NOAA Technical Report NMFS Circular 420

Preliminary Keys to Otoliths of Some Adult Fishes of the Gulf of Alaska, Bering Sea, and Beaufort Sea

James E. Morrow

February 1979

U.S. DEPARTMENT OF COMMERCE
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National Marine Fisheries Service

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Juanita M. Kreps, Secretary

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator
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National Marine Fisheries Service

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Preliminary Keys to Otoliths of Some Adult Fishes of the Gulf of Alaska, Bering Sea, and Beaufort Sea

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ABSTRACT

Keys and outline drawings are provided for the identification of the otoliths of 142 species of marine fishes from the Gulf of Alaska, Bering Sea, and Beaufort Sea.

INTRODUCTION

Fish otoliths have proved useful in determining food habits of man, marine mammals, birds, fishes, crabs, and squids, to name a few. These otoliths may be found anywhere in the digestive tract of the predator (but especially in the stomach), in droppings, or in kitchen middens, camp sites, and garbage dumps of ancient man. The otoliths found in these situations have almost always suffered some degree of attrition from digestive action or breakage, or both, and this must be taken into consideration when making identifications.

While the use of keys will, in the great majority of situations, lead to correct identifications, there is no substitute for making direct comparisons, on a size-for-size basis, with known material. Those involved in food habits analyses and prey-predator studies should make a strong effort to build a comparative collection. For any given predator in a given area, this should not be difficult. Normally, fewer than 10 species will account for more than 90% of the prey. The keys and illustrations presented here will put the food habits investigator at least in the right general group and show what species ought to be collected for purposes of comparison.

It must be emphasized that neither stomach contents nor specimens from which otoliths are to be removed should ever be put into formaldehyde "for preservation until they can be worked on." Formaldehyde solution very quickly destroys the salient features needed for identification and renders otoliths so frangible that they crumble at a touch.

Preparation of these keys was undertaken as a part of the Outer Continental Shelf Environmental Assessment Program of the Bureau of Land Management and the National Oceanographic and Atmospheric Administration. The objective was to provide a means of identifying otoliths found in the stomachs of fishes, seabirds, and marine mammals, thus aiding analyses of food habits. The geographic area inhabited by the various species included ranges from the Gulf of Alaska northward through the Bering and Chukchi Seas to the Beaufort Sea. The arrangement of groups and use of scientific and common names follow, with a few exceptions, Bailey et al. (1970) and Quast and Hall (1972). Geographic ranges are based on statements in the latter publication and include only the ranges in western North America.

These keys are based on otoliths taken from fresh or frozen specimens of adult fishes. Because considerable changes in the shape and other features of the otolith may occur during development, the otoliths of postlarvae and young juveniles may not be susceptible of accurate identification from these keys. Freakish, abnormal otoliths occur occasionally, even frequently in some groups, and these, likewise, cannot be reliably identified, although they can usually be keyed to family and sometimes generic level. There will also be a small percentage of normal, adult otoliths which will not key out properly.

ACCURACY

The otoliths of some species are highly variable. Whenever possible, these appear more than once in the keys to cover as much variation as possible. In some genera, the otoliths of various species are so similar that the reliability of species identification is low. Such genera or groups of species are combined in the keys, without attempting to carry the identification to species level. However, an otolith of each species is illustrated.

These keys include 142 species of fishes known from Alaskan waters. Because of the nature of the collecting gear, shore fishes and pelagic species, in particular, are underrepresented. No attempt has been made to include scarce forms which are rarely encountered. Likewise, species which may be common elsewhere and occasionally venture into the area covered have not been included. It is therefore quite possible that species not included in the keys will be wrongly identified. However, the chances are good that correct identification can be made to the family level, perhaps even to genus. For those families where all Alaskan species are included, identification to the species level should be at least 75% accurate, perhaps even 90% accurate. Where 75% accuracy could not be achieved, species have been lumped together.

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Except for *Stichaeus punctatus* and *Icelus canaliculatus*, each of which was represented in the study material by only a single pair of otoliths, we have had available from 4 to 20 pairs of otoliths of each species included in the keys. Accuracy of the keys was tested by keying out additional, known material, not only by us but also by five other biologists. In the light of the notes and remarks provided by these people, 75-90% accuracy seems about right.

POTENTIAL PROBLEMS AND SOURCES OF ERROR

It must be remembered that digestive acids and enzymes tend to reduce the prominence of surface features of the otolith. Shape and features of the margin are generally little affected until digestion has gone on for some time, but other features, such as the relative prominence of the cristae, may be affected quite soon. Allowance must be made for this when attempting to key out partially digested material. It may sometimes be necessary to resort to comparing such specimens with the illustrations. Comparison with known material is always desirable.

Perhaps the most common error encountered in using the keys involves the decision as to whether or not an excisura is present (Plate I). We found that, in some groups where excisurae (especially the minor) are normally present, the end of the sulcus is occasionally enclosed by a rim, leading to the conclusion that the excisura is absent (see section on Definitions). Where these anomalies were fairly frequent, the groups involved were included in more than one key. However, if an obviously erroneous identification is reached, it may be necessary to start again at the beginning and choose another alternative.

Another problem encountered fairly frequently concerns the state of the cristae, whether well or poorly developed (see below). This can usually be solved by directing a beam of light nearly horizontally at the otolith, so that a well-developed crista casts a shadow as the otolith is turned this way and that. It may be necessary to pick the otolith up, using fine tweezers, and look along the length of the sulcus. This will almost always show the condition of the cristae.

DEFINITIONS

The following terms are used to designate certain features of the otolith (see also Plate I). This terminology is slightly modified from that used by Frizzell and Dante (1965).

Antirostrum — The anterodorsal corner of the otolith, just dorsal to the notch of the excisura major.

Cauda — The posterior portion of the sulcus, posterior to the collum.

Colliculum — The raised portion of the floor of the sulcus. May exist in the ostium, cauda, both, or neither. In some groups (e.g., the Scorpaenidae), the anterior colliculum may be so large as to obscure the notch of the excisura major.

Collum — A constriction of the sulcus, usually (if present) located near the middle of the sulcus.

Crista inferior — The ventral rim of the sulcus. If present as a distinct, raised ridge, it is termed "well developed." If no ridge is present, the crista is "poorly developed" or "absent."

Crista superior — The dorsal rim of the sulcus. Same descriptive terms as for the crista inferior.

Dorsal area — That portion of the otolith dorsal to the sulcus.

Excisura — The opening of the sulcus on the margin of the otolith. The anterior opening of the sulcus is the excisura major, the posterior opening is the excisura minor. The excisurae often open into an excisural notch. If the sulcus does not reach the margin of the otolith, there is no excisura, even though a notch may be present.

Height of dorsal area or ventral area — The greatest straight line distance from the center line of the sulcus to the dorsal or ventral margin of the otolith.

Height of otolith — The greatest straight line distance from the dorsal to the ventral margin of the otolith, taken at right angles to the long axis.

Height of rostrum — The distance, measured at right angles to the long axis, between the apex of the excisural notch and the ventral margin of the otolith. If the notch is occluded by the colliculum, the height of the rostrum is measured to a horizontal through the point where the dorsal edge of the colliculum meets the margin of the otolith (Plate I).

Length of otolith — The straight line distance from the most anterior to the most posterior margin of the otolith.

Length of rostrum — The straight line distance from the tip of the rostrum to the apex of the excisural notch. If the notch is occluded by the colliculum, the length of the rostrum is measured to a vertical through the point where the dorsal edge of the colliculum meets the margin of the otolith (Plate I).

Ostium — The anterior portion of the sulcus, anterior to the collum.

Postcaudal trough — A groove or depression on the posteroventral portion of the otolith, extending (when present) from the posterior end of the sulcus to the posteroventral margin of the otolith.

Rostrum — The anterior extension of the ventral portion of the otolith below the excisural notch.

Sulcus — The longitudinal groove on the medial surface of the otolith.

Ventral area — That portion of the otolith ventral to the sulcus.

LIST OF SPECIES INCLUDED

Clupeidae

Clupea harengus pallasi—Pacific herring. Chukchi Sea—California.

Osmeridae

Hypomesus olidus—Pond smelt. Arctic Alaska—California.

Hypomesus pretiosus—Surf smelt. Bristol Bay—California.

Mallotus villosus—Capelin. Arctic Alaska—Washington.

Osmerus eperlanus—Rainbow smelt. Arctic Ocean—British Columbia.

Spirinchus thaleichthys—Longfin smelt. Bristol Bay—San Francisco Bay.

Thaleichthys pacificus—Eulachon. Bering Sea—California.

Moridae

Antimora microlepis—Longfin cod. Bering Sea—California.

Gadidae

Boreogadus saida—Arctic cod. Arctic Ocean, Chukchi Sea—Kuskokwim Bay.

Eleginus gracilis—Saffron cod. Chukchi Sea—Gulf of Alaska.

Gadus macrocephalus—Pacific cod. Bering Sea—California.

Merluccius productus—Pacific hake. Gulf of Alaska—Gulf of California.

Microgadus proximus—Pacific tomcod. Aleutian Islands—California.

Theragra chalcogramma—Walleye pollock. Bering Sea—Baja California.

Zoarcidae

Bothrocara brunneum—Twoline eelpout. Bering Sea—California.

Bothrocara molle—Soft eelpout. Bering Sea—Mexico.

Bothrocara pusillum—Alaska eelpout. Bering Sea—Southeast Alaska.

Embryx crotalina—Snakehead eelpout. Shumagin Islands—California.

Lycodes brevipes—Shortfin eelpout. Bering Sea—Oregon.

Lycodes diapterus—Black eelpout. Bering Sea—California.

Lycodes palearis—Wattled eelpout. Arctic Ocean—Washington.

Lycodopsis pacifica—Blackbelly eelpout. Gulf of Alaska—California.

Trichodontidae

Arctoscopus japonicus—Sailfin sandfish. Bering Sea.

Trichodon trichodon—Pacific sandfish. Bering Sea—California.

Bathymasteridae

Bathymaster caeruleofasciatus—Alaskan ronquil. Bering Sea—Southeast Alaska.

Bathymaster signatus—Searcher. Bering Sea—Washington.

Ronquilus jordani—Northern ronquil. Bering Sea—California.

Stichaeidae

Acantholumpenus mackayi—Pighead prickleback. Bering Sea, Aleutian Islands.

Lumpenella longirostris—Longsnout prickleback. Gulf of Alaska—British Columbia.

