapeake Bay
Myoxocephalus aenaeus (Mitchill) - Grubby - Nova Scotia to New Jersey
Myoxocephalus octodecemspinosus (Mitchill) - Longhorn sculpin - Newfoundland to New Jersey
Triglops nybelini Jensen - Mailed sculpin - Greenland to Cape Cod

Family Agonidae

Aspidophoroides monopterygius (Bloch) - Alligatorfish - Greenland to New Jersey

Order Pleuronectiformes

Family Bothidae

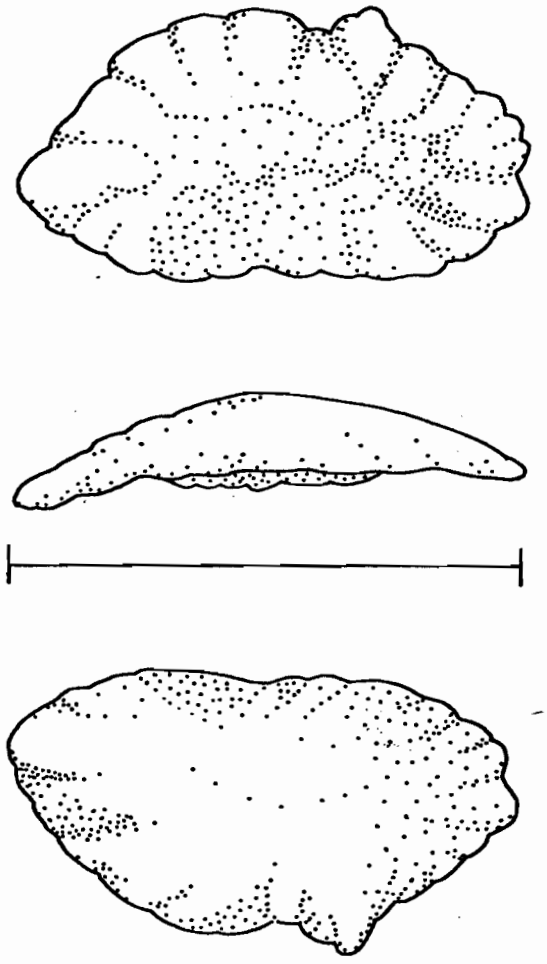
Citharichthys arctifrons Goode - Gulf Stream flounder - Georges Bank to South Carolina
Paralichthys dentatus (Linnaeus) - Summer flounder - Gulf of Maine to Florida
Paralichthys oblongus (Mitchill) - Fourspot flounder - Georges Bank to South Carolina
Scophthalmus aquosus (Mitchill) - Windowpane - Gulf of St. Lawrence to South Carolina

Family Pleuronectidae

Glyptocephalus cynoglossus (Linnaeus) - Witch flounder - Newfoundland to North Carolina
Hippoglossoides platessoides (Fabricius) - American plaice - Nova Scotia to Cape Cod
Hippoglossus hippoglossus (Linnaeus) - Atlantic halibut - Labrador to Chesapeake Bay
Limanda ferruginea (Storer) - Yellowtail flounder - Nova Scotia to Chesapeake Bay
Pseudopleuronectes americanus (Walbaum) - Winter flounder - Nova Scotia to Georgia

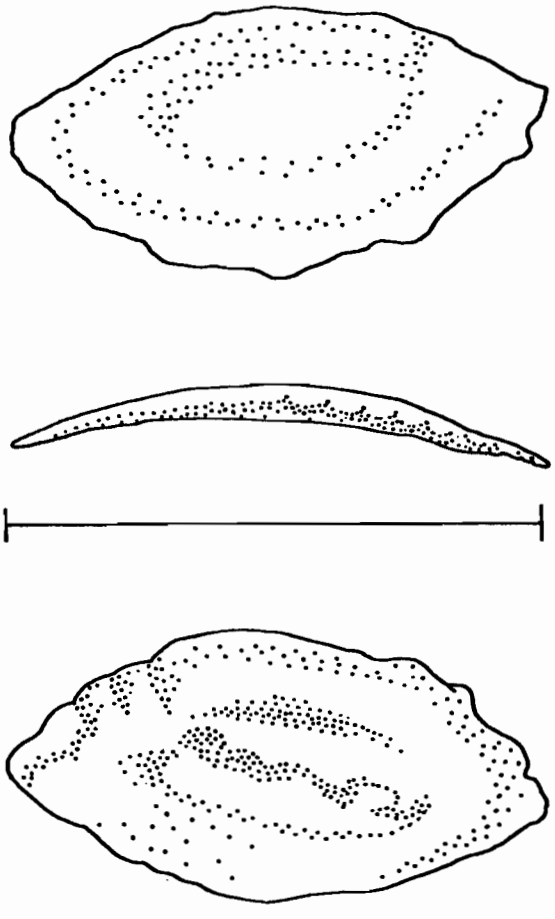
List of Plates by Species Scientific Name

List of Plates by Species Common Name



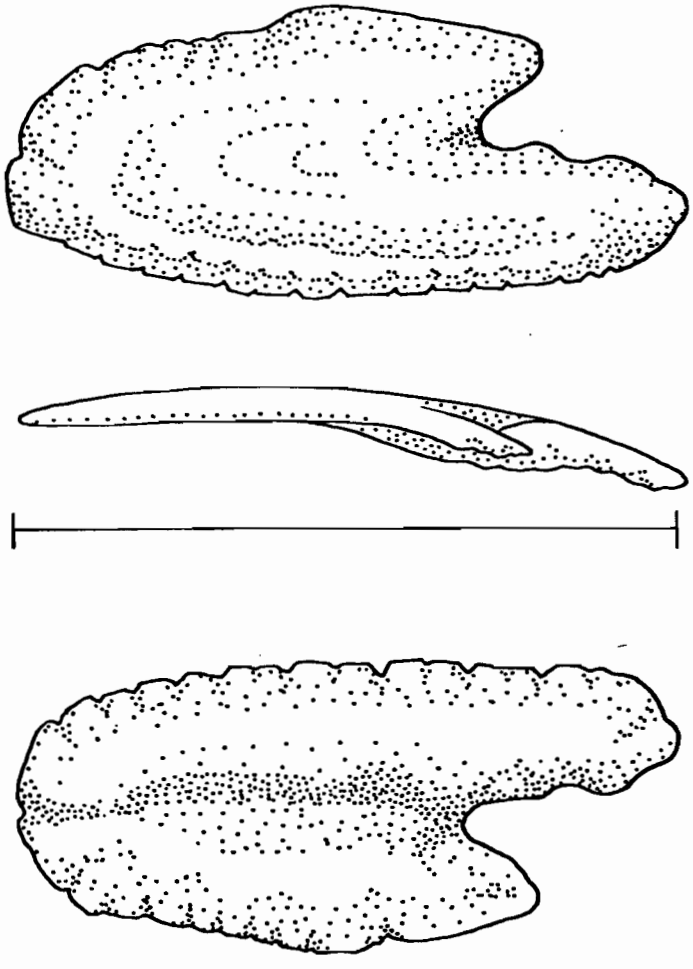
Anguilla rostrata (Lesueur)

American eel
fish length 5.6 cm
scale bar 3.6 mm



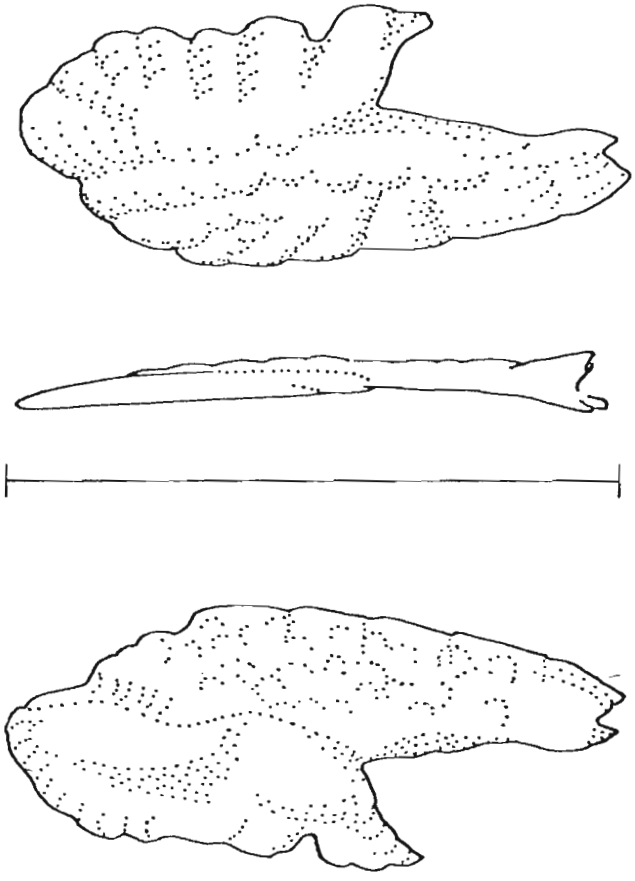
Alosa aestivalis (Mitchill)

Blueback herring
fish length 12 cm
scale bar 3.6 mm



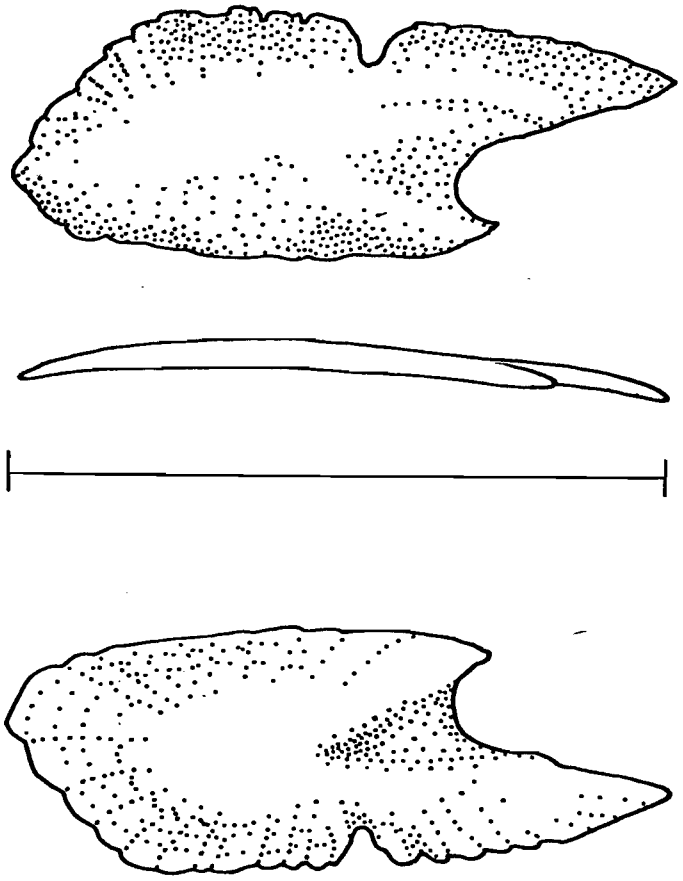
Alosa pseudoharengus (Wilson)

Alewife
fish length 25 cm
scale bar 7.4 mm



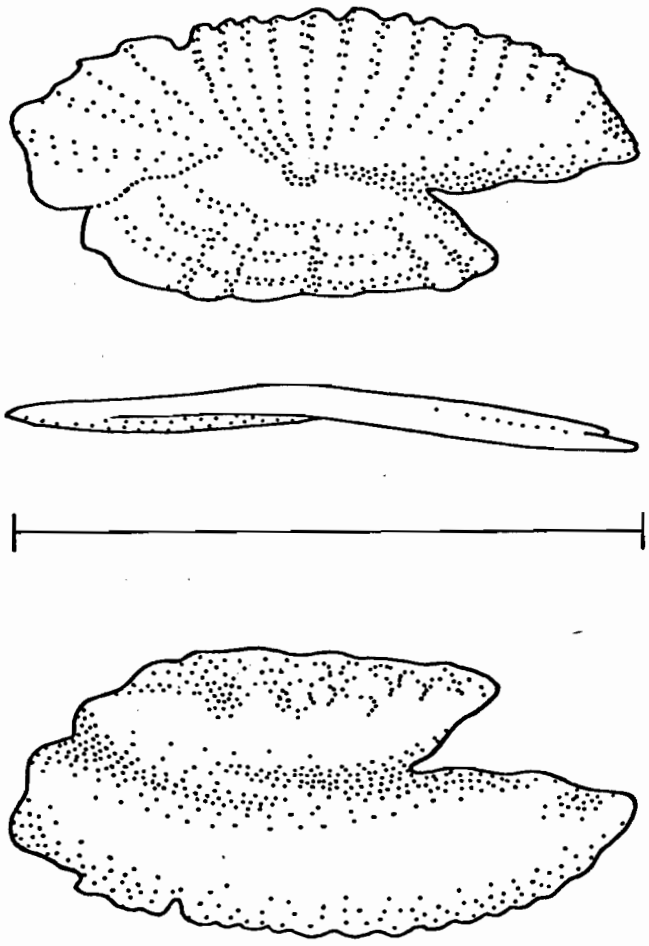
Alosa sapidissima (Wilson)

American shad
fish length 42 cm
scale bar 4.0 mm



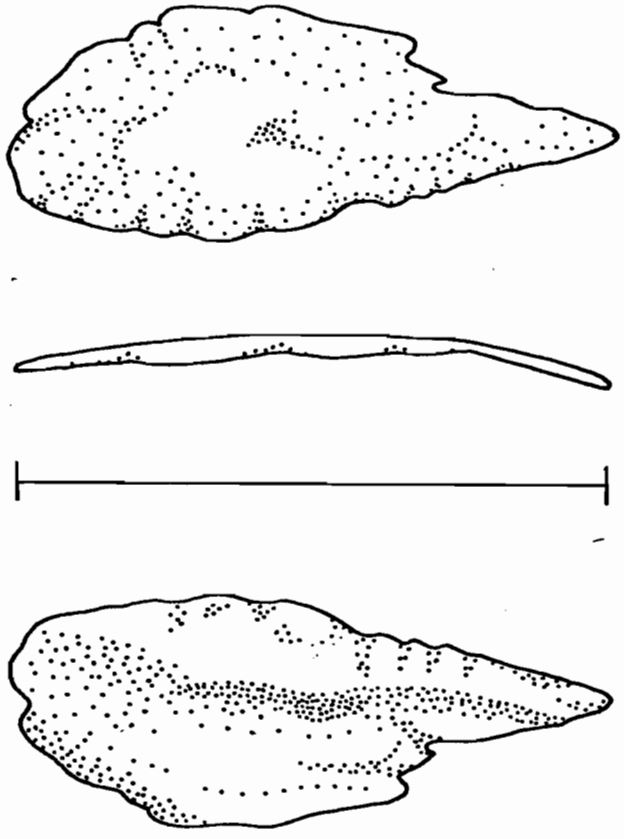
Brevoortia tyrannus (Latrobe)

Atlantic menhaden
scale bar 4.5 mm



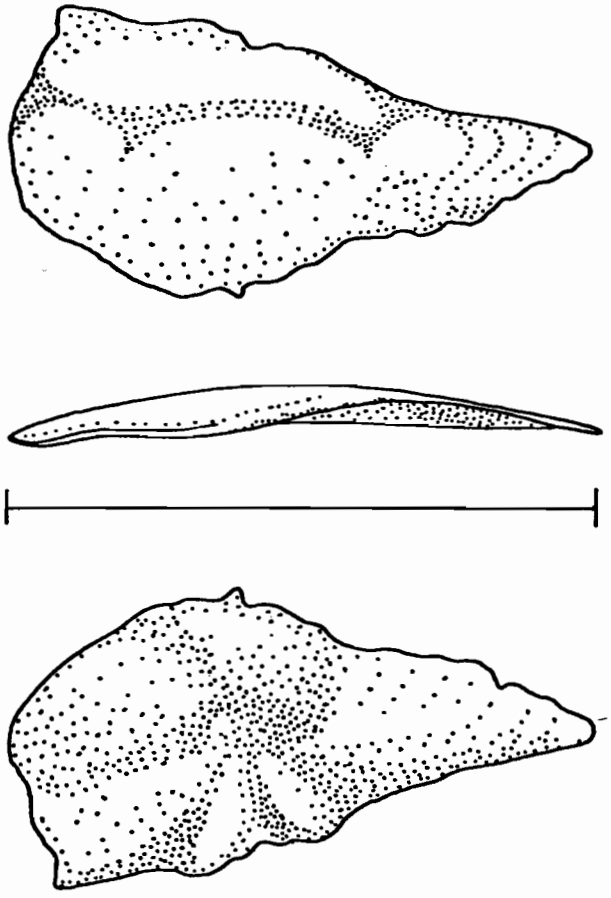
Clupea harengus harengus Linnaeus

Atlantic herring
fish length 28 cm
scale bar 4.4 mm



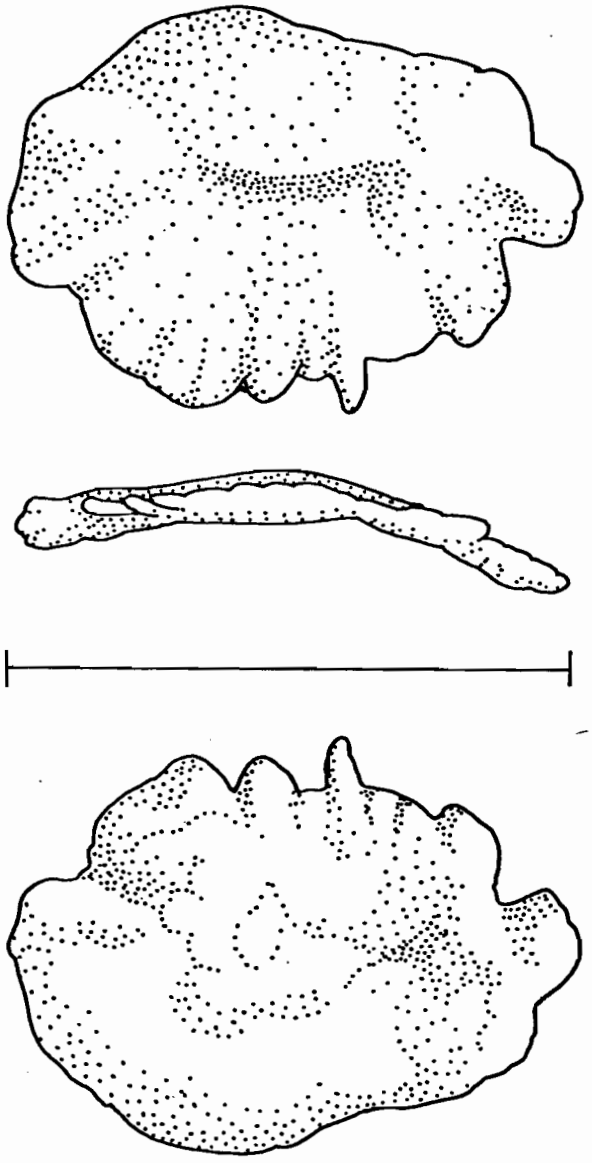
Etrumeus teres (DeKay)

Round herring
fish length 15.7 cm
scale bar 13.2 mm



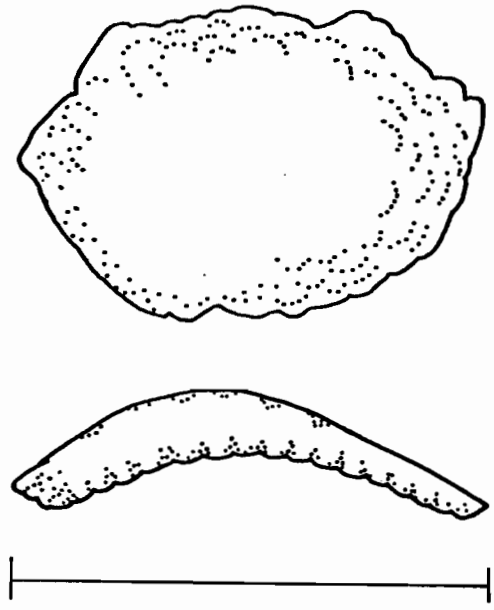
Argentina silus Ascanius

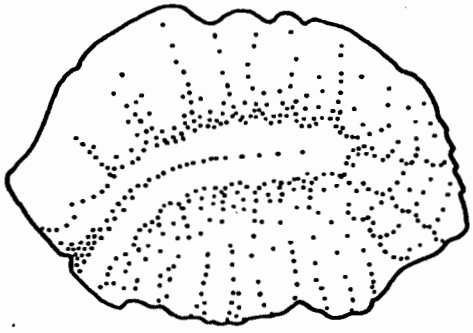
Atlantic argentine
fish length 37 cm
scale bar 10 mm



Lophius americanus Valenciennes

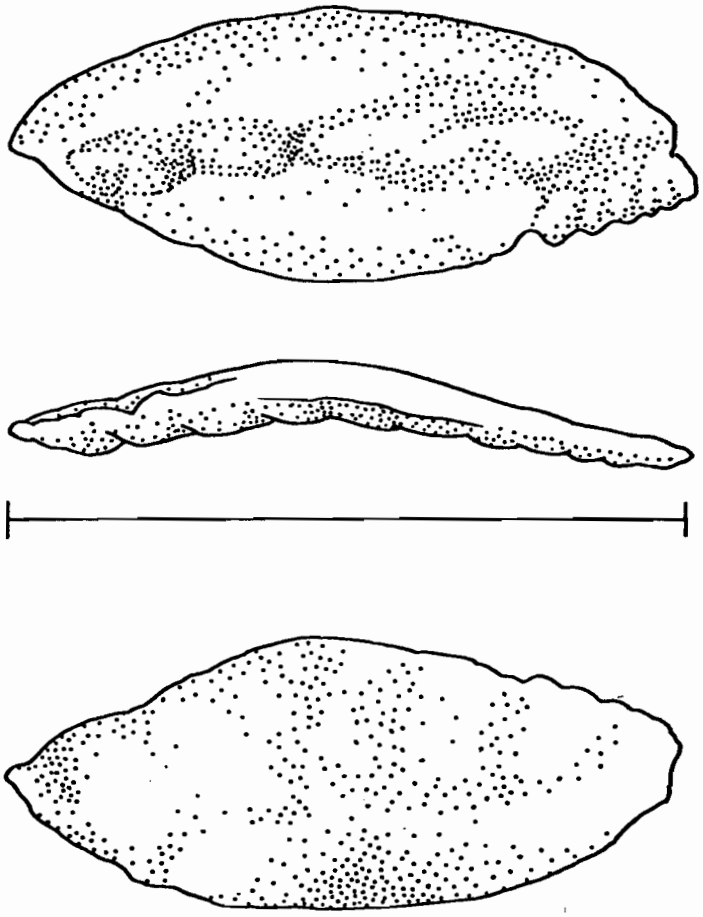
Goosefish
fish length 61.8 cm
scale bar 8.5 mm





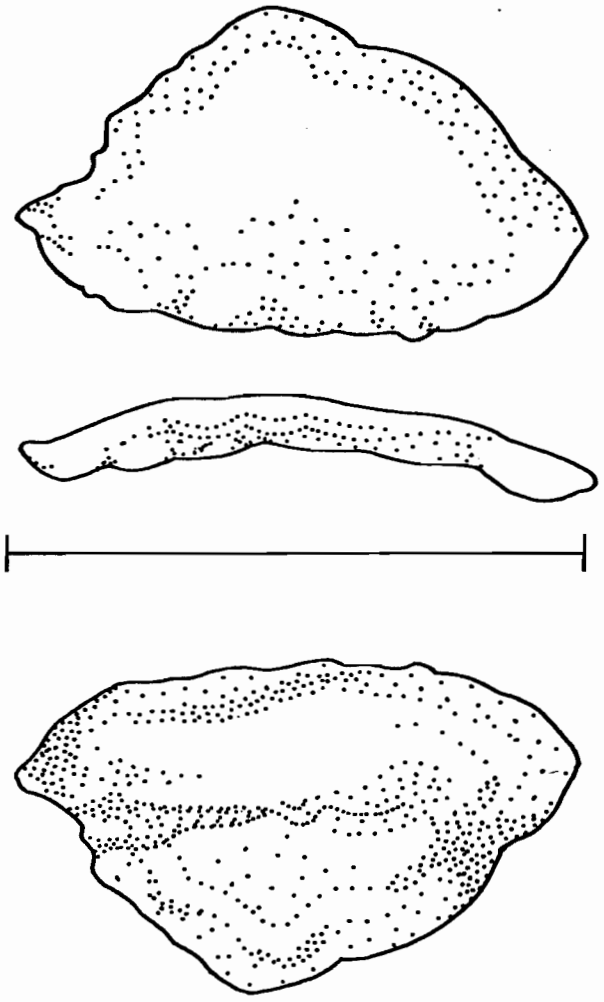
Opsanus tau (Linnaeus)

Oyster toadfish
fish length 24 cm
scale bar 7 mm



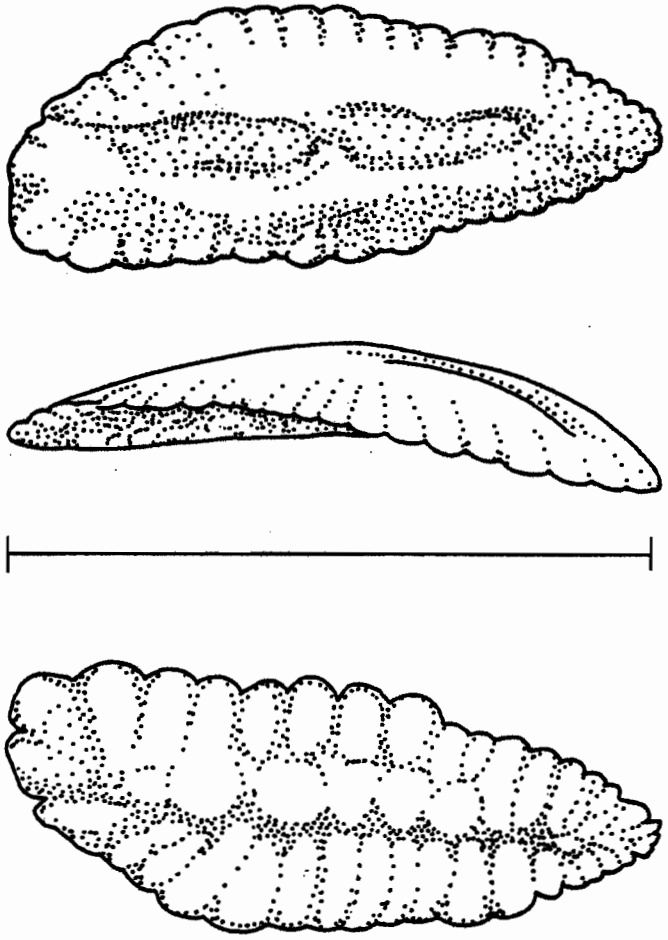
Brosme brosme (Müller)

Cusk
fish length 77 cm
scale bar 16 mm



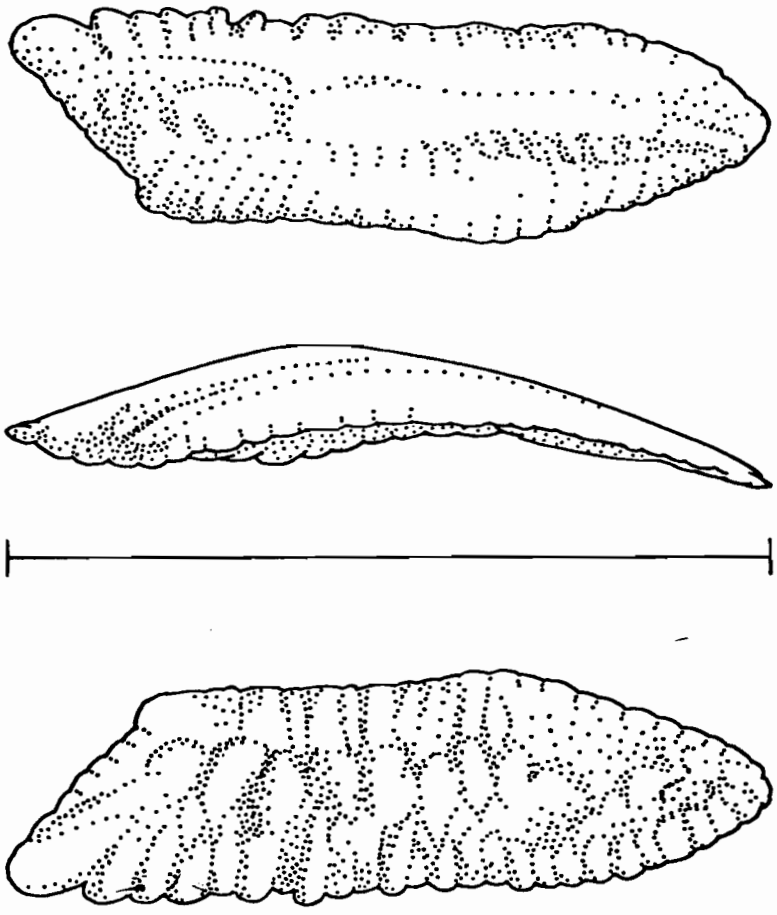
Enchelyopus cimbrius (Linnaeus)