Lumpenus fabricii—Slender eelblenny. Arctic Alaska—Southeast Alaska.

Lumpenus maculatus—Daubed shanny. Arctic Alaska—Washington.

Lumpenus sagitta—Snake prickleback. Bering Sea—California.

Poroclinus rothrocki—Whitebarred prickleback. Bering Sea—California.

Stichaeus punctatus—Arctic shanny. Arctic Alaska—Southeast Alaska.

Pholididae

Apodichthys flavidus—Penpoint gunnel. Kodiak Island—California.

Pholis ornata—Saddleback gunnel. Bering Sea—California.

Anarhichadidae

Anarhichas orientalis—Bering wolffish. Bering Sea.

Anarrhichthys ocellatus—Wolf-eel. Gulf of Alaska—California.

Cryptacanthodidae

Delolepis gigantea—Giant wrymouth. Bering Sea—California.

Lyconectes aleutensis—Dwarf wrymouth. Bering Sea—California.

Ammodytidae

Ammodytes hexapterus—Pacific sandlance. Arctic Alaska—California.

Scorpaenidae

Sebastes aleutianus—Rougheye rockfish. Aleutian Islands—California.

Sebastes alutus—Pacific ocean perch. Bering Sea—California.

Sebastes aurora—Aurora rockfish. Prince William Sound—California.

Sebastes babcocki—Redbanded rockfish. Aleutian Islands—California.

Sebastes borealis—Shortraker rockfish. Bering Sea—Oregon.

Sebastes brevispinis—Silvergray rockfish. Bering Sea—California.

Sebastes caurinus—Copper rockfish. Kenai Peninsula—California.

Sebastes ciliatus—Dusky rockfish. Bering Sea—Southeast Alaska.

Sebastes crameri—Darkblotched rockfish. Bering Sea—California.

Sebastes entomelas—Widow rockfish. Southeast Alaska—California.

Sebastes maliger—Quillback rockfish. Gulf of Alaska—California.

Sebastes melanops—Black rockfish. Aleutian Islands—California.

Sebastes melanostomus—Blackgill rockfish. Bering Sea—Baja California.

Sebastes mystinus—Blue rockfish. Bering Sea—California.

Sebastes polyspinis—Northern rockfish. Bering Sea—Southeast Alaska.

Sebastes proriger—Redstripe rockfish. Bering Sea—California.

Sebastes ruberrimus—Yelloweye rockfish. Gulf of Alaska—California.

Sebastes variegatus—Harlequin rockfish. Unimak Pass—Queen Charlotte Sound.

Sebastes zacentrus—Sharpchin rockfish. Gulf of Alaska—California.

Sebastolobus alascanus—Shortspine thornyhead. Bering Sea—Baja California.

Sebastolobus altivelis—Longspine thornyhead. Aleutian Islands—Baja California.

Anoplopomatidae

Anoplopoma fimbria—Sablefish. Bering Sea—California.

Erilepis zonifer—Skilfish. Gulf of Alaska—California.

Hexagrammidae

Hexagrammos decagrammus—Kelp greenling. Aleutian Islands—California.

Hexagrammos lagocephalus—Rock greenling. Bering Sea—California.

Hexagrammos octogrammus—Masked greenling. Bering Sea—Southeast Alaska.

Hexagrammos stelleri—Whitespotted greenling. Bering Sea—California.

Ophiodon elongatus—Lingcod. Kodiak Island—Baja California.

Pleurogrammus monopterygius—Atka mackerel. Bering Sea—California.

Cottidae

Artedius fenestralis—Padded sculpin. Aleutian Islands—California.

Artedius harringtoni—Scalyhead sculpin. Gulf of Alaska—Southern California.

Blepsias bilobus—Crested sculpin. Bering Sea—British Columbia.

Belpsias cirrhosus—Silverspotted sculpin. Bering Sea—California.

Dasycottus setiger—Spinyhead sculpin. Bering Sea—Washington.

Enophrys bison—Buffalo sculpin. Gulf of Alaska—California.

Enophrys diceraus—Antlered sculpin. Bering Sea—Southeast Alaska.

Enophrys sp.—Bering Sea.

Gymnocanthus galeatus—Armorhead sculpin. Bering Sea—Southeast Alaska.

Gymnocanthus tricuspis—Arctic staghorn sculpin. Arctic Ocean—Bering Sea.

Hemilepidotus hemilepidotus—Red Irish lord. Bering Sea—California.

Hemilepidotus jordani—Yellow Irish lord. Bering Sea—Southeast Alaska.

Hemilepidotus spinosus—Brown Irish lord. Southeast Alaska—California.

Hemitripterus bolini—Bigmouth sculpin. Bering Sea—British Columbia.

Icelinus borealis—Northern sculpin. Bering Sea—Washington.

Icelus canaliculatus—No common name. Bering Sea.

Icelus spatula—Spatulate sculpin. Bering Sea, Arctic Ocean.

Icelus spiniger—No common name. Bering Sea—Southeast Alaska.

Leptocottus armatus—Pacific staghorn sculpin. Gulf of Alaska—Baja California.

Malacocottus kincaidi—Blackfin sculpin. Bering Sea—Washington.

Megalocottus platycephalus—Belligerent sculpin. Chukchi and Bering Seas.

Myoxocephalus jaok—Plain sculpin. Chukchi Sea—Aleutian Islands.

Myoxocephalus polyacanthocephalus—Great sculpin. Bering Sea—Washington.

Myoxocephalus quadricornis—Fourhorn sculpin. Arctic Ocean—Bering Sea.

Myoxocephalus scorpius—Shorthorn sculpin. Chukchi Sea—Aleutian Islands.

Nautichthys robustus—No common name. Aleutian Islands—British Columbia.

Psychrolutes paradoxus—Tadpole sculpin. Bering Sea—Washington.

Radulinus asprellus—Slim sculpin. Gulf of Alaska—Baja California.

Rhamphocottus richardsoni—Grunt sculpin. Bering Sea—California.

Triglops forficata—Scissortail sculpin. Bering Sea—Gulf of Alaska.

Triglops macellus—Roughspine sculpin. Bering Sea—Washington.

Triglops pingeli—Ribbed sculpin. Chukchi Sea—Washington.

Triglops scepticus—Spectacled sculpin. Bering Sea—Gulf of Alaska.

Agonidae

Agonus acipenserinus—Sturgeon poacher. Point Barrow—Washington.

Anoplagonus inermis—Smooth alligatorfish. Aleutian Islands—British Columbia.

Bathyagonus alascanus—Gray starsnout. Bering Sea—Washington.

Bathyagonus infraspinatus—Spinycheek starsnout. Bering Sea—California.

Bathyagonus nigripinnis—Blackfin poacher. Bering Sea—Oregon.

Bathyagonus pentacanthus—Bigeye poacher. Bering Sea—California.

Hypsagonus quadricornis—Fourhorn poacher. Bering Sea—Washington.

Occella dodecaedron—Bering poacher. Bering Sea—northern Gulf of Alaska.

Occella verrucosa—Warty poacher. Bristol Bay—California.

Pallasina barbata—Tubenose poacher. Bering Sea—Puget Sound.
Sarritor frenatus—Sawback poacher. Bering Sea—Southeast Alaska.
Sarritor leptorhynchus—Longnose poacher. Bering Sea—Gulf of Alaska.

Cyclopteridae
Careproctus furcellus—No common name. Bering Sea.
Careproctus melanurus—Blacktail snailfish. Aleutian Islands—California.
Careproctus sp.—Bering Sea.
Eumicrotremus orbis—Pacific spiny lumpsucker. Chukchi Sea—Washington.
Liparis dennyi—Marbled snailfish. Gulf of Alaska—Washington.
Liparis gibbus—No common name. Chukchi Sea—Southeast Alaska.
Liparis liparis—Striped seasnail. Arctic Ocean, Chukchi Sea.
Liparis pulchellus—Showy snailfish. Bering Sea—California.
Nectoliparis pelagicus—Tadpole snailfish. Bering Sea—California.

Bothidae
Citharichthys sordidus—Pacific sanddab. Bering Sea—California.

Pleuronectidae
Atheresthes stomias—Arrowtooth flounder. Chukchi Sea—California.
Eopsetta jordani—Petrale sole. Gulf of Alaska—Baja California.
Glyptocephalus zachirus—Rex sole. Bering Sea—California.
Hippoglossoides elassodon—Flathead sole. Chukchi Sea—Oregon.
Hippoglossoides robustus—Bering flounder. Chukchi Sea—Aleutian Islands.
Hippoglossus stenolepis—Pacific halibut. Bering Sea—California.
Isopsetta isolepis—Butter sole. Bering Sea—California.
Lepidopsetta bilineata—Rock sole. Bering Sea—California.
Limanda aspera—Yellowfin sole. Chukchi Sea—British Columbia.
Limanda proboscidea—Longhead dab. Chukchi Sea—Bristol Bay.
Liopsetta glacialis—Arctic flounder. Arctic Ocean—Bering Strait.
Microstomus pacificus—Dover sole. Chukchi Sea—Baja California.
Parophrys vetulus—English sole. Aleutian Islands—Baja California.
Platichthys stellatus—Starry flounder. Bering Strait—California.
Pleuronectes quadrituberculatus—Alaska plaice. Chukchi Sea—Washington.
Psettichthys melanostictus—Sand sole. Gulf of Alaska—California.
Reinhardtius hippoglossoides—Greenland halibut. Chukchi Sea—California.

KEYS TO FAMILIES

A. Both excisurae present ..... Key I
B. Both excisurae absent ..... Key II
C. Excisura major present, excisura minor absent ..... Key III

Key I. Both Excisurae Present

1a. Sulcus divided into dorsal and ventral chambers by a long, thin, bladelike colliculum ..... *Antimora microlepis* (Fig. 1)

1b. Sulcus not divided as in 1a 2

2a. Height of otolith 55% or less of its length 3

2b. Height of otolith more than 55% of its length 5

3a. Notch of excisura major deep and narrow, forming an angle of much less than 90°. Dorsal and ventral margins of otolith roughly parallel. Ventral margin incised ..... *Clupea harengus pallasi* (Fig. 2)

3b. Notch of excisura major broad, usually about 90° or more, always greater than 60°. Margins various 4

4a. Ends of sulcus extremely deep. Collum well developed. A prominent notch in ventral margin below collum (except in juveniles). Tiny otoliths, never more than 2 mm long . . . . . Family Pholididae . . *Apodichthys flavidus* (Fig. 39)

4b. Without the above combination of characters . . . . . Family Salmonidae (some *Oncorhynchus*)[2]

5a. Sulcus deep and well defined 6

5b. Sulcus shallow, rather poorly defined . . . . . Family Trichodontidae, p. 11

6a. Greatest height of ventral area distinctly behind middle of otolith length . . . . . Family Osmeridae, p. 9

6b. Greatest height of otolith about at middle of otolith length 7

7a. Angle of notch of excisura major less than 90°. A deep channel present below crista inferior . . . . . Family Anarhichadidae . . . *Anarrhichthys ocellatus* (Fig. 41)

7b. Angle of notch of excisura major about 90° or more. No deep channel below crista inferior 8

8a. General shape more or less an equilateral triangle. Height of otolith 90% or more of its length, or thickness of otolith more than 50% of its length. A fan-shaped area dorsal to sulcus . . . . . Family Zoarcidae (Genus *Bothrocara*), p. 10

8b. Not as in 8a . . . . . Family Salmonidae (some *Oncorhynchus*)[2]

Key II. Both Excisurae Absent

1a. Sulcus well defined, consists either of a fairly deep, straight groove or of one or two pits 4

1b. Sulcus shallow and poorly defined 2

2a. Sulcus constricted at collum, broad at each end. Anterior end of otolith highest, otolith tapers posteriorly . . . . . Family Gadidae, p. 10

2b. Sulcus not constricted at collum, about the same width throughout its length. Otolith not shaped as in 2a 3

3a. Sulcus straight. Surface of otolith like frosted glass. Otolith nearly round in cross section. Otolith of small to moderate size . . . . . Family Cryptacanthodidae . . . *Lyconectes aleutensis* (Fig. 3)

3b. Sulcus arched dorsad. Surface of otolith not like frosted glass. Otolith compressed laterally, oval in cross section. Otolith tiny, never longer than 2 mm . . . . . Family Cottidae . . . *Psychrolutes paradoxus* (Fig. 73)

4a. Otolith almond-shaped. Sulcus reaches or nearly reaches anterior tip 5

4b. Not as in 4a 6

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[2]For a key to otoliths of *Oncorhynchus*, see: Casteel, R. W. 1974. Identification of the species of Pacific salmon (Genus *Oncorhynchus*) native to North America based upon otoliths. Copeia 1974:305-311.

5a. Dorsal margin smooth. Height of otolith about 50% of its length. Sulcus fails to reach posterior end of otolith by more than 20% of otolith length. No crista superior. Otolith never longer than 3 mm ..... *Ammodytes hexapterus* (Fig. 6)

5b. Dorsal margin crenulate or wavy. Height of otolith about 36% of its length. Sulcus fails to reach posterior margin of otolith by less than 10% of otolith length. Crista superior high, sharp. Otolith larger than in 5a ..... Family Anoplopomatidae . . . some *Anoplopoma fimbria* (Fig. 65)

6a. Otolith thick, heavy, massive. Always a deep notch anteriorly, often a posterior notch also. A thick, rounded ridge separates ostium of sulcus from cauda ..... Family Cryptacanthodidae . . . *Delolepis gigantea* (Figs. 4, 5)

6b. Not as in 6a 7

7a. Dorsal area with a deep, fan-shaped depression ..... Family Zoarcidae . . . *Embryx crotalina* (Fig. 19)

7b. Not as in 7a 8

8a. Lateral side of otolith distinctly concave ..... Family Cottidae, p. 15

8b. Lateral side of otolith flat to convex, not distinctly concave ..... Pleuronectiformes, p. 19

Key III. Excisura Major Present, Excisura Minor Absent

1a. Long axis straight or nearly so when viewed from above 2

1b. Long axis distinctly curved 14

2a. Otolith almond-shaped. Sulcus opens at extreme tip ..... *Ammodytes hexapterus* (Fig. 6)

2b. Otolith not almond-shaped. Sulcus opens somewhere behind extreme anterior tip 3

3a. Ends of sulcus extremely deep. Collum well developed. Tiny otoliths, never longer than 2 mm ..... Family Pholididae . . . *Apodichthys flavidus* (Fig. 39)

3b. Not as in 3a 4

4a. Dorsal area of medial side with definite radiating lines 5

4b. Dorsal area without radiating lines 7

5a. Excisural notch shallow or absent. Rostrum not or scarcely longer than antirostrum 6

5b. Excisural notch generally obvious. Rostrum much longer than antirostrum ..... Family Cyclopteridae, p. 19

6a. Height of otolith more than 65% of its length, usually more than 70% of length .... Family Trichodontidae, p. 11

6b. Height of otolith less than 65% of its length, usually less than 60% of length ..... Family Cyclopteridae, p. 19

7a. Medial side flat, surfaces of dorsal and ventral areas in same plane. Rostrum not sharply separated from antirostrum . . . . . Family Cyclopteridae, p. 19

7b. Medial side more or less rounded, or surfaces of dorsal and ventral areas not in same plane, or rostrum prominent and clearly separated from antirostrum 8

8a. Ventral margin of otolith distinctly curved 9

8b. Ventral margin straight or nearly so, at least in its middle portion 12

9a. Sulcus not parallel with long axis of otolith, may be curved 11

9b. Sulcus parallel with long axis of otolith 10

10a. Rostrum sharply pointed. Ventral margin deeply rounded. Dorsal margin irregular, but more or less parallel to sulcus . . . . . Family Osmeridae, p. 9

10b. Not with the above combination of characters . . . . . Family Cottidae, p. 15

11a. Excisural notch distinct, V-shaped. Rostrum pointed Family Stichaeidae . . . *Poroclinus rothrocki* (Fig. 34)

11b. Excisural notch various. Rostrum rounded or blunt . . . . . Family Agonidae (Genus *Sarritor*), p. 18

12a. Crista inferior forming at least a slight ridge . . . . . Family Stichaeidae, p. 11

12b. Crista inferior poorly developed, not forming a ridge 13

13a. Rostrum short, blunt . . . . . Family Agonidae, p. 18

13b. Rostrum long, pointed . . . . . Family Anarhichadidae, p. 12

14a. Otolith heavy, massive. A thick, rounded ridge projects anteriorly in the sulcus and separates ostium from cauda horizontally . . . . . Family Cryptacanthodidae . . . *Delolepis gigantea* (Figs. 4, 5)

14b. Not as in 14a 15

15a. Surface of otolith like frosted glass. Sulcus shallow, with a well-developed colliculum . . . . . Family Cryptacanthodidae . . . *Lyconectes aleutensis* (Fig. 3)

15b. Surface not like frosted glass, or sulcus deep and without a colliculum 16

16a. Crista superior well developed, appears as a distinct ridge 19

16b. Crista superior poorly developed, not raised as a ridge above surface of dorsal area 17

17a. Ostium V-shaped, its bottom (lateral surface) flat, without a colliculum . . . . . Family Pholididae . . . *Pholis ornata* (Fig. 40)

17b. Ostium various, but not with above combination of characters 18

18a. Excisural notch prominent and without a colliculum. Dorsal margin of otolith not deeply crenulate ..... Family Agonidae, p. 18

18b. Excisural notch not prominent, or if prominent, there is a well-developed colliculum in the notch or the dorsal margin of the otolith is markedly crenulate ..... Family Cottidae, p. 15

19a. Central axis of sulcus with a distinct ventrad bend at its posterior end 21

19b. Central axis of sulcus without a ventrad bend at its posterior end 20

20a. Height of otolith less than 45% of its length. Rostrum long and narrow, well separated anteriorly from antirostrum ..... Family Bathymasteridae . . . *Bathymaster signatus* (Fig. 30)

20b. Height of otolith more than 45% of its length. If less, then rostrum short and broad and poorly separated from antirostrum ..... Family Scorpaenidae, p. 12

21a. Postcaudal trough broad, well developed, meets posterior end of sulcus ..... Family Hexagrammidae, p. 15

21b. Postcaudal trough absent (one or two grooves with V-shaped cross sections may be present), or, if present and broad, meets posteroventral end of sulcus 22

22a. Medial surface of otolith curved dorsoventrally ..... Family Bathymasteridae, p. 11

22b. Medial surface of otolith nearly flat dorsoventrally ..... Family Anoplopomatidae, p. 14

FAMILY OSMERIDAE

1a. Anteroventral margin rounded 3

1b. Anteroventral margin straight 2

2a. Posterodorsal and dorsal margins curved. Otolith height greatest at about two-thirds of length . ..... *Mallotus villosus* (Fig. 7)

2b. Posterodorsal and dorsal margins straight or nearly so. Otolith height greatest at posterior end ..... *Thaleichthys pacificus* (Fig. 8)

3a. Rostrum broad, its tip blunt. Dorsal rim of sulcus curves ventrad at posterior end. Postcaudal trough indistinct or absent ..... *Hypomesus pretiosus* (Fig. 9)

3b. Rostrum narrow, more or less pointed. Dorsal rim of sulcus straight. Postcaudal trough distinct 4

4a. Posterior margin more or less truncate, approximately at right angles to long axis of sulcus .... *Osmerus eperlanus* (Fig. 10)

4b. Posterior margin rounded 5

5a. Height of otolith 59% (56-61%) of its length ..... *Spirinchus thaleichthys* (Fig. 11)

5b. Height of otolith 67% (65-68%) of its length ..... *Hypomesus olidus* (Fig. 12)

FAMILY GADIDAE

1a. Medial surface strongly convex, lateral surface distinctly concave 2

1b. Medial surface only moderately convex, lateral surface flat or nearly so, or concave only above midline 3

2a. Height of otolith more than 44% of its length. Posterodorsal (more pointed end) margin forms angle of about 60° with longitudinal axis . . . . . *Gadus macrocephalus* (Fig. 13)

2b. Height of otolith 44% or less of its length. Posterodorsal margin forms angle of about 45° with longitudinal axis . . . . . *Theragra chalcogramma* (Fig. 14)

3a. Lateral surface smooth, without rounded lumps 4

3b. Lateral surface with rounded lumps, especially near center of otolith 5

4a. Anterodorsal (higher end) margin forms angle of 30°-45° (usually about 30°) with long axis. Anterior end rounded or with numerous, small lobules. Otoliths of adults may exceed 20 mm in length . . . . . *Merluccius productus* (Fig. 15)

4b. Anterodorsal margin forms angle of 15°-25° (usually 20° or less) with long axis. Anterior end bilobed, a distinct notch separating the two lobes. Otoliths small, rarely over 8 mm long . . . . . *Boreogadus saida* (Fig. 16)