Fourbeard rockling
fish length 26 cm
scale bar 4.8 mm



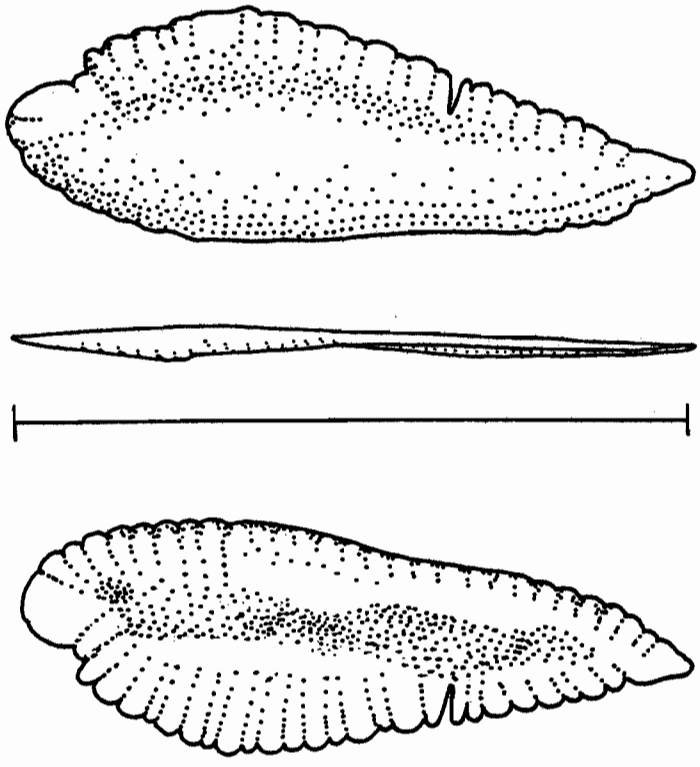
Gadus morhua Linnaeus

Atlantic cod
fish length 74.0 cm
scale bar 19.6 mm



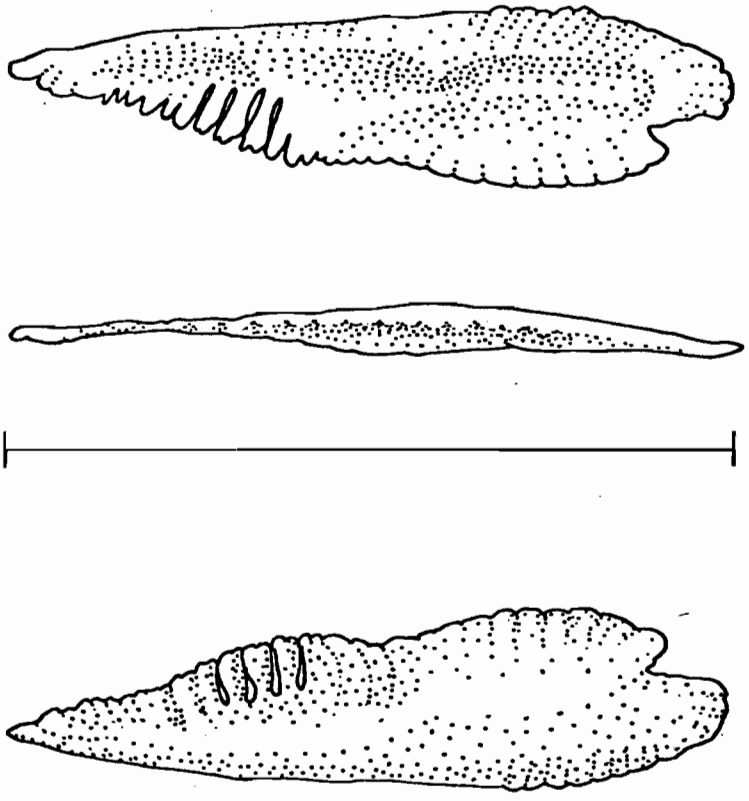
Melanogrammus aeglefinus (Linnaeus)

Haddock
fish length 69 cm
scale bar 21.5 mm



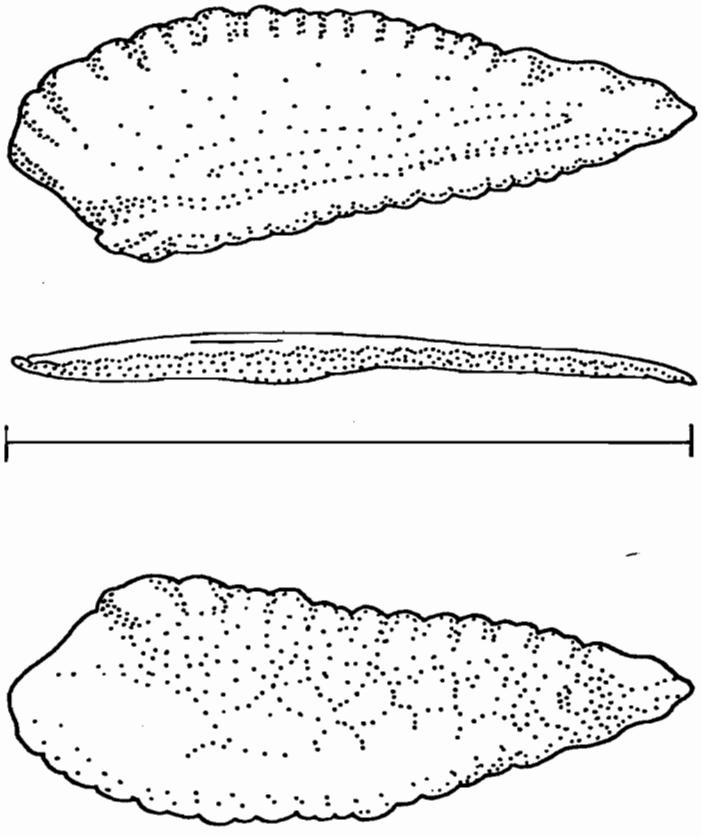
Merluccius albidus (Mitchill)

Offshore hake
fish length 52 cm
scale bar 24 mm



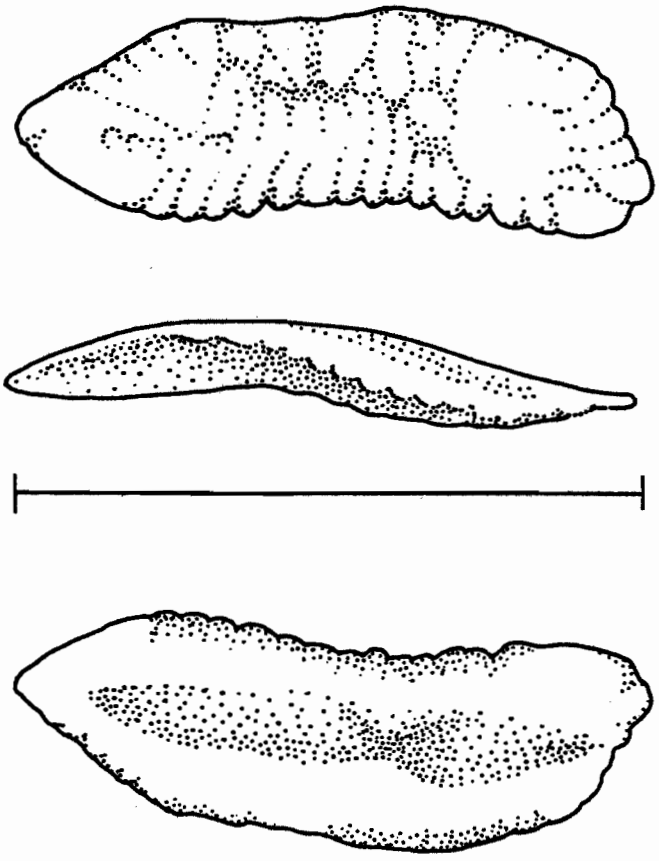
Merluccius bilinearis (Mitchill)

Silver hake
fish length 45 cm
scale bar 21.6 mm



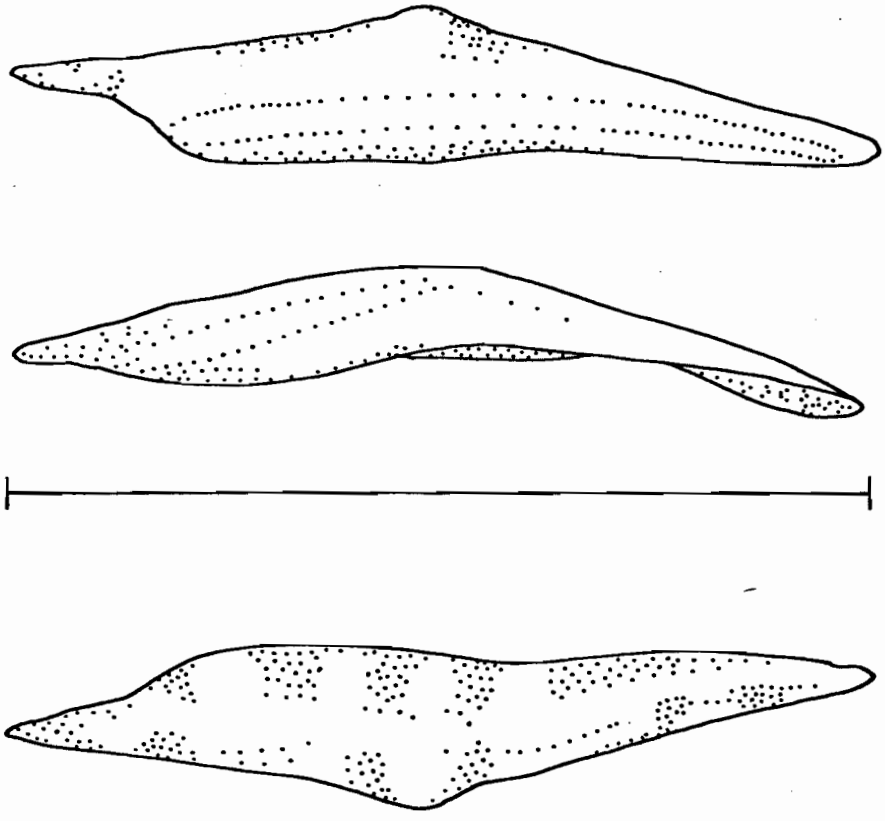
Phycis chesteri Goode & Bean

Longfin hake
fish length 20 cm
scale bar 8.1 mm



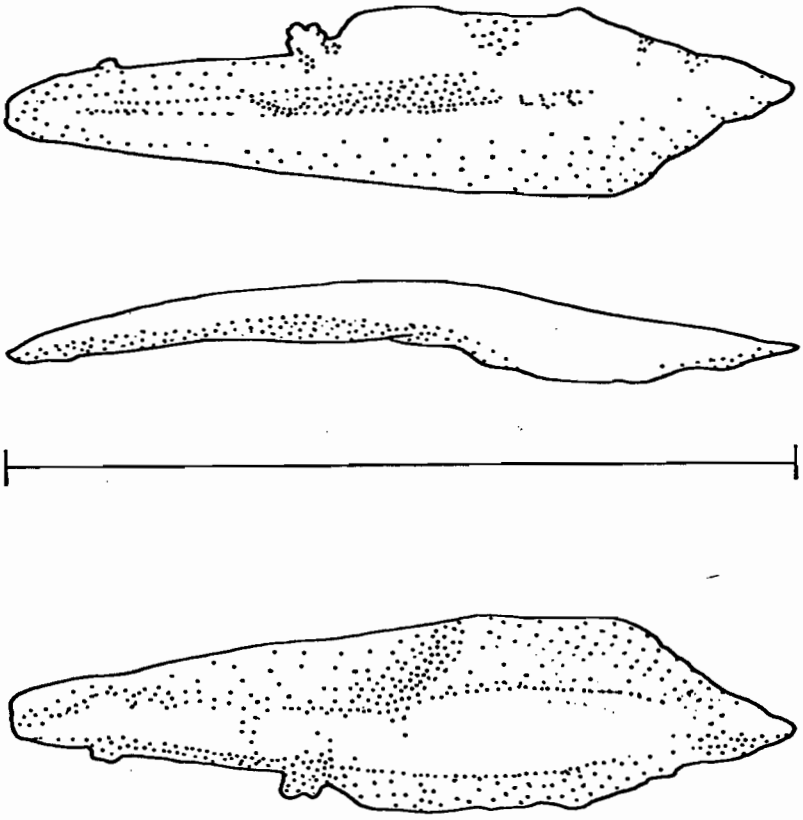
Pollachius virens (Linnaeus)

Pollock
fish length 66 cm
scale bar 17 mm



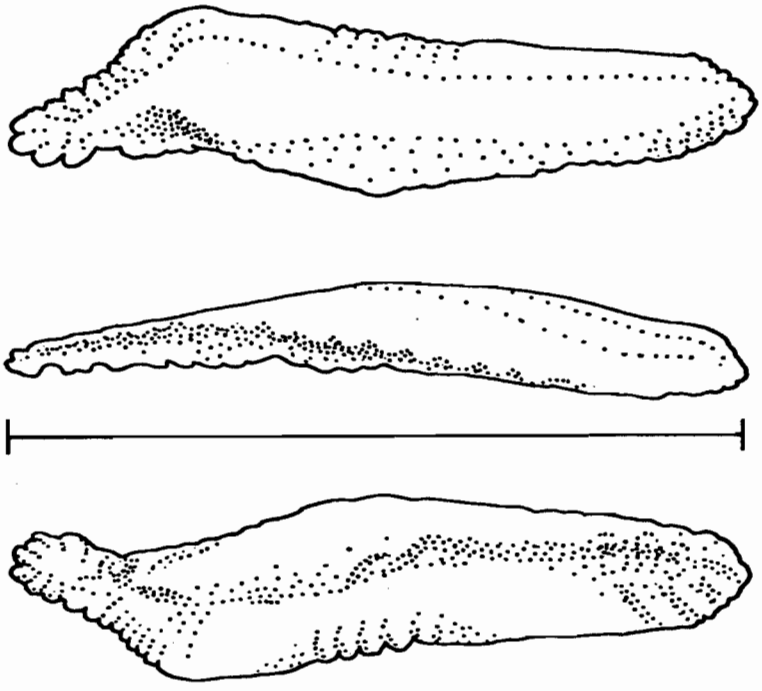
Urophycis chuss (Walbaum)

Red hake
fish length 58 cm
scale bar 22.3 mm



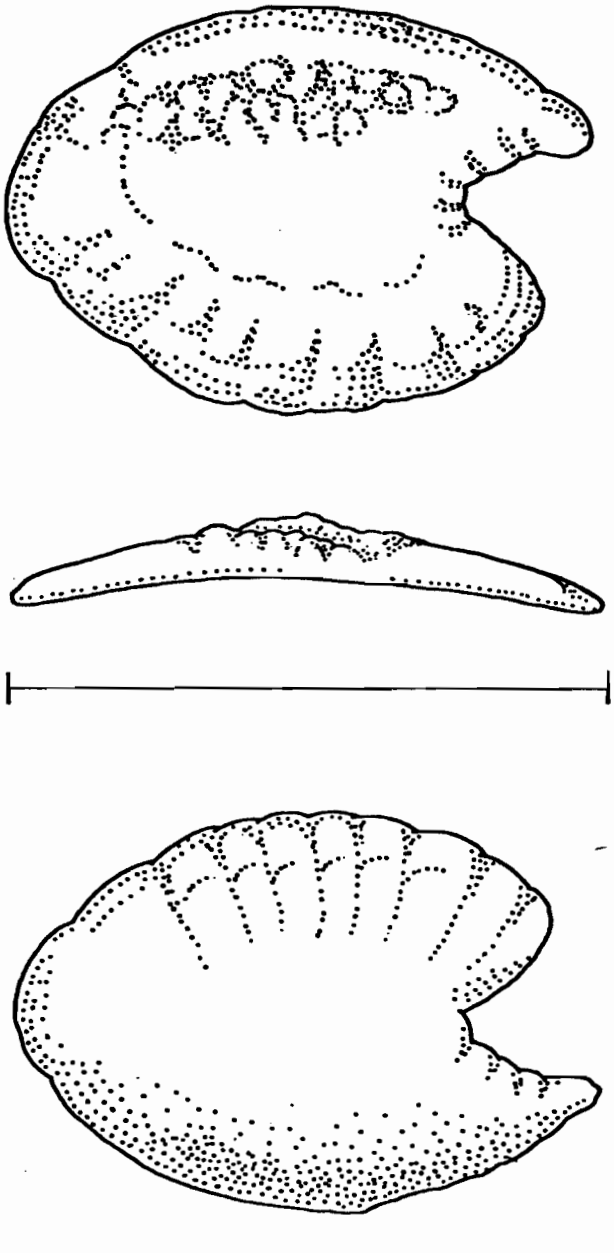
Urophycis regius (Walbaum)

Spotted hake
fish length 36 cm
scale bar 13.2 mm



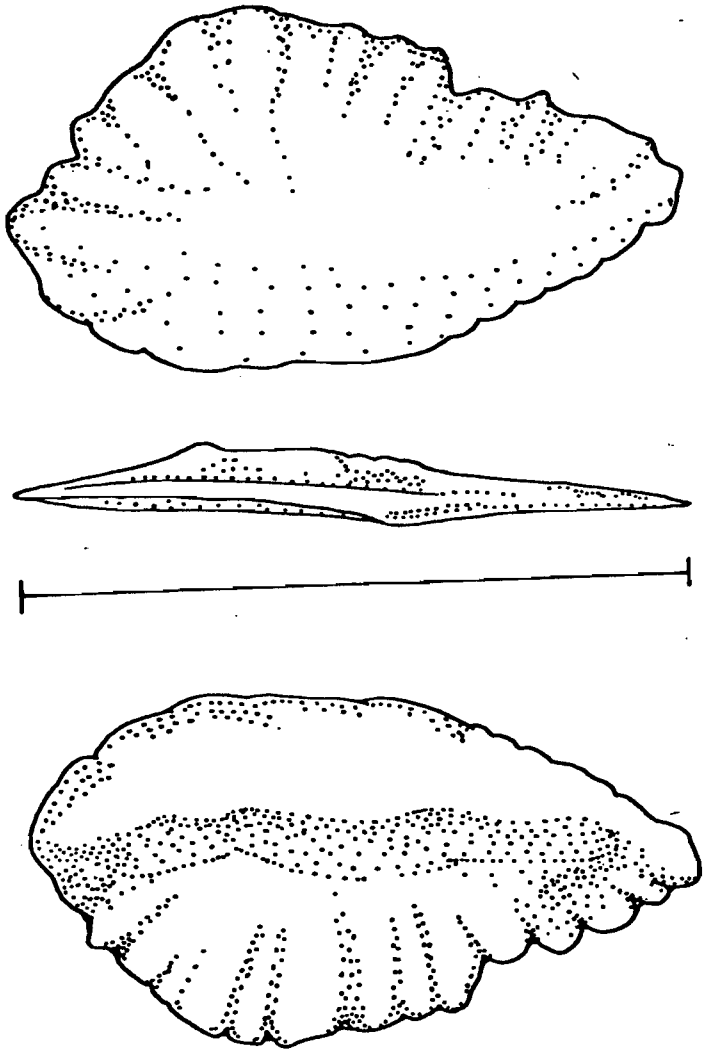
Urophycis tenuis (Mitchill)

White hake
fish length 77 cm
scale bar 26.8 mm



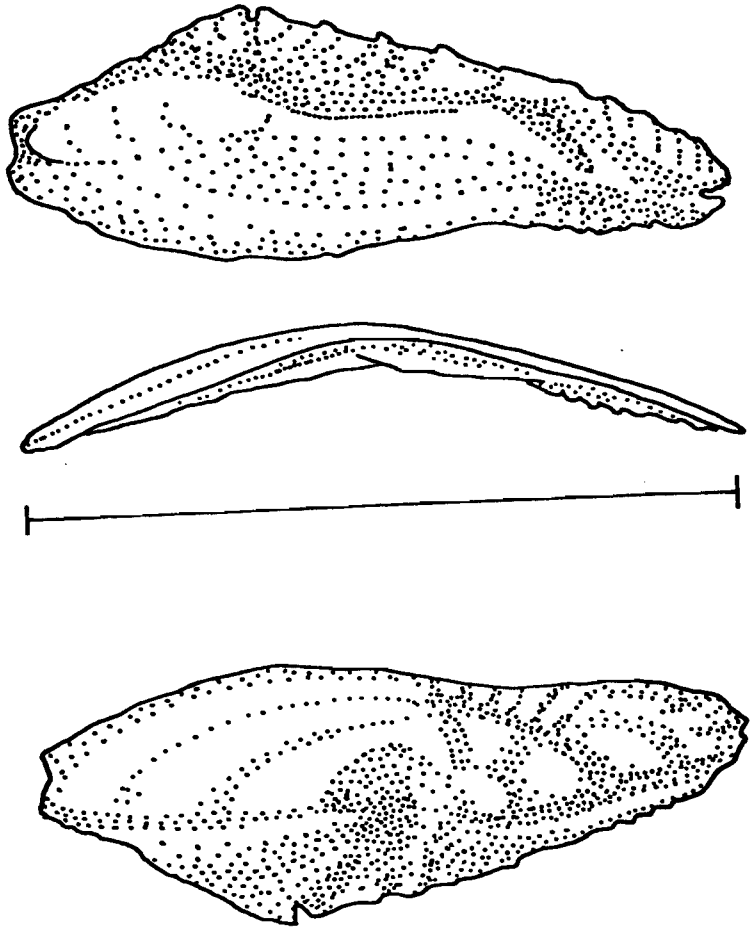
Macrozoarces americanus (Block & Schneider)

Ocean pout
fish length 82 cm
scale bar 4.7 mm



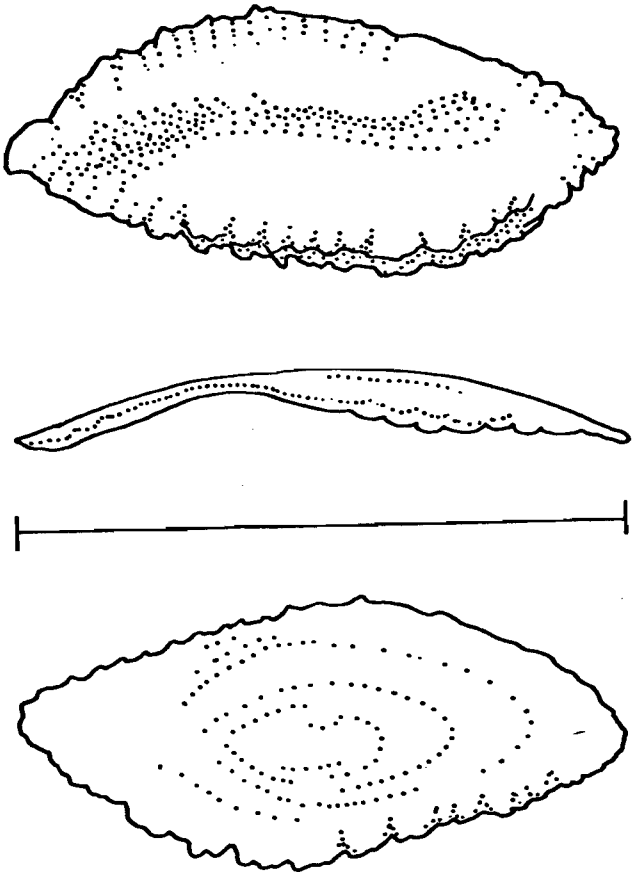
Nezumia bairdi (Goode & Bean)

Marlin-spike
fish length 31 cm
scale bar 19 mm



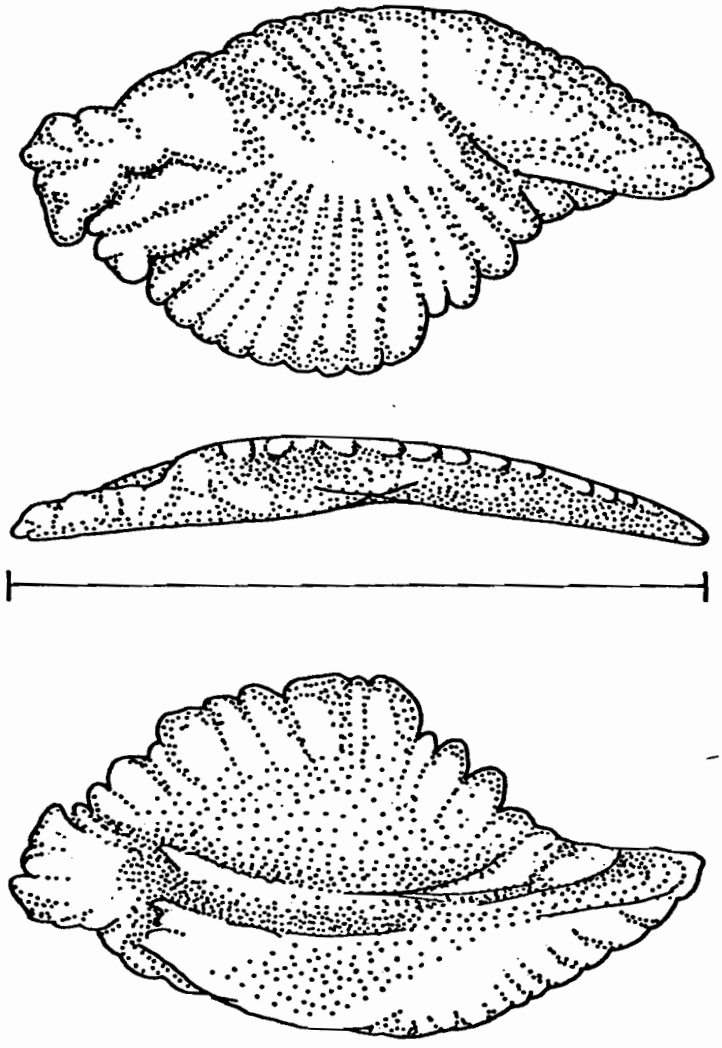
Morone saxatilis (Walbaum)

Striped bass
fish length 25.8 cm
scale bar 16 mm



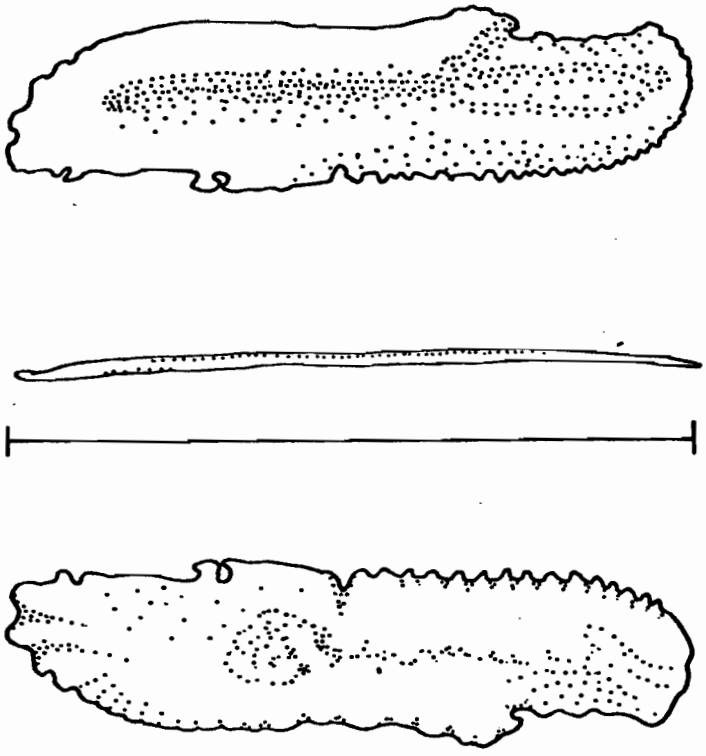
Centropristis striata (Linnaeus)