5a. Posterodorsal margin slightly concave, forms angle of 25°-30° (usually about 30°) with long axis. Posterodorsal rim quite thin . . . . . *Microgadus proximus* (Fig. 17)

5b. Posterodorsal margin straight to slightly convex, forms angle of about 20° with long axis. Posterodorsal rim slightly thickened . . . . . *Eleginus gracilis* (Fig. 18)

FAMILY ZOARCIDAE

1a. Sulcus ends on rostrum, usually does not open on anterior margin. A deep groove, usually in the form of two elongate pits, below sulcus. A deep pit in dorsal area . . . . . *Embryx crotalina* (Fig. 19)

1b. Not as in 1a 2

2a. General shape approximately an equilateral triangle. Height of otolith 90% or more of its length, or thickness more than 50% of length (Genus *Bothrocara*) 3

2b. General shape more or less triangular, but not equilateral. Height of otolith less than 85% of length, thickness less than 50% of length 5

3a. Lateral side an exaggerated, round dome. Thickness more than 50% of length. Large specimens with ventral area expanded anteroposteriorly . . . . . *Bothrocara brunneum* (Fig. 20)

3b. Lateral side convex, but not domelike. Thickness less than 50% of length. Ventral area not expanded both anteriorly and posteriorly 4

4a. Anteroventral corner expanded to form a short, rounded lobe . . . . . *Bothrocara pusillum* (Fig. 21)

4b. Anteroventral corner not expanded . . . . . *Bothrocara molle* (Fig. 22)

5a. Height of otolith 66% or less of its length ..... *Lycodopsis pacifica* (Fig. 23)

5b. Height of otolith 69-83% of its length (Genus *Lycodes*) 6

6a. Dorsal margin more or less rounded. Greatest height of otolith at or behind middle of length. Posterodorsal margin typically convex ..... *Lycodes palearis* (Fig. 24)

6b. Dorsal margin usually with a distinct angle. Greatest height of otolith at or before middle of length. Posterodorsal margin straight or concave 7

7a. Greatest height distinctly anterior to middle of length. Texture smooth ..... *Lycodes brevipes* (Fig. 25)

7b. Greatest height near center of length. Texture less smooth ..... *Lycodes diapterus* (Fig. 26)

FAMILY TRICHODONTIDAE

1a. Rostrum short, blunt. Inner face of otolith thickened below center of sulcus ..... *Trichodon trichodon* (Fig. 27)

1b. Rostrum long, pointed. Inner face of otolith flat, not thickened ..... *Arctoscopus japonicus* (Fig. 28)

FAMILY BATHYMASTERIDAE

1a. Posterior end of otolith pointed ..... *Ronquilus jordani* (Fig. 29)

1b. Posterior end of otolith rounded or lobate 2

2a. Dorsal margin crenulate. Posterior end of sulcus bent ventrad at angle of 10°-15°. Height of otolith 40% or more of its length. Lateral surface with distinct radiating lines ..... *Bathymaster signatus* (Fig. 30)

2b. Dorsal margins wavy, not crenulate. Posterior end of sulcus bent ventrad at an angle of 20°. Height of otolith less than 40% of its length. Lateral surface smooth; if radiating lines are present, they are few in number and hard to see ..... *Bathymaster caeruleofasciatus* (Fig. 31)

FAMILY STICHAEIDAE

1a. Height of otolith 65% or more of its length 2

1b. Height of otolith less than 65% of its length, usually less than 60% 3

2a. Excisural notch very shallow ..... *Lumpenella longirostris* (Fig. 32)

2b. Excisural notch deep and obvious ..... *Lumpenus maculatus* (Fig. 33)

3a. Excisural notch deep and obvious. Anterior end of sulcus opens in notch 4

3b. Excisural notch poorly defined and/or sulcus does not open in the notch. A groove may be present from the notch to the dorsal edge of the sulcus 5

4a. Tip of rostrum pointed (rarely blunt), antirostrum angular ..... *Poroclinus rothrocki* (Fig. 34)

4b. Both rostrum and antirostrum broadly rounded ..... *Acantholumpenus mackayi* (Fig. 35)

5a. Excisural notch present, forming an angle of more than 45°. Height of dorsal area 1.0-1.2 times that of ventral area ..... *Lumpenus fabricii* (Fig. 36)

5b. Excisural notch virtually absent, if present forms an angle of about 45°. Height of dorsal area 1.5-2.0 times that of ventral area 6

6a. A prominent lobe on posterodorsal margin ..... *Lumpenus sagitta* (Fig. 37)

6b. No prominent lobe on posterodorsal margin ..... *Stichaeus punctatus* (Fig. 38)

FAMILY PHOLIDIDAE

1a. Sulcus very deep, reaches or almost reaches posterior margin. Crista inferior deeply undercut. Often a notch near middle of ventral margin ..... *Apodichthys flavidus* (Fig. 39)

1b. Sulcus moderately deep, does not reach posterior margin. Crista inferior not undercut. No notch in ventral margin ..... *Pholis ornata* (Fig. 40)

FAMILY ANARHICHADIDAE

1a. Excisura major deep and narrow. A deep furrow present below crista inferior. Lateral surface usually with a clump of nodules in nuclear area ..... *Anarrhichthys ocellatus* (Fig. 41)

1b. Excisura major a rather shallow, V-shaped notch. Crista inferior scarcely evident, no furrow below it. Lateral surface smooth ..... *Anarhichas orientalis* (Fig. 42)

FAMILY SCORPAENIDAE

This key to the otoliths of Alaskan Scorpaenidae is based on adult specimens. The otoliths of juveniles (i.e., otoliths less than about 10 mm long) are all very similar, generally resembling the otoliths of the dwarf species *Sebastes variegatus*. They cannot be distinguished with any degree of reliability.

1a. Height of dorsal area about 2× height of ventral area (only about 1.2× in small juveniles) ..... *Sebastolobus altivelis* (Fig. 43) and *S. alascanus* (Fig. 44)

1b. Height of dorsal and ventral areas about equal 2

2a. Height of otolith usually less than 45% of its length, always less than 50% 3

2b. Height of otolith more than 45% of its length 7

3a. Height of otolith 38-43% of its length. Dorsal margin nearly straight, although incised ..... *Sebastes entomelas* (Fig. 45)

3b. Height of otolith 43-48% of its length. Dorsal margin slightly but distinctly convex 4

4a. Dorsal margin with coarse, broad irregularities 5

4b. Dorsal margin with small, fine incisions and irregularities 6

5a. Anterior portion of dorsal margin behind colliculum rounded. Postcaudal trough absent; if present, shallow and ends in a broad, shallow indentation of posteroventral margin ... *Sebastes brevispinis* (Fig. 46)

5b. Anterior portion of dorsal margin behind colliculum nearly straight. Postcaudal trough prominent, ends in a deep notch in posteroventral margin ..... *Sebastes proriger* (Fig. 47)

6a. Tip of rostrum pointed. Postcaudal trough prominent ..... *Sebastes caurinus* (Fig. 48)

6b. Tip of rostrum blunt. Postcaudal trough poorly developed ..... *Sebastes mystinus* (Fig. 49)

7a. Dorsal margin with fine, irregular incisions 8

7b. Dorsal margin not as in 7a, except on posterior portion in some species. If deeply incised, the incisions are coarse, the projections usually toothlike 10

8a. Height of ventral area 80% or more of height of dorsal area ..... *Sebastes maliger* (Fig. 50)

8b. Height of ventral area less than 80% of height of dorsal area 9

9a. Posteroventral margin usually with one or two deep indentations ..... *Sebastes caurinus* (Fig. 48)

9b. Posteroventral margin without deep indentations ..... *Sebstes melanostomus* (Fig. 51)

10a. Ventral margin smooth (sometimes a few weak irregularities in *Sebastes melanops*) 11

10b. Ventral margin with crenulations, teeth or noticeable irregularities, at least on rostrum 14

11a. Height of otolith 60-68% of its length. Thickness of otolith about 30% of its height ..... *Sebastes aurora* (Fig. 52)

11b. Height of otolith less than 55% of its length. Thickness much less than 30% of height 12

12a. Height of otolith 50-54% of its length ..... *Sebastes ciliatus* (Fig. 53)

12b. Height of otolith less than 50% (usually 45-49%) of its length 13

13a. Postcaudal trough follows axis of sulcus to posterior margin of otolith (a ventrally directed branch of the trough may be present) ..... *Sebastes melanops* (Fig. 54)

13b. Postcaudal trough forms an angle of about 30° with axis of sulcus ..... *Sebastes polyspinis* (Fig. 55)

14a. Crista inferior raised above surface of ventral area 15

14b. Crista inferior not sharply set off from surface of ventral area (a longitudinal groove may be present in ventral area) 22

15a. Height of otolith 46% or less of its length ..... *Sebastes brevispinis* (Fig. 46)

15b. Height of otolith 49% or more of its length 16

16a. A prominent postcaudal trough present 17

16b. Postcaudal trough absent, or at least not prominent 20

17a. Postcaudal trough does not end in a notch on posteroventral margin ..... *Sebastes babcocki* (Fig. 56)

17b. Postcaudal trough ends in an indentation in posteroventral margin 18

18a. Dorsal margin smoothly rounded, except at posterior end ..... *Sebastes aurora* (Fig. 52)

18b. Dorsal margin irregular and/or incised 19

19a. Ventral margin smooth or nearly so ..... *Sebastes zacentrus* (Fig. 57)

19b. Ventral margin with numerous, small teeth ..... *Sebastes maliger* (Fig. 50)

20a. Posterior margin rounded, usually deeply incised, often almost frilly or fishtaillike 21

20b. Posterior margin truncate, not frilly or fishtaillike, sometimes with small, irregular projections ..... *Sebastes borealis* (Fig. 58)

21a. Usually one or two large indentations in posterodorsal margin ..... *Sebastes brevispinis* (Fig. 46)

21b. No large indentations in posterodorsal margin ..... *Sebastes crameri* (Fig. 59)

22a. Dorsal margin quite smooth (may have a few shallow crenulations) .... *Sebastes variegatus* (Fig. 60) and juvenile *S. aleutianus*

22b. Dorsal margin crenulate or irregularly incised 23

23a. Excisural notch fairly obvious, rostrum clearly set off from antirostrum 24

23b. Excisural notch shallow or absent, rostrum not clearly separated from antirostrum 25

24a. Posterior part of ventral margin of rostrum usually toothed or crenulate. Dorsal area usually with fine, radiating lines ..... *Sebastes alutus* (Fig. 61)