Black sea bass
fish length 33.6 cm
scale bar 11 mm



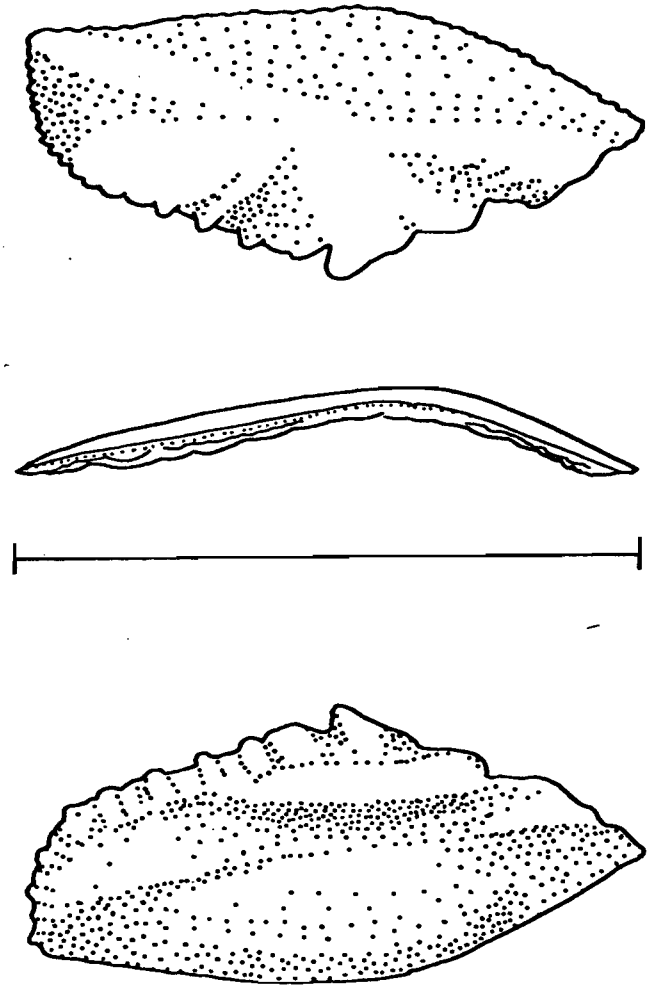
Lopholatius chamaeleonticeps (Goode & Bean)

Tilefish
fish length 57 cm
scale bar 18.8 mm



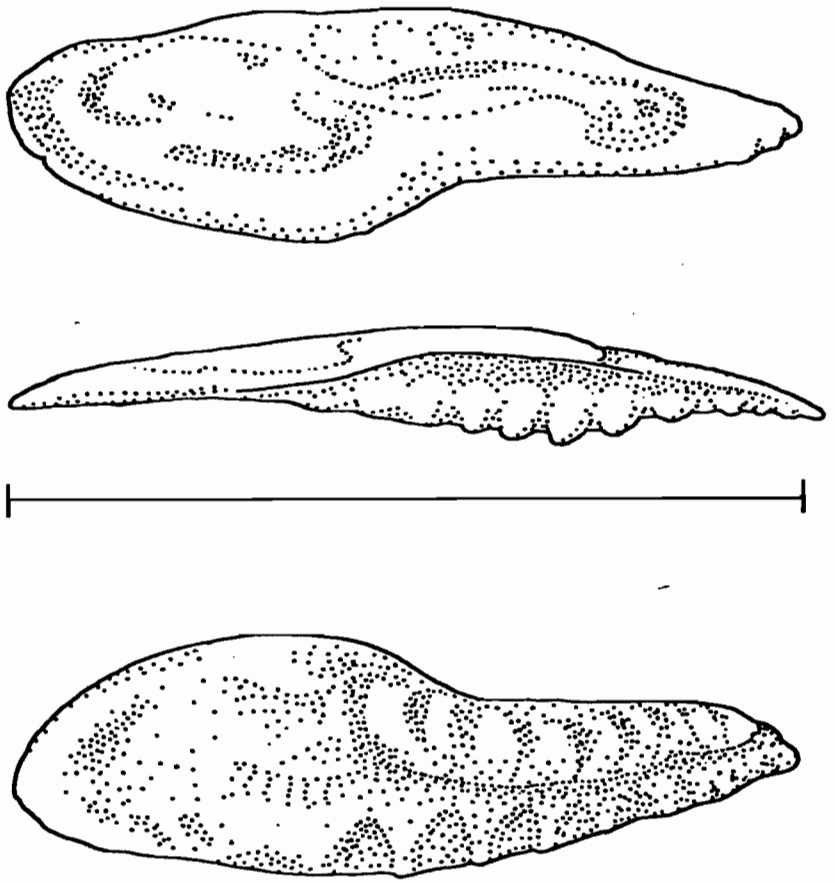
Pomatomus saltatrix (Linnaeus)

Bluefish
fish length 61 cm
scale bar 14 mm



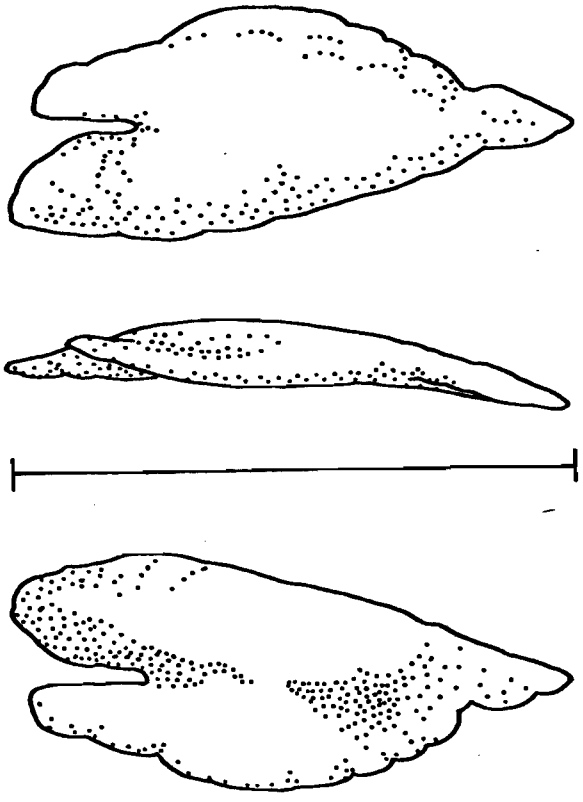
Stenotomus chrysops (Linnaeus)

Scup
fish length 26 cm
scale bar 10 mm



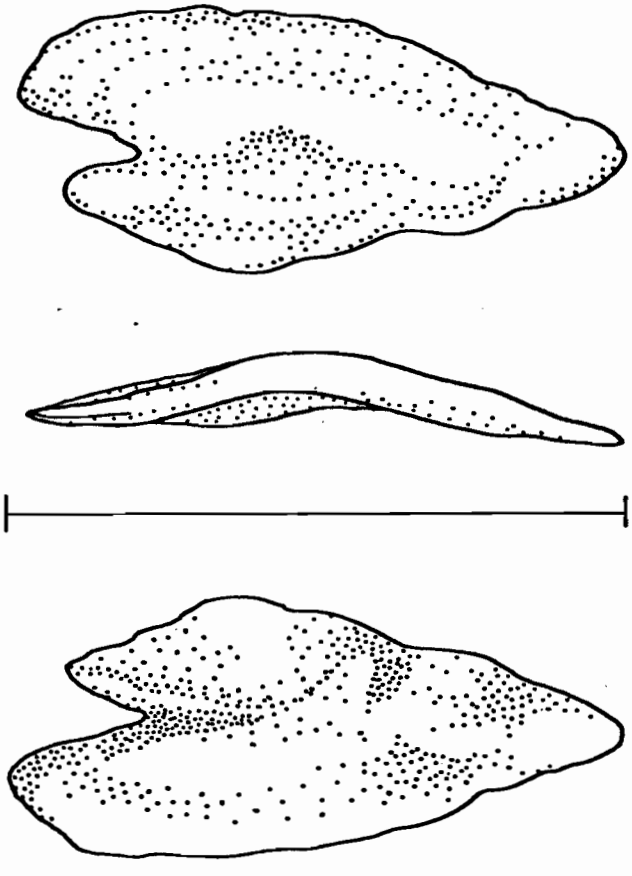
Cynoscion regalis (Bloch & Schneider)

Weakfish
fish length 76 cm
scale bar 32 mm



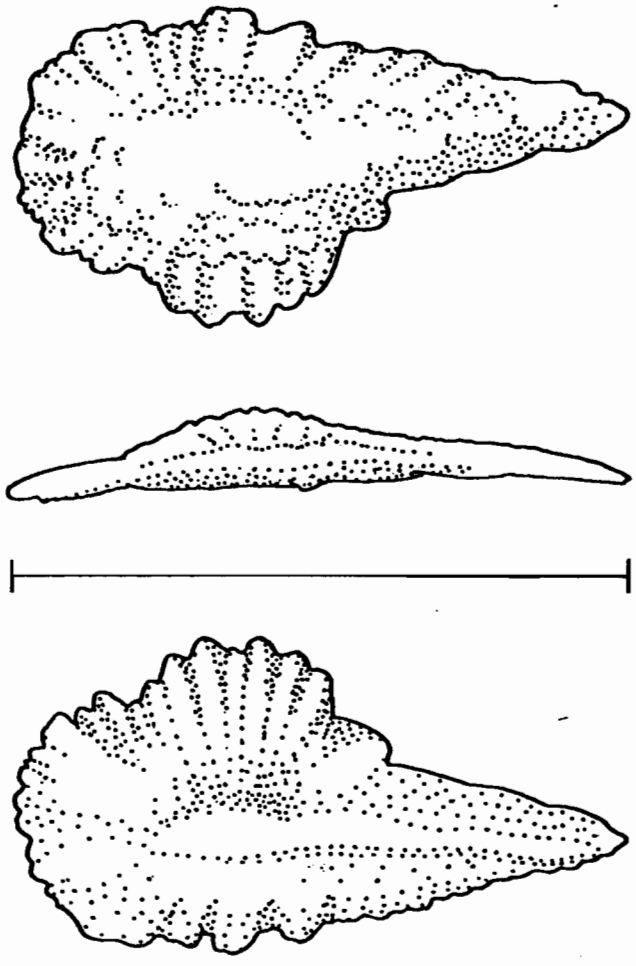
Tautoga onitis (Linnaeus)

Tautog
fish length 18 cm
scale bar 3.3 mm



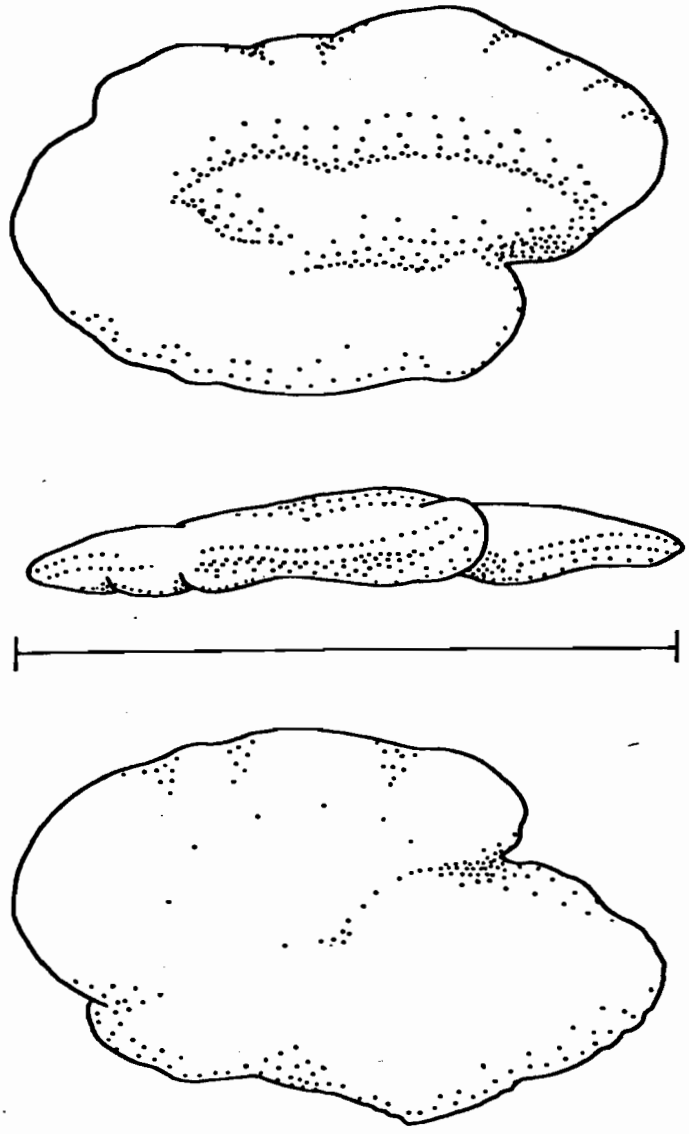
Tautogolabrus adspersus (Walbaum)

Cunner
fish length 14 cm
scale bar 2.5 mm



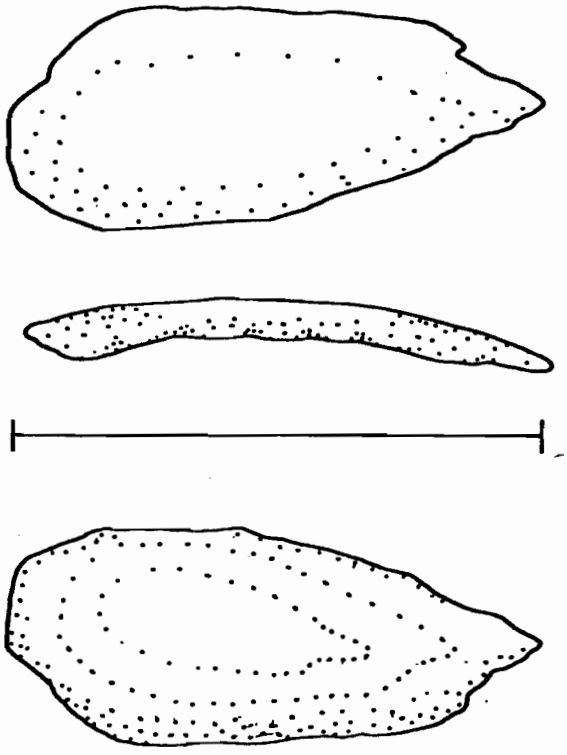
Anarhichas lupus Linnaeus

Atlantic wolffish
fish length 76.0 cm
scale bar 4.7 mm



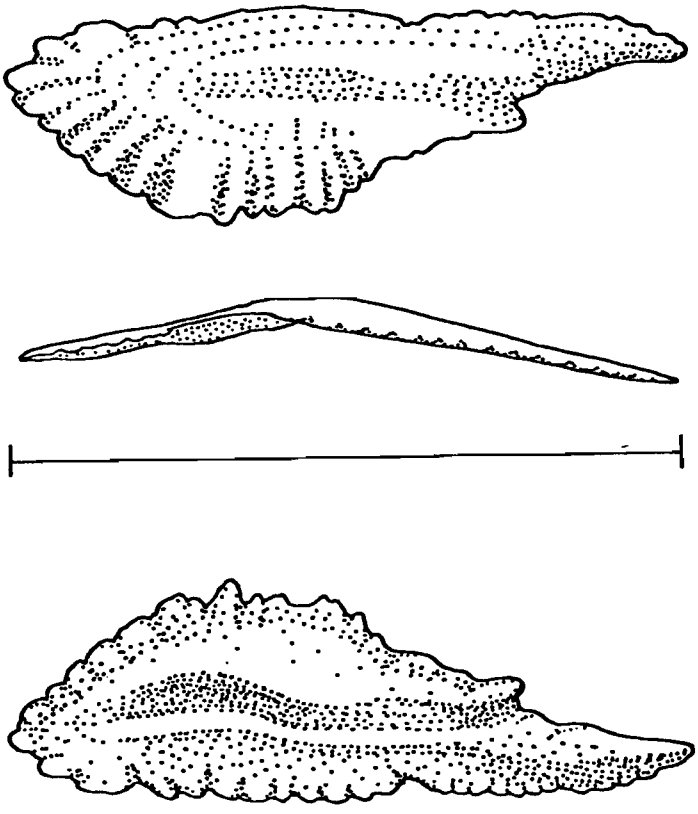
Cryptacanthodes maculatus Storer

Wrymouth
fish length 80.3 cm
scale bar 10.2 mm



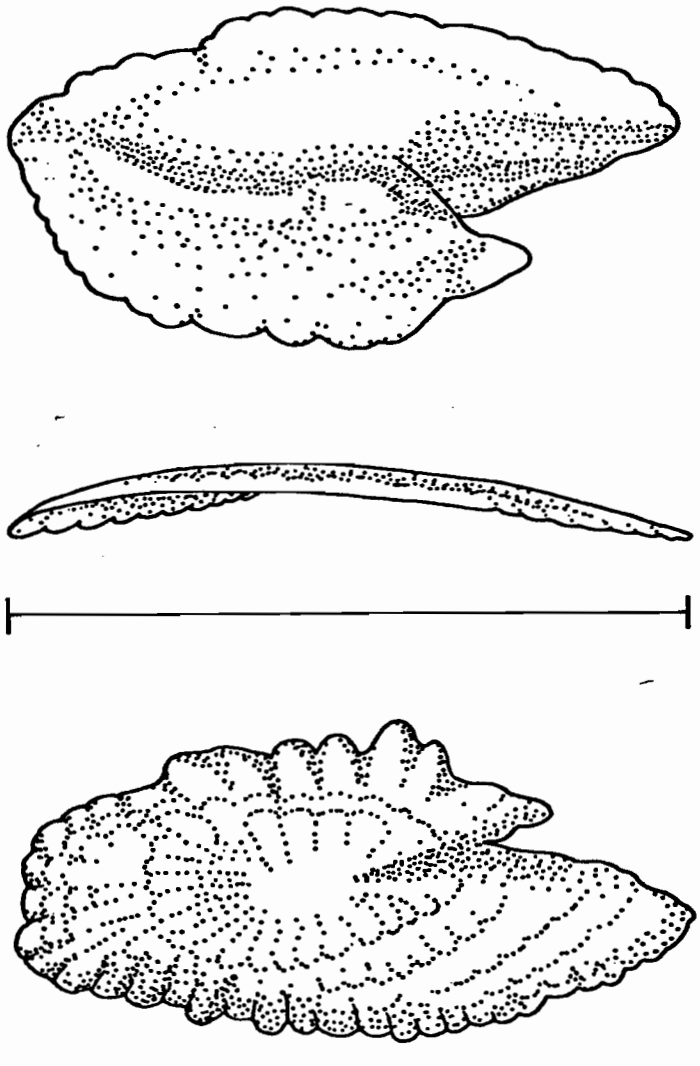
Ammodytes americanus (DeKay)

American sand lance
fish length 23.0 cm
scale bar 3.5 mm



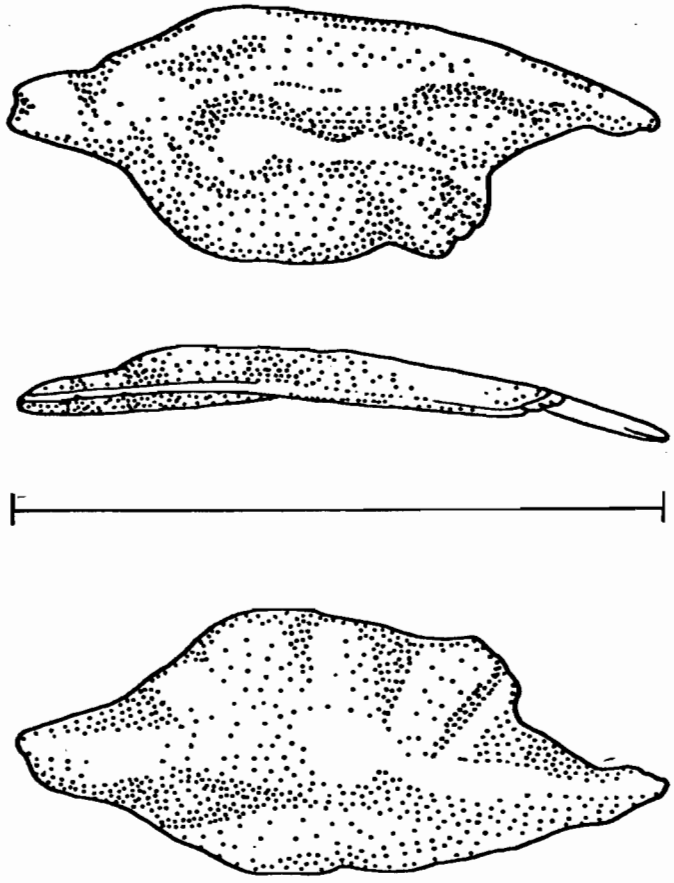
Scomber scombrus Linnaeus

Atlantic mackerel
fish length 36.7 cm
scale bar 5.2 mm



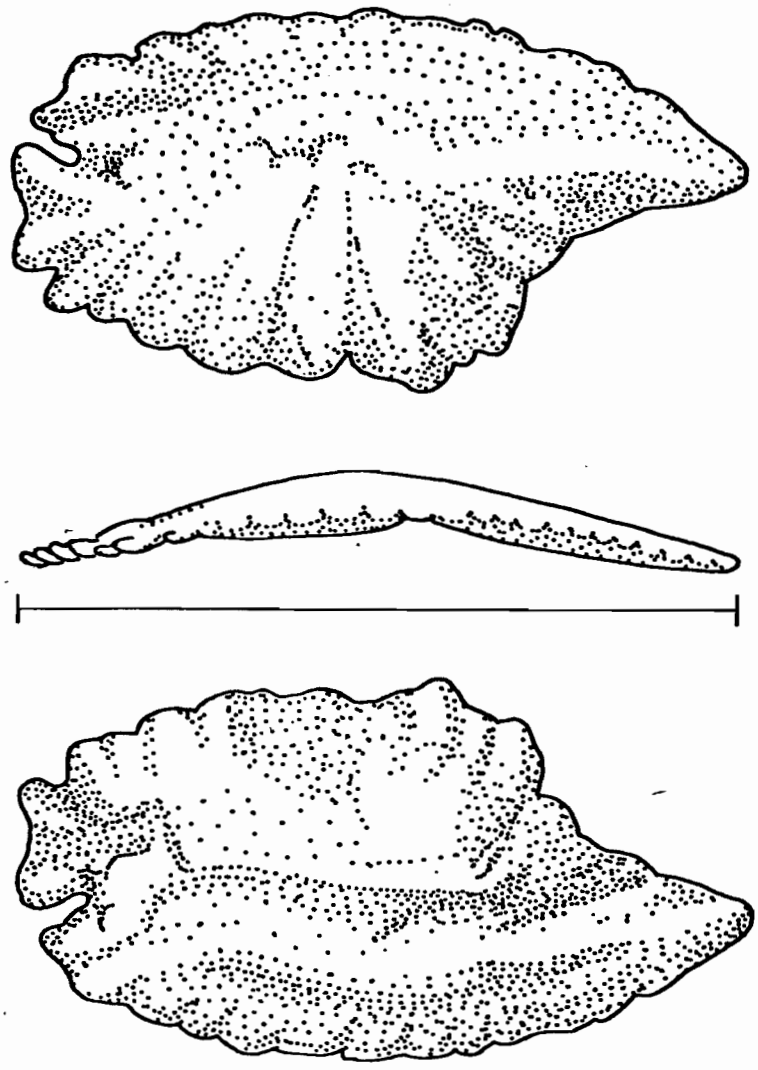
Peprilus triacanthus (Peck)

Butterfish
fish length 20 cm
scale bar 7.2 mm



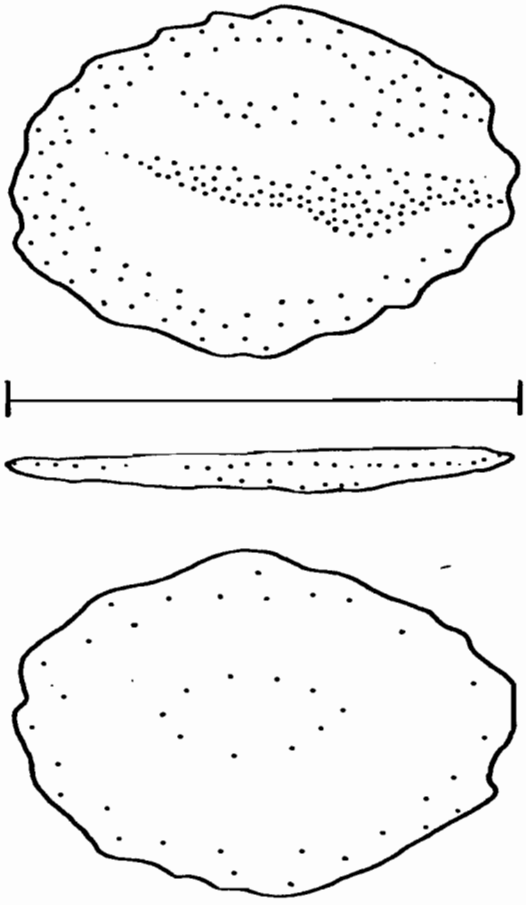
Helicolenus dactylopterus (De la Roche)

Blackbelly rosefish
fish length 36 cm
scale bar 14.7 mm



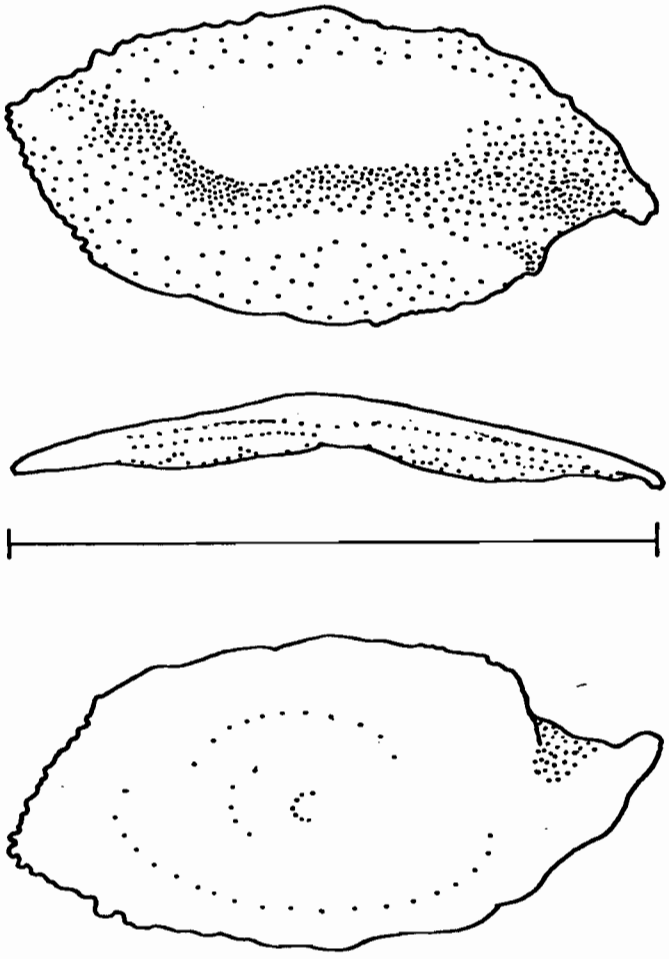
Sebastes marinus (Linnaeus)