24b. Posterior part of ventral margin of rostrum not toothed, but may have shallow crenulations or irregularities. Dorsal area without radiating lines ..... *Sebastes aleutianus* (Fig. 62)

25a. Posterior margin of otolith crenulate to moderately incised ..... *Sebastes polyspinis* (Fig. 55)

25b. Posterior margin of otolith deeply incised, frilly, onten fishtaillike 26

26a. Ventral margin more or less crenulate or toothed. Dorsal margin usually rather deeply incised, often frilly. Height of otolith 43-48% of its length (usually more than 45%) ..... *Sebastes caurinus* (Fig. 48)

26b. Ventral margin smooth or slightly irregular. Dorsal margin with shallow incisions or crenulations, these usually deeper towards posterior end of otolith. Height of otolith 48% or more of its length ..... *Sebastes ruberrimus* (Fig. 63)

FAMILY ANOPLOPOMATIDAE

1a. Height of otolith 50-60% of its length. Crista superior overhangs sulcus, especially in large specimens ..... *Erilepis zonifer* (Fig. 64)

1b. Height of otolith 40-45% of length. Crista superior does not overhang sulcus ..... *Anoplopoma fimbria* (Fig. 65)

FAMILY HEXAGRAMMIDAE

1a. Crista superior a well-defined ridge; crista inferior rises smoothly from surface of ventral area 2

1b. Both cristae prominent and well defined. Crista superior a sharp ridge; crista inferior rounded and heavy (Genus *Hexagrammos*) 3

2a. Rostrum pointed. Otolith small, rarely longer than 6 mm . . . . . *Pleurogrammus monopterygius* (Fig. 66)

2b. Rostrum blunt. Otolith may exceed 12 mm long . . . . . *Ophiodon elongatus* (Fig. 67)

3a. Tip of rostrum rounded 4

3b. Tip of rostrum pointed 5

4a. Crista inferior extremely prominent, undercut on ventral side. Collum prominent . . . . . *Hexagrammos lagocephalus* (Fig. 68)

4b. Crista inferior a broad, thick ridge rising smoothly from surface of ventral area. Collum not especially prominent . . . . . *Hexagrammos stelleri* (Fig. 69)

5a. Lateral surface without concentric rings . . . . . *Hexagrammos octogrammus* (Fig. 70)

5b. Lateral surface with numerous concentric rings . . . . . *Hexagrammos decagrammus* (Fig. 71)

FAMILY COTTIDAE

1a. Both excisurae absent 2

1b. Excisura major present, excisura minor present or absent 7

2a. Long axis curved, lateral side concave 4

2b. Long axis straight 3

3a. Dorsal margin crenulate. Otoliths large, often exceed 8 mm long . . . . . *Dasycottus setiger* (Fig. 72)

3b. Dorsal margin smooth. Otoliths tiny, never longer than 2 mm . . . . . *Psychrolutes paradoxus* (Fig. 73)

4a. Ventral margin smooth or irregularly wavy 5

4b. Ventral margin more or less crenulate . . . . . Genus *Myoxocephalus* (Figs. 75, 76, 77)

5a. Ventral margin curved. Height of otolith about 60% of its length . . . . . *Myoxocephalus quadricornis* (Fig. 74)

5b. Ventral margin irregular, but nearly straight. Height of otolith about 50% of its length 6

6a. Dorsal margin with a few broad crenulations . . . . . *Enophrys bison* (Fig. 97)

6b. Dorsal margin with more numerous, deeper crenulations . . . . . *Enophrys diceraus* (Fig. 96)

7a. Both excisurae present. Dorsal margin deeply crenulate, ventral margin smooth ..... *Malacocottus kincaidi* (Fig. 78)

7b. Excisura major present, excisura minor absent. Margins various 8

8a. Long axis straight or nearly so 9

8b. Long axis distinctly curved, usually strongly so 19

9a. One or more prominent bulges on lateral side, or ventral area notably thicker than dorsal area 10

9b. No prominent bulges on lateral side 13

10a. A moderate bulge on ventral area of lateral side with a central bulge dorsal to it and clearly outlined by grooves ..... *Nautichthys robustus* (Fig. 79)

10b. A single, extremely prominent bulge on lateral side of ventral area, or ventral area notably thicker than dorsal area 11

11a. Dorsal margin with numerous, deep crenulations ..... *Malacocottus kincaidi* (Fig. 78)

11b. Dorsal margin with few, shallow crenulations or irregularities 12

12a. Rostrum short, blunt ..... *Blepsias bilobus* (Fig. 80)

12b. Rostrum long, pointed ..... *Blepsias cirrhosus* (Fig. 81)

13a. Height of otolith about 80% of its length ..... *Hemitripterus bolini* (Fig. 82)

13b. Height of otolith much less than 80% of its length, usually less than 65% 14

14a. Dorsal margin crenulate (some *Radulinus* almost in 14b) 15

14b. Dorsal margin smooth or irregular 18

15a. Sulcus reaches anterior margin at or near tip of rostrum 17

15b. Sulcus ends anteriorly in excisural notch, does not reach tip of rostrum 16

16a. Sulcus bends dorsad anteriorly. Colliculum poorly developed or absent ..... *Icelus spiniger* (Fig. 83)

16b. Sulcus straight anteriorly. Colliculum well developed and prominent ..... *Icelus canaliculatus* (Fig. 84)

17a. Rostrum pointed, excisural notch absent or very shallow ..... *Radulinus asprellus* (Fig. 85)

17b. Rostrum blunt, excisural notch obvious ..... *Gymnocanthus galeatus* (Fig. 86)

18a. Rostrum blunt ..... *Icelus spatula* (Fig. 87)

18b. Rostrum pointed ..... *Icelinus borealis* (Fig. 88) and *Gymnocanthus tricuspis* (Fig. 89)

19a. Dorsal margin smooth 20

19b. Dorsal margin with at least a few definite crenulations 21

20a. Central part of dorsal margin arched, antero- and posterodorsal margins concave. Texture like frosted glass. Posterior end of otolith thickened ..... *Rhamphocottus richardsoni* (Fig. 90)

20b. Dorsal margin evenly curved, may be concave only at excisural notch. Texture not like frosted glass. Posterior end not thicker than rest of otolith ..... Genus *Artedius* (Figs. 91, 92)

21a. Both dorsal and ventral margins crenulate 22

21b. Dorsal margin crenulate, ventral margin smooth 23

22a. Postcaudal trough generally prominent except in very small specimens. Surface, especially on lateral side, rough and/or bulbous ..... Genus *Hemilepidotus* (Figs. 93, 94, 95)

22b. Postcaudal trough absent. Surface smooth ..... Genus *Myoxocephalus* (Figs. 75, 76, 77)

23a. Dorsal margin with a few broad crenulations 24

23b. Dorsal margin with fairly numerous crenulations 26

24a. Rostrum short, 15-20% of otolith length, or not distinguishable 25

24b. Rostrum long, 30% or more of otolith length ..... *Enophrys* sp. (Fig. 97A)

25a. Height of otolith about 60% of its length ..... *Icelus canaliculatus* (Fig. 84)

25b. Height of otolith about 50% of its length ..... *Enophrys bison* (Fig. 97)

26a. Crista superior present along almost entire dorsal edge of sulcus ..... *Enophrys diceraus* (Fig. 96)

26b. Crista superior either virtually absent or well developed only on anterior or posterior half of sulcus 27

27a. Crista superior poorly developed, virtually absent (Genus *Triglops*) 29

27b. Crista superior well developed on either anterior or posterior half of sulcus 28

28a. Crista superior well developed on anterior half of sulcus ..... *Leptocottus armatus* (Fig. 98)

28b. Crista superior well developed on posterior end of sulcus ..... *Megalocottus platycephalus* (Fig. 99)

29a. Excisural notch prominent ..... *Triglops scepticus* (Fig. 100)

29b. Excisural notch poorly developed, anterodorsal margin of otolith not or only slightly indented 30

30a. Tip of rostrum broadly rounded, slightly upturned. Height of otolith 45% or less of its length . . . . . *Triglops forficata* (Fig. 101)

30b. Tip of rostrum more or less pointed, not upturned. Height of otolith 48% or more of its length 31

31a. Posterior end broadly rounded (may show one or two crenulations), notably broader than anterior point . . . . . *Triglops pingeli* (Fig. 102)

31b. Posterior end pointed, similar to anterior point . . . . . *Triglops macellus* (Fig. 103)

FAMILY AGONIDAE

1a. Longitudinal axis distinctly curved when viewed from above 2

1b. Longitudinal axis straight or nearly so 3

2a. Postcaudal trough deep and obvious . . . . . *Agonus acipenserinus* (Fig. 104)

2b. Postcaudal trough shallow or absent . . . . . *Occella dodecaedron* (Fig. 105) and *O. verrucosa* (Fig. 106)

3a. Otolith notably thicker near ventral edge than near dorsal edge. Medial side flat 4

3b. Otolith of nearly uniform thickness. Both sides of similar curvature 5

4a. Rostrum well defined. Dorsal area rises abruptly from base of rostrum or they are separated by a notch and the colliculum is bulbous . . . . *Bathyagonus nigripinnis* (Fig. 107) and *B. pentacanthus* (Fig. 108)

4b. Rostrum not clearly separated from margin of dorsal area. If separated by a notch, the colliculum is absent or concave . . . . . *Bathyagonus infraspinatus* (Fig. 109) and *B. alascanus* (Fig. 110)

5a. Height of otolith less than 45% of its length . . . . . *Anoplagonus inermis* (Fig. 111)

5b. Height of otolith more than 45% of its length 6

6a. Both dorsal and ventral margins smooth 7

6b. Dorsal margin and sometimes ventral margin crenulate 8

7a. No postcaudal trough . . . . . *Pallasina barbata* (Fig. 112)

7b. Postcaudal trough present, prominent, reaches posterior margin . . . . . *Hypsagonus quadricornis* (Fig. 113)

8a. Postcaudal trough obvious, reaches posteroventral margin of otolith. No dorsal branch to postcaudal trough . . . . . *Sarritor frenatus* (Fig. 114)

8b. Postcaudal trough shallow, divided into channels to posteroventral and posterodorsal margins, the dorsal branch more obvious than the ventral . . . . . *Sarritor leptorhynchus* (Fig. 115)

FAMILY CYCLOPTERIDAE

Because of the large number of species in this family, the difficulties involved in identifying them accurately, and the small amount of material available, the members of this group are not keyed out to species. Such reliably identified material as has been available has been illustrated.