Redfish
fish length 36 cm
scale bar 16.2 mm



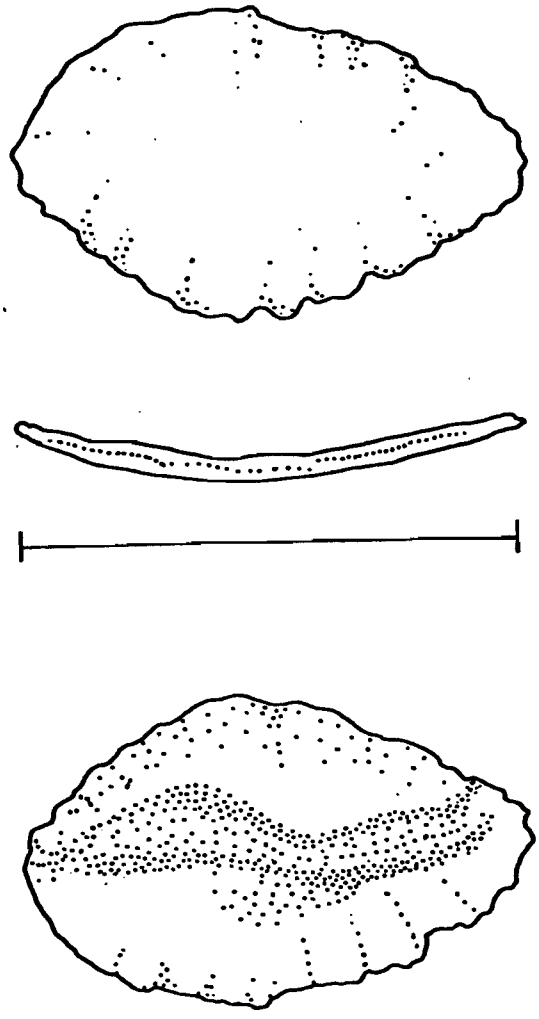
Peristedion miniatum Goode

Armored Sea Robin
scale bar 5.5 mm



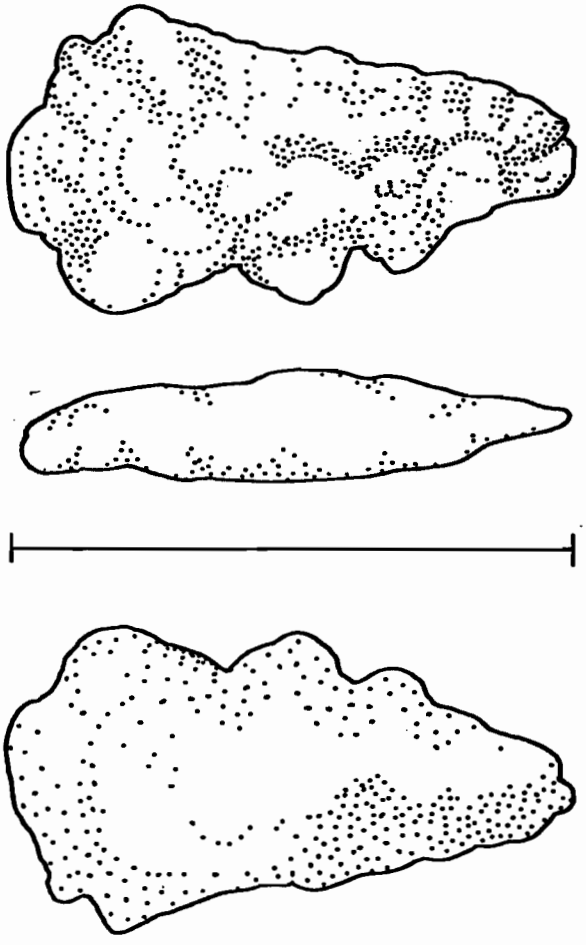
Prionotus carolinus (Linnaeus)

Northern searobin
fish length 31.6 cm
scale bar 8.6 mm



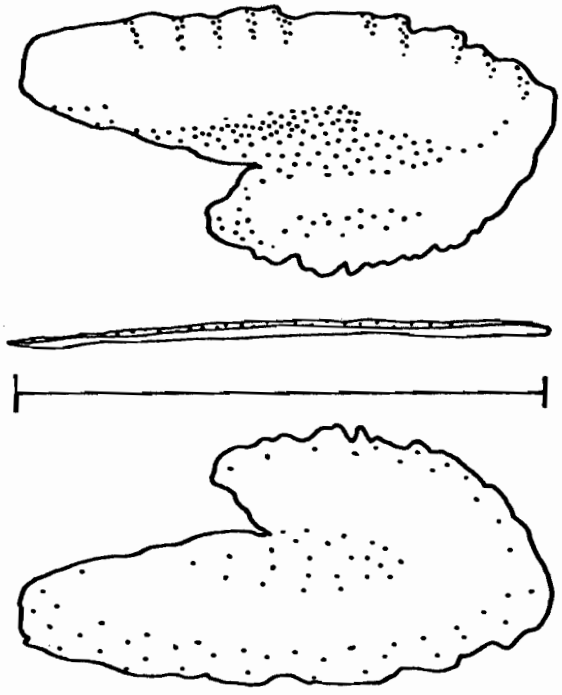
Prionotus evolans (Linnaeus)

Striped searobin
fish length 32.7 cm
scale bar 9 mm



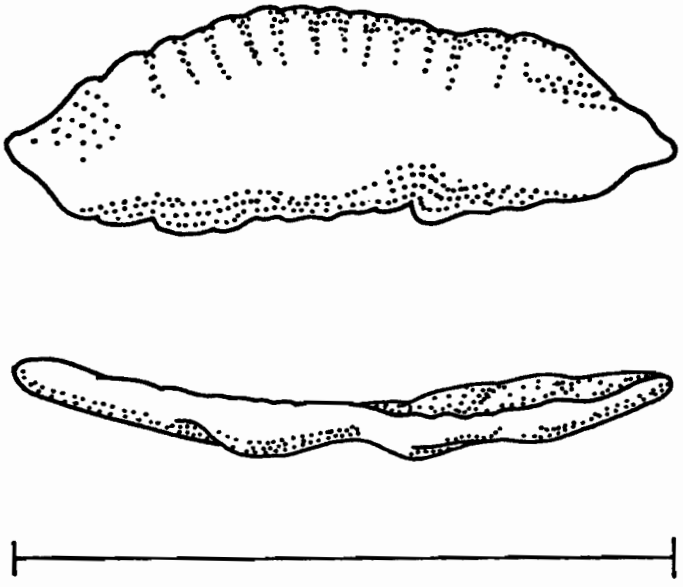
Hemitripterus americanus (Gmelin)

Sea raven
fish length 35.4 cm
scale bar 4.6 mm



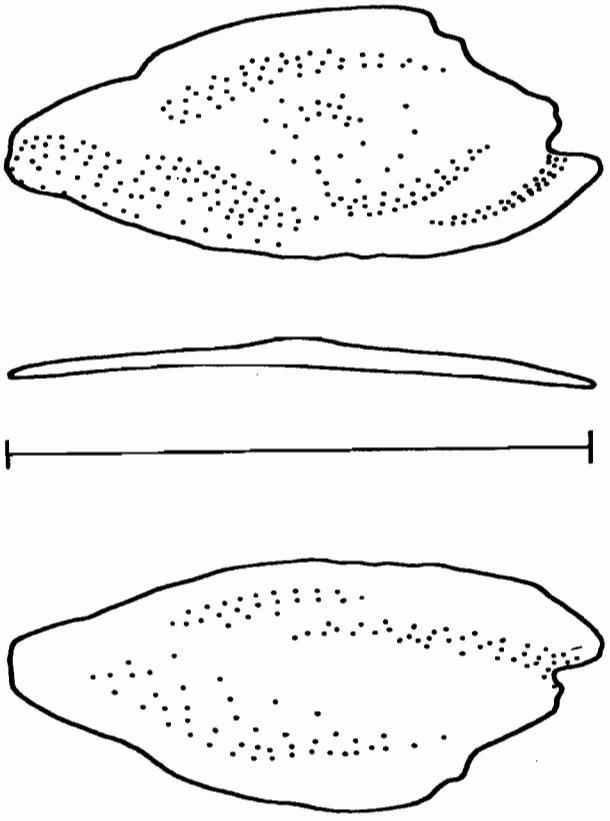
Myoxocephalus aenaeus (Mitchill)

Grubby
fish length 12 cm
scale bar 3.3 mm



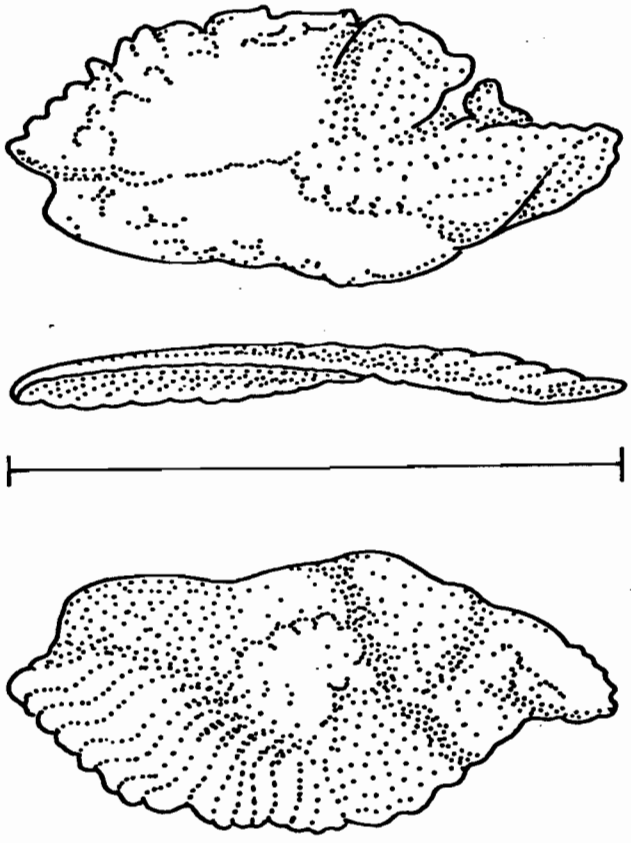
Myoxocephalus octodecemspinosus (Mitchell)

Longhorn sculpin
fish length 22 cm
scale bar 8.6 mm



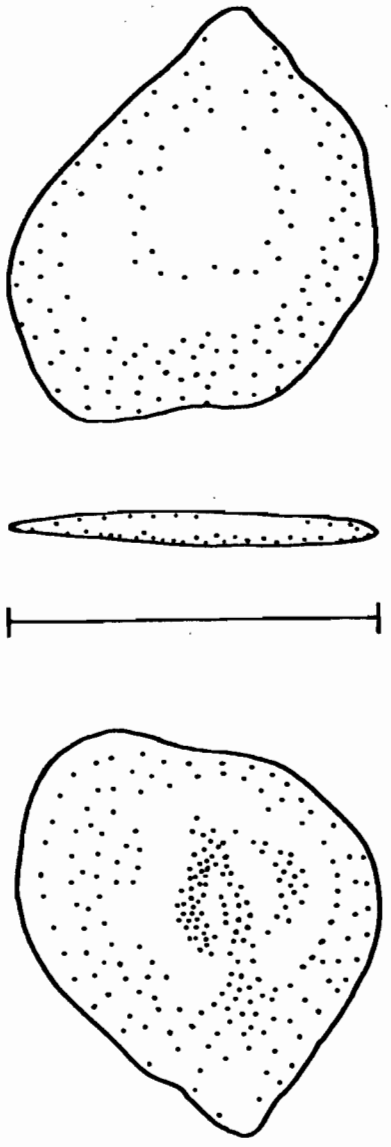
Triglops nybelini Jensen

Mailed sculpin
fish length 21 cm
scale bar 3.9 mm



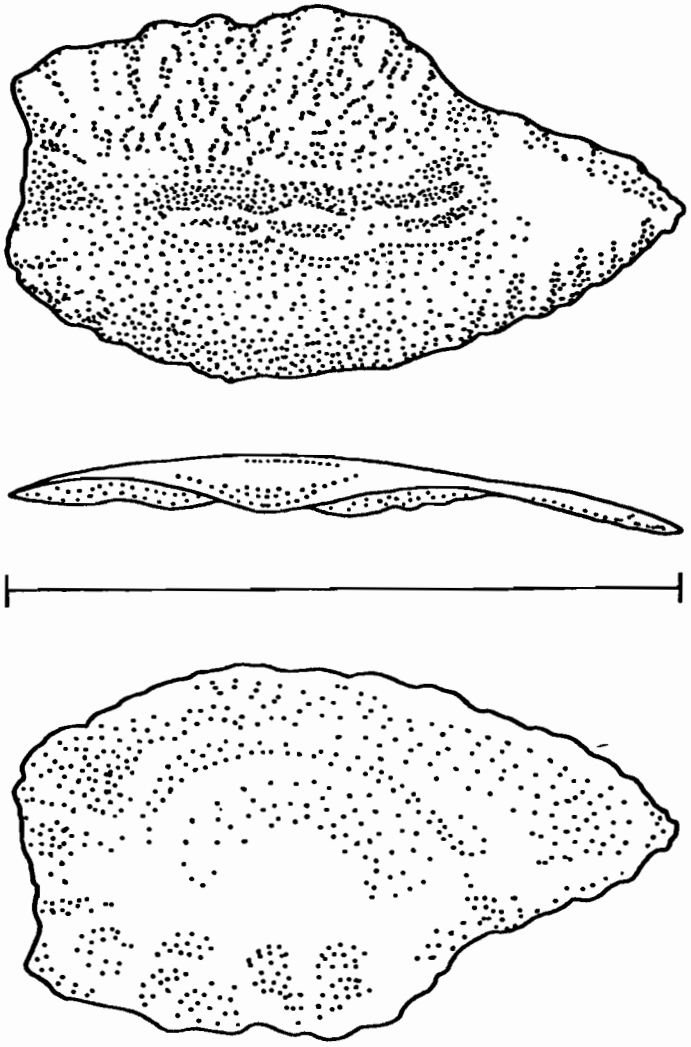
Aspidophoroides monopterygius (Bloch)