1a. Height of otolith less than 65% of its length ..... Genus *Liparis* (Figs. 121-124)

1b. Height of otolith more than 70% of its length 2

2a. Rostrum present, distinct ..... Genus *Careproctus* (Figs. 118-120)

2b. No rostrum 3

3a. Margins very smooth. Thickness of otolith more than 43% of its height. Otolith dense, opaque, porcelainous ..... Genus *Eumicrotremus* (Fig. 116)

3b. Margins roughened. Thickness of otolith less than 40% of its height. Otolith translucent, glassy ..... Genus *Nectoliparis* (Fig. 117)

PLEURONECTIFORMES

The otoliths of pleuronectiform fishes show distinct differences between the right and the left otoliths. The sulcus of the left otolith always shows a small cauda and a large ostium separated by a distinct collum, while in the right otolith the two portions are nearly equal or are not, or but scarcely, separated. In some species, the right and left otoliths are of different shapes. For the majority of species included here, both the right and left otoliths will key out to the same couplets, in which differences are described (e.g., couplets 13-15 below). Where marked differences exist between right and left otoliths, each is keyed out separately (e.g., *Liopsetta glacialis*: right, couplet 5; left, couplet 10).

1a. Otolith very thin and delicate, flat to slightly concave on medial side, usually a raised center on both sides. Shape highly variable, larger ones with deeply incised margins ..... *Reinhardtius hippoglossoides* (Fig. 125)

1b. Not as in 1a 2

2a. Margins notably smooth except for a small posterodorsal notch. Medial surface flat, lateral surface a smooth dome. Sulcus a shallow, oval pit with undeveloped cristae ..... *Citharichthys sordidus* (Fig. 126)

2b. Margins various, but usually at least a few irregularities, indentations, or projections. Medial surface usually slightly rounded, lateral surface concave or irregularly convex. Sulcus with cristae present 3

3a. Outline of otolith resembles a slice of bread 4

3b. Outline of otolith not as in 3a 7

4a. Medial side flat or nearly so 6

4b. Medial side convex 5

5a. Otolith thin, its thickness less than 20% of its length ..... *Liopsetta glacialis* (right) (Fig. 127B)

5b. Otolith more robust, its thickness more than 20% of its length ..... *Hippoglossoides robustus* (Fig. 128) and *Isopsetta isolepis* (Fig. 129)

6a. Axis of sulcus parallel with dorsal margin of otolith ..... *Limanda proboscidea* (Fig. 130)

6b. Axis of sulcus slants ventrad anteriorly ..... *Glyptocephalus zachirus* (Fig. 131)

7a. A distinct, well-defined notch in anterodorsal margin, usually about 90° or less 8

7b. Notch absent or poorly defined; if present, usually broader than 90° 9

8a. Notch V-shaped, forming angle of 60°-90°. Posterodorsal corner of otolith square or rounded, without a distinct projection. Height of dorsal area averages 90% (87-107%) of height of ventral area. Ventral margin sometimes irregular, but not lobed ..... *Hippoglossus stenolepis* (Fig. 132)

8b. Notch usually forms angle of 90° or more. Posterodorsal corner of otolith usually with a distinct projection. Height of dorsal area averages 86% (75-93%) of height of ventral area. Ventral margin lobate ..... *Platichthys stellatus* (Fig. 133)

9a. Dorsal margin rounded, usually with almost same curvature as ventral margin. Otolith oval to almond-shaped 10

9b. Dorsal margin straight or nearly so, often indented. Otolith not oval or almond-shaped 12

10a. Posterior end of otolith much thicker than anterior end. Dorsal margin crenulate ..... *Liopsetta glacialis* (left) (Fig. 127A)

10b. Both ends of otolith about the same thickness. Dorsal margin not crenulate 11

11a. Height of otolith 65% (62-67%) of its length. Otolith large, may exceed 15 mm long. Otolith thin, one of 8-mm length will be less than 1 mm thick ..... *Atheresthes stomias* (Fig. 134)

11b. Height of otolith 58% (56-62%) of its length. Otolith small, rarely longer than 8 mm, and thick, an 8-mm otolith will be more than 1.5 mm thick ..... *Microstomus pacificus* (Fig. 135)

12a. Anterior end of otolith broadly rounded 13

12b. Anterior end of otolith more or less tapered 16

13a. Left sulcus shorter than 75% of height of otolith. Right otolith thicker posteriorly than anteriorly. Right sulcus generally shorter than 65% of otolith height 14

13b. Left sulcus longer than 75% of height of otolith. Right otolith not much thicker posteriorly than anteriorly. Right sulcus generally longer than 65% of otolith height 15

14a. Posterodorsal corner sharp, usually forming an angle of 90°-95°. Ventral margin of otolith almost always crenulate or lobate ..... *Pleuronectes quadrituberculatus* (Fig. 136)

14b. Posterodorsal corner not particularly sharp, generally forming an angle of 110° or more. Ventral margin of otolith smooth to irregular, rarely crenulate ..... *Hippoglossoides elassodon* (Fig. 137)

15a. Ventral margin of otolith nearly straight. Dorsal and ventral margins of sulcus parallel .... *Psettichthys melanostictus* (Fig. 138)

15b. Ventral margin of otolith rounded. Dorsal and ventral margins of sulcus flare apart anteriorly ..... *Limanda aspera* (Fig. 139)

16a. Dorsal margin of otolith usually with a prominent notch near its middle. Lateral surface with a prominent, deep groove opening into the notch, groove present even when notch is absent 18

16b. No notch on dorsal margin of otolith. Groove on lateral surface, if present, broad and shallow, not prominent 17

17a. Greatest height of otolith near middle of its length ..... *Hippoglossus stenolepis* (Fig. 132)

17b. Greatest height of otolith near posterior end ..... *Lepidopsetta bilineata* (Fig. 140)

18a. Margins of otolith usually lobate or crenulate. Dorsal margin of otolith parallel to sulcus. Posterior margin of otolith usually rounded ..... *Parophrys vetulus* (Fig. 141)

18b. Margins of otolith usually smooth, rarely lobate. Dorsal margin diverges from sulcus posteriorly. Posterior margin of otolith nearly always straight ..... *Eopsetta jordani* (Fig. 142)

ACKNOWLEDGMENTS

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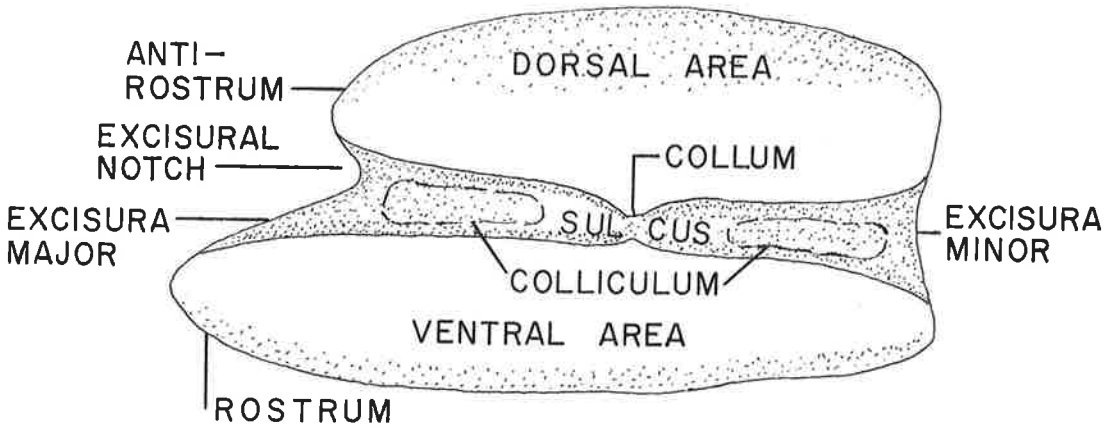
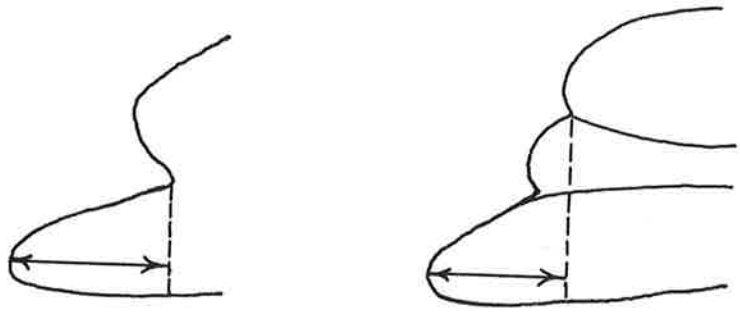
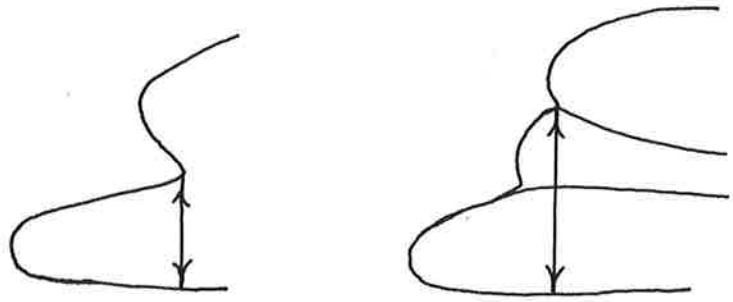




LENGTH OF ROSTRUM



HEIGHT OF ROSTRUM

Plate I.—Diagrams of medial sides of right otoliths, showing major features and measurements.