Alligatorfish
fish length 25.4 cm
scale bar 3.2 mm



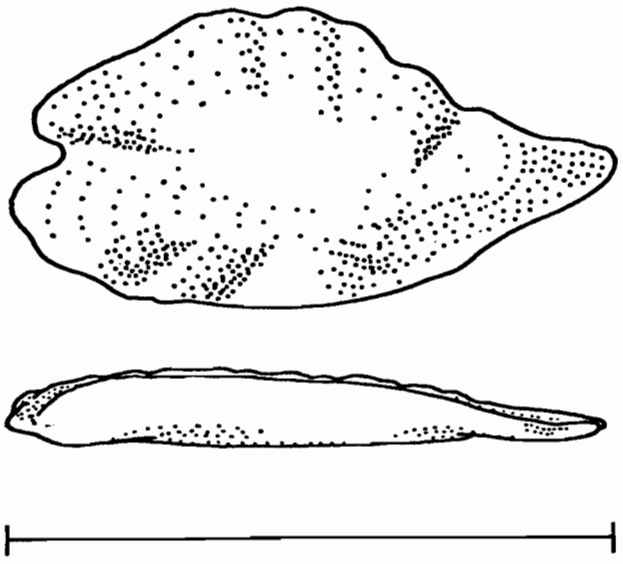
Citharichthys arctifrons Goode

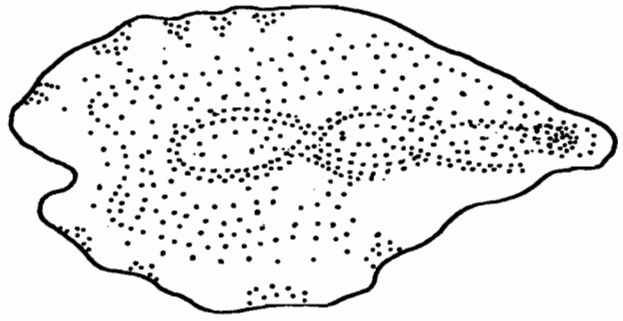
Gulf Stream flounder
fish length 19 cm
scale bar 3 mm



Paralichthys dentatus (Linnaeus)

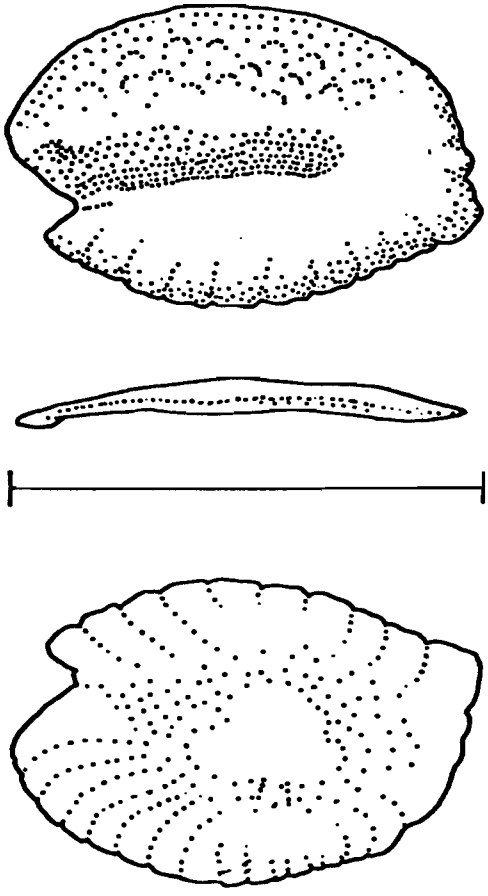
Summer flounder
fish length 59 cm
scale bar 9 mm





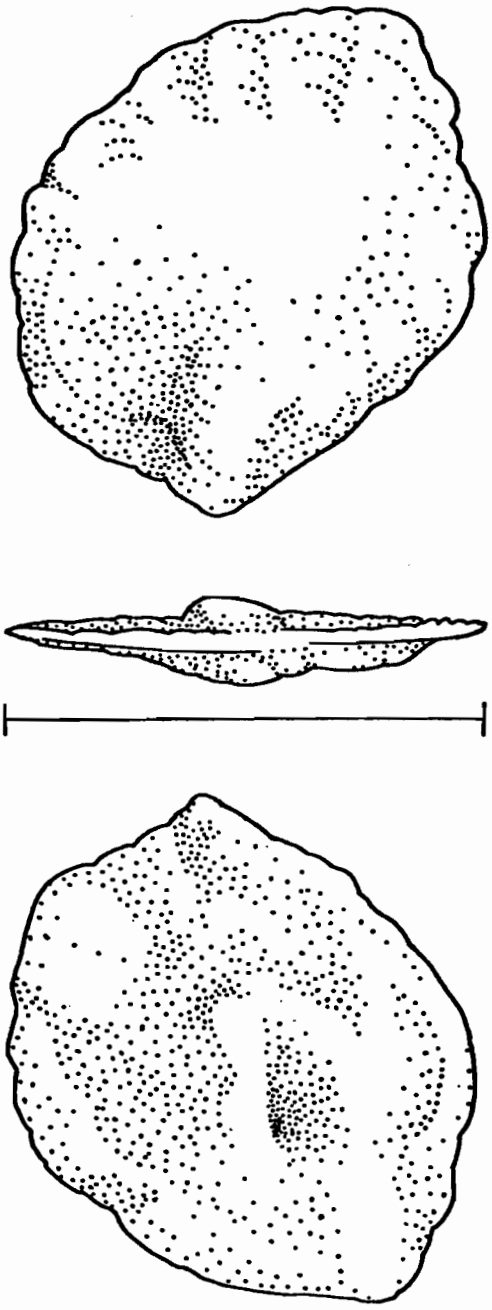
Paralichthys oblongus (Mitchill)

Fourspot flounder
fish length 39.5 cm
scale bar 8 mm



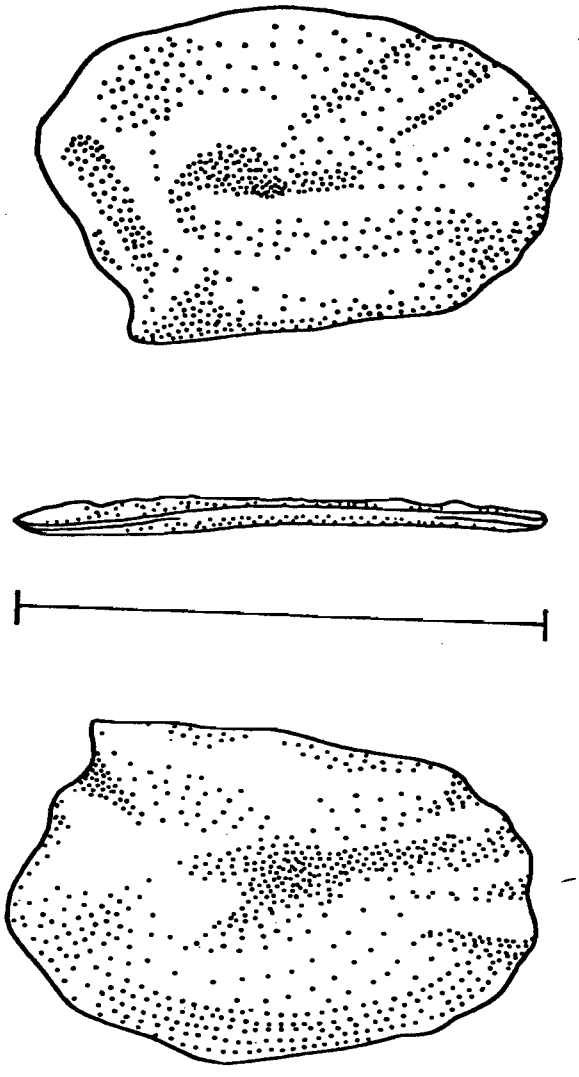
Scophthalmus aquosus (Mitchill)

Windowpane
fish length 30 cm
scale bar 4.7 mm



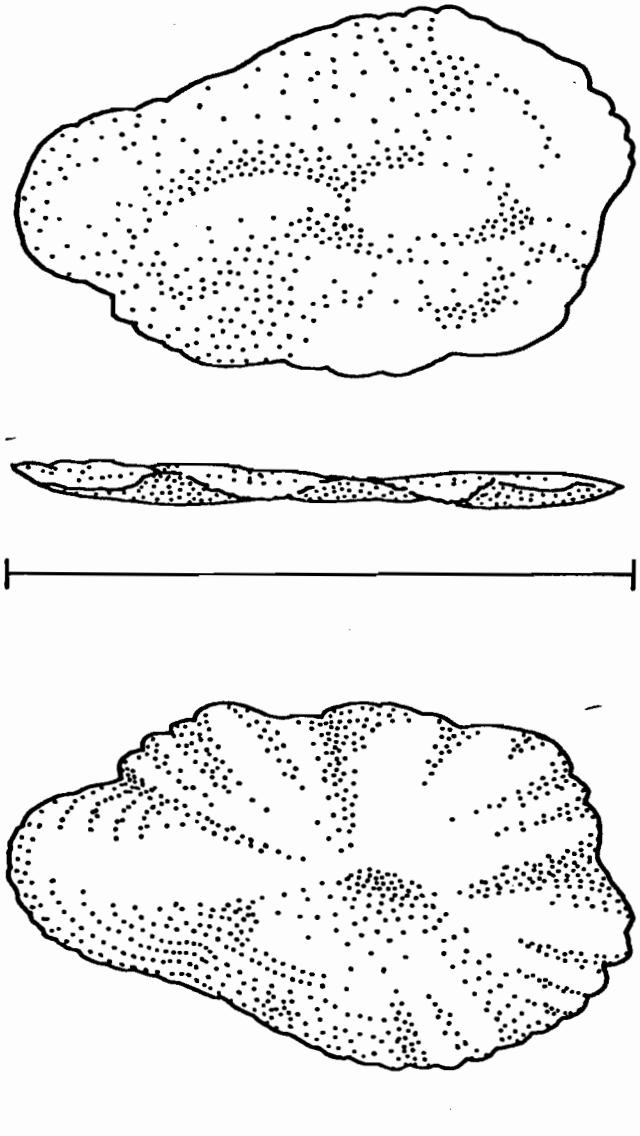
Glyptocephalus cynoglossus (Linnaeus)

Witch flounder
fish length 57 cm
scale bar 8 mm



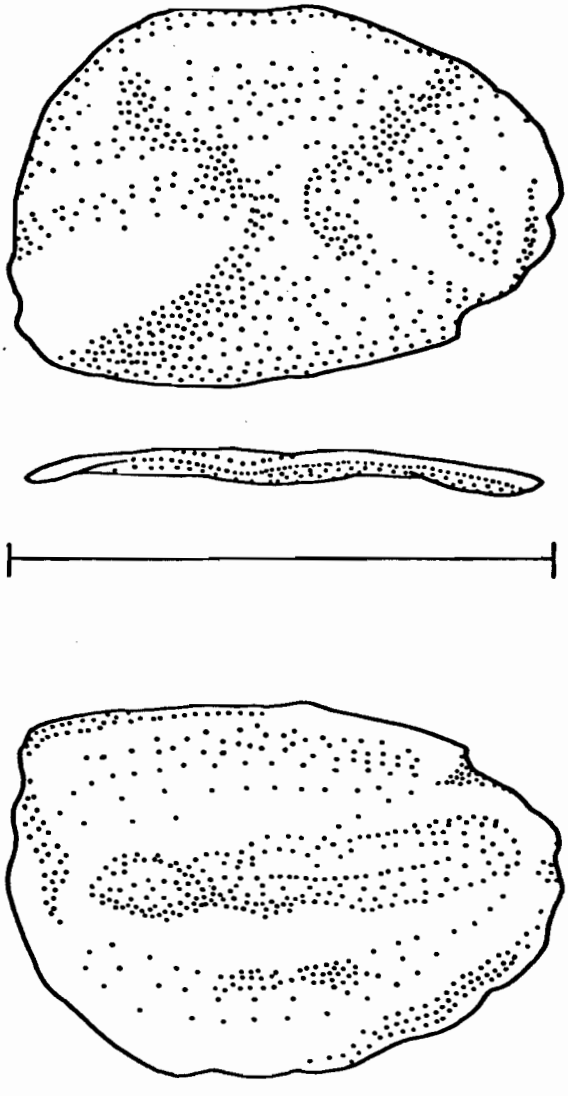
Hippoglossoides platessoides (Fabricius)

American plaice
fish length 50 cm
scale bar 9.5 mm



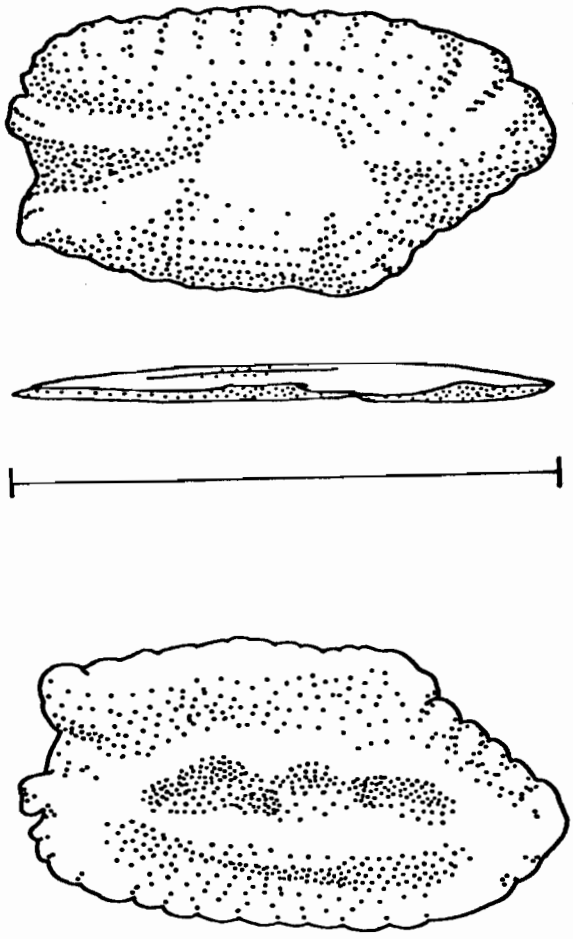
Hippoglossus hippoglossus (Linnaeus)

Atlantic halibut
fish length 108 cm
scale bar 12.5 mm



Limanda ferruginea (Storer)

Yellowtail flounder
fish length 37 cm
scale bar 7.2 mm



Pseudopleuronectes americanus (Walbaum)

Winter flounder
fish length 51 cm
scale bar 7.3 mm