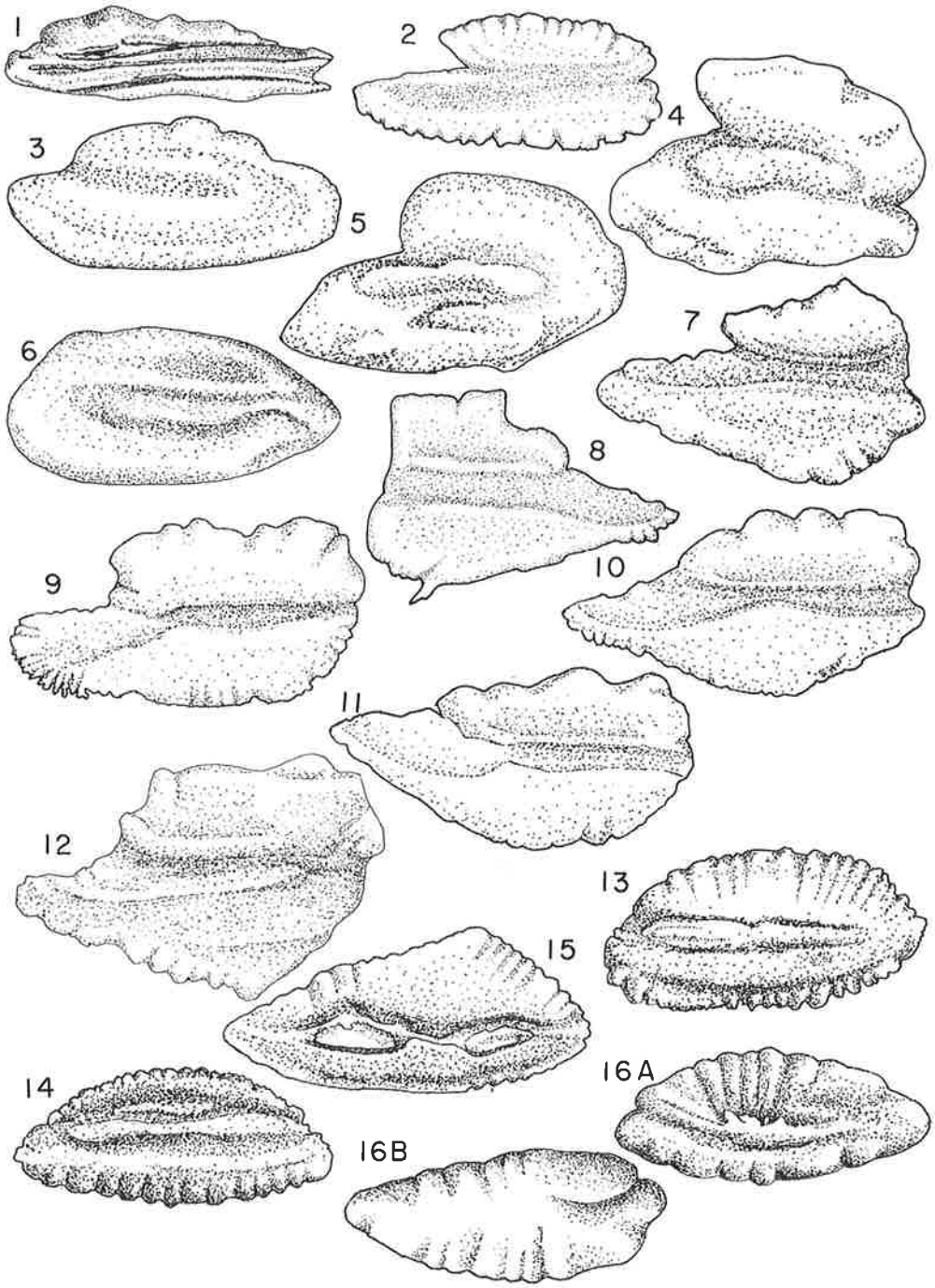


Plate II.—Figures 1 through 16. Medial side (except as noted) of otoliths of Antimoridae, Clupeidae, Cryptacanthodidae, Ammodytidae, Osmeridae, and Gadidae. Figures: 1.—*Antimora microlepis*—Longfin cod. Left otolith 10.4 mm long. 2.—*Clupea harengus pallasi*—Pacific herring. Right otolith 4.1 mm long. 3.—*Lyconectes aleutensis*—Dwarf wrymouth. Right otolith 4.5 mm long. 4.—*Delolepis gigantea*—Giant wrymouth. Right otolith 8.5 mm long. 5.—*Delolepis gigantea*—Giant wrymouth. Right otolith 7.9 mm long. 6.—*Ammodytes hexapterus*—Pacific sandlance. Left otolith 1.3 mm long. 7.—*Mallotus villosus*—Capelin. Left otolith 2.4 mm long. 8.—*Thaleichthys pacificus*—Eulachon. Right otolith 4.4 mm long. 9.—*Hypomesus pretiosus*—Surf smelt. Right otolith 5.0 mm long. 10.—*Osmerus eperlanus*—Rainbow smelt. Right otolith 4.0 mm long. 11.—*Spirinchus thaleichthys*—Longfin smelt. Right otolith 4.5 mm long. 12.—*Hypomesus olidus*—Pond smelt. Right otolith 2.5 mm long. 13.—*Gadus macrocephalus*—Pacific cod. Right otolith 14.0 mm long. 14.—*Theragra chalcogramma*—Walleye pollock. Left otolith 15.0 mm long. 15.—*Merluccius productus*—Pacific hake. Left otolith 16.0 mm long. 16.—*Boreogadus saida*—Arctic cod. A. Medial side of right otolith 6.8 mm long. B. Lateral side of same otolith.

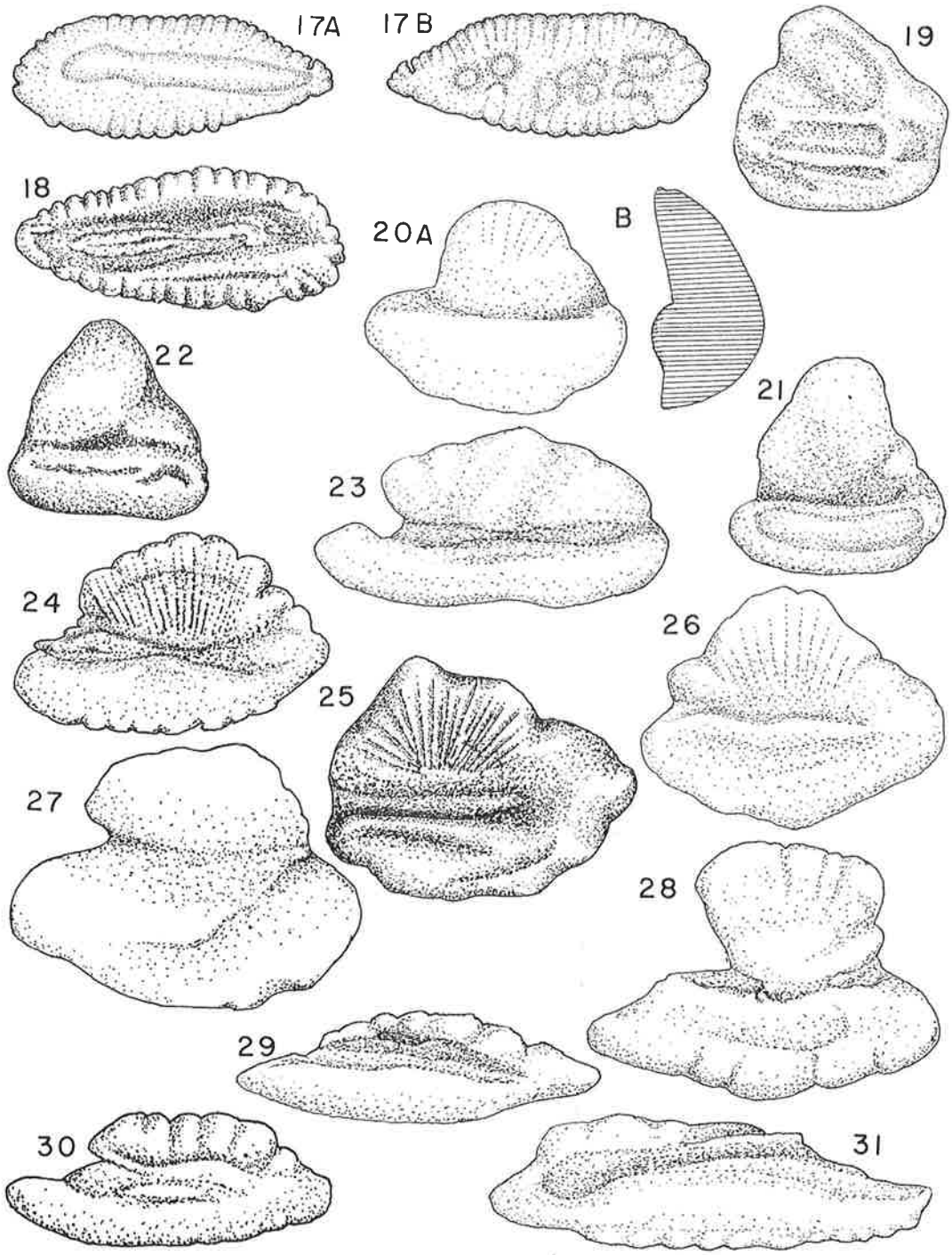


Plate III.—Figures 17 through 31. Medial side (except as noted) of otoliths of Gadidae, Zoarcidae, Trichodontidae, and Bathymasteridae. Figures: 17.—*Microgadus proximus*—Pacific tomcod. A. Medial side of right otolith 12.3 mm long. B. Lateral side of same otolith. 18.—*Eleginus gracilis*—Saffron cod. Left otolith 11.2 mm long. 19.—*Embryx crotalina*—Snakehead eelpout. Right otolith 2.9 mm long. 20.—*Bothrocara brunneum*—Twoline eelpout. A. Right otolith 5.0 mm long. B. Cross section. 21.—*Bothrocara pusillum*—Alaska eelpout. Right otolith 2.0 mm long. 22.—*Bothrocara molle*—Soft eelpout. Left otolith 1.9 mm long. 23.—*Lycodopsis pacifica*—Blackbelly eelpout. Right otolith 4.5 mm long. 24.—*Lycodes palearis*—Wattled eelpout. Right otolith 5.0 mm long. 25.—*Lycodes brevipes*—Shortfin eelpout. Right otolith 5.0 mm long. 26.—*Lycodes diapterus*—Black eelpout. Right otolith 5.7 mm long. 27.—*Trichodon trichodon*—Pacific sandfish. Right otolith 4.3 mm long. 28.—*Arctoscopus japonicus*—Sailfin sandfish. Right otolith 6.0 mm long. 29.—*Ronquilus jordani*—Northern ronquil. Right otolith 5.3 mm long. 30.—*Bathymaster signatus*—Searcher. Right otolith 5.0 mm long. 31.—*Bathymaster caeruleofasciatus*—Alaska ronquil. Left otolith 8.0 mm long.

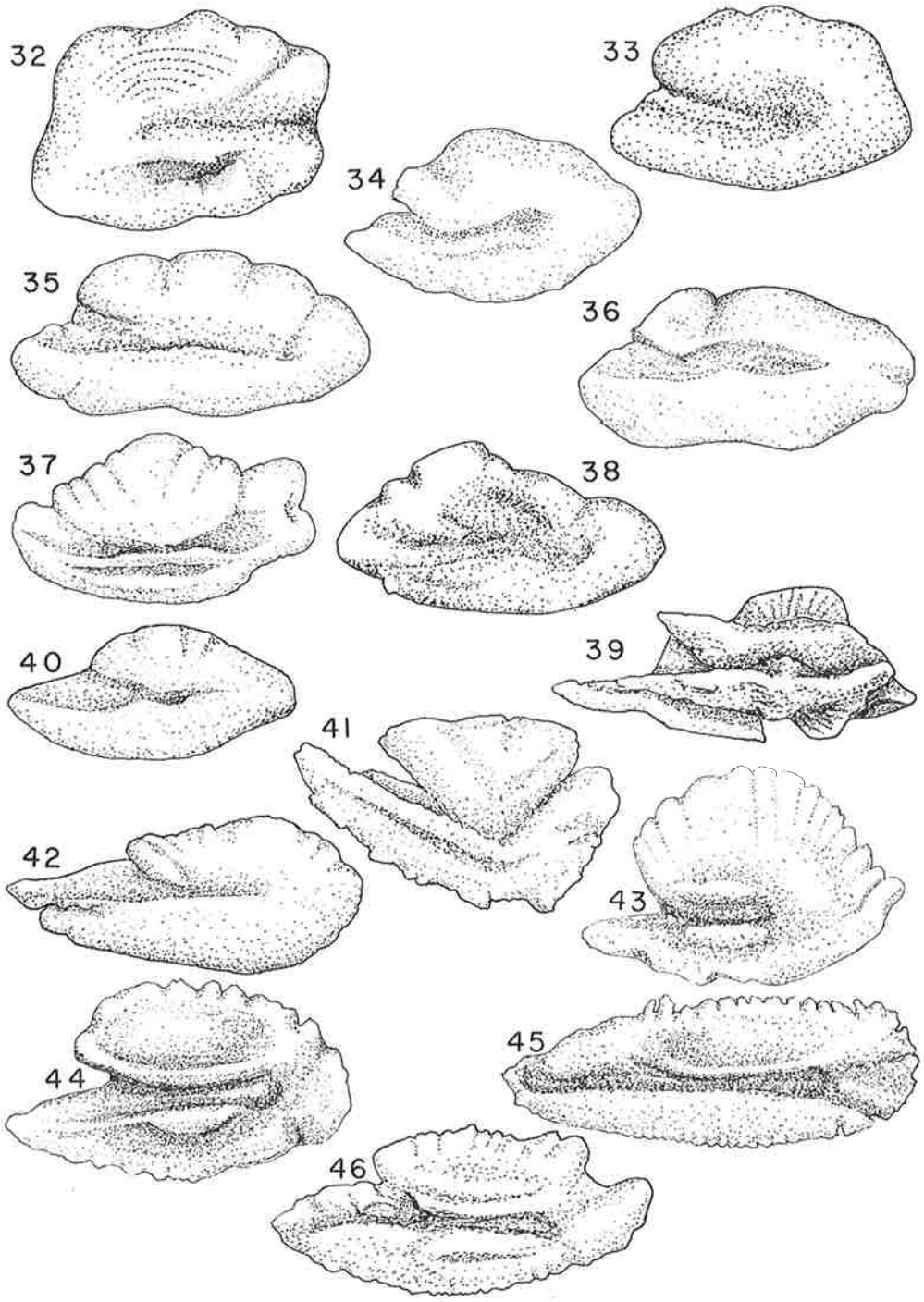


Plate IV.—Figures 32 through 46. Medial side of otoliths of Stichaeidae, Pholididae, Anarhichadidae, and Scorpaenidae. Figures: 32.—*Lumpenella longirostris*—Longsnout prickleback. Left otolith 3.6 mm long. 33.—*Lumpenus maculatus*—Daubed shanny. Right otolith 1.9 mm long. 34.—*Poroclinus rothrocki*—Whitebarred prickleback. Right otolith 2.9 mm long. 35.—*Acantholumpenus mackayi*—Pighead prickleback. Right otolith 2.8 mm long. 36.—*Lumpenus fabricii*—Slender eelblenny. Right otolith 2.3 mm long. 37.—*Lumpenus sagitta*—Snake prickleback. Right otolith 3.5 mm long. 38.—*Stichaeus punctatus*—Arctic shanny. Right otolith 3.2 mm long. 39.—*Apodichthys flavidus*—Penpoint gunnel. Right otolith 2.2 mm long. 40.—*Pholis ornata*—Saddleback gunnel. Right otolith 2.0 mm long. 41.—*Anarrhichthys ocellatus*—Wolf-eel. Right otolith 4.3 mm long. 42.—*Anarhichas orientalis*—Bering wolffish. Right otolith 3.4 mm long. 43.—*Sebastolobus altivelis*—Longspine thornyhead. Right otolith 12.0 mm long. 44.—*Sebastolobus alascanus*—Shortspine thornyhead. Right otolith 12.0 mm long. 45.—*Sebastes entomelas*—Widow rockfish. Right otolith 17.0 mm long. 46.—*Sebastes brevispinis*—Silvergray rockfish. Right otolith 17.0 mm long.

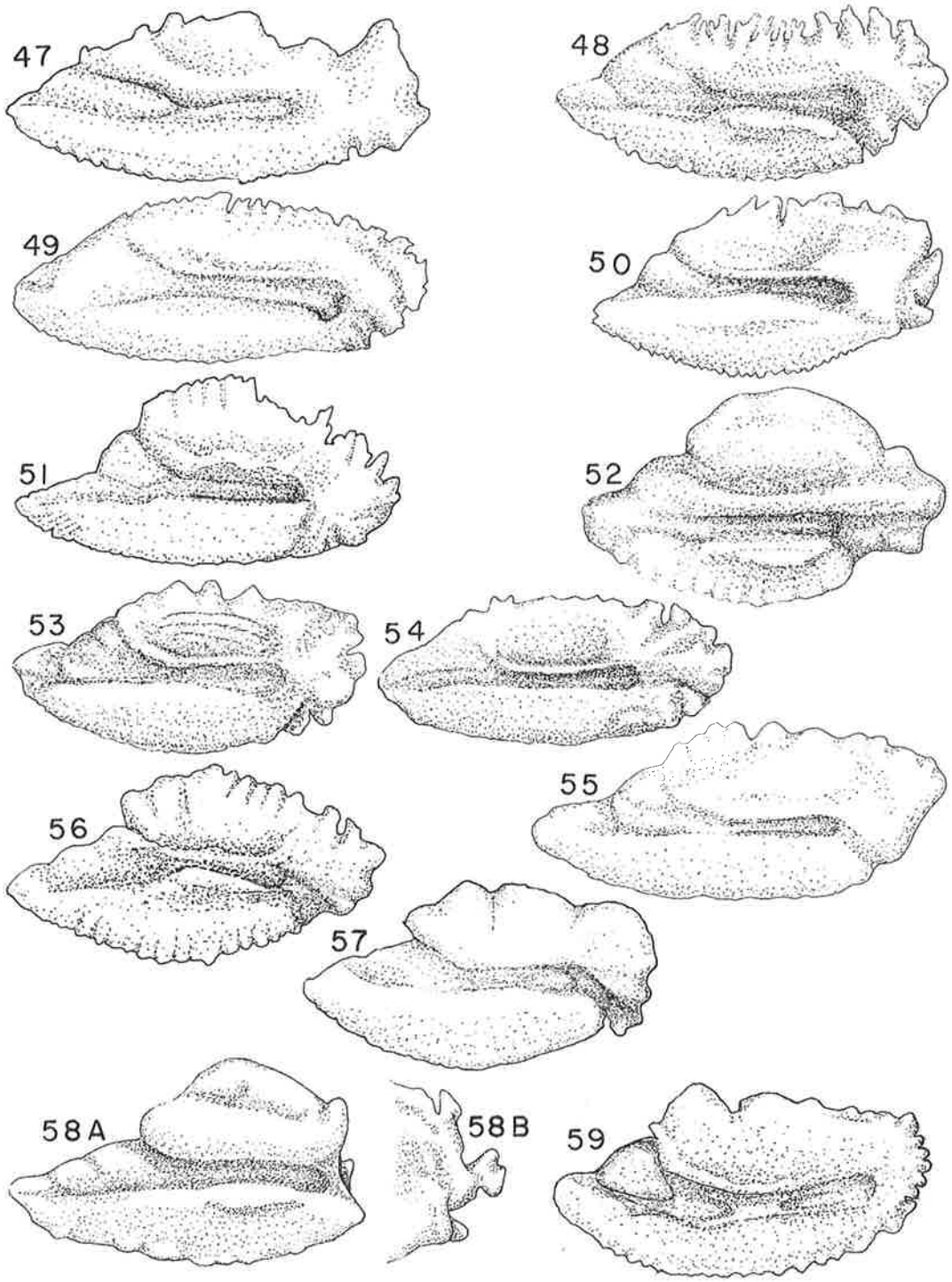


Plate V.—Figures 47 through 59. Medial side of otoliths of Scorpaenidae. Figures: 47.—*Sebastes proriger*—Redstripe rockfish. Right otolith 13.0 mm long. 48.—*Sebastes caurinus*—Copper rockfish. Right otolith 20.5 mm long. 49.—*Sebastes mystinus*—Blue rockfish. Right otolith 16.0 mm long. 50.—*Sebastes maliger*—Quillback rockfish. Right otolith 14.5 mm long. 51.—*Sebastes melanostomus*—Blackgill rockfish. Right otolith 20.0 mm long. 52.—*Sebastes aurora*—Aurora rockfish. Right otolith 12.0 mm long. 53.—*Sebastes ciliatus*—Dusky rockfish. Right otolith 13.0 mm long. 54.—*Sebastes melanops*—Black rockfish. Right otolith 17.0 mm long. 55.—*Sebastes polyspinis*—Northern rockfish. Right otolith 14.0 mm long. 56.—*Sebastes babcocki*—Redbanded rockfish. Right otolith 18.0 mm long. 57.—*Sebastes zacentrus*—Sharpchin rockfish. Right otolith 13.0 mm long. 58.—*Sebastes borealis*—Shortraker rockfish. A. Right otolith 23.0 mm long. B. Posterior end of another otolith to show typical projections. 59.—*Sebastes crameri*—Darkblotched rockfish. Right otolith 17.0 mm long.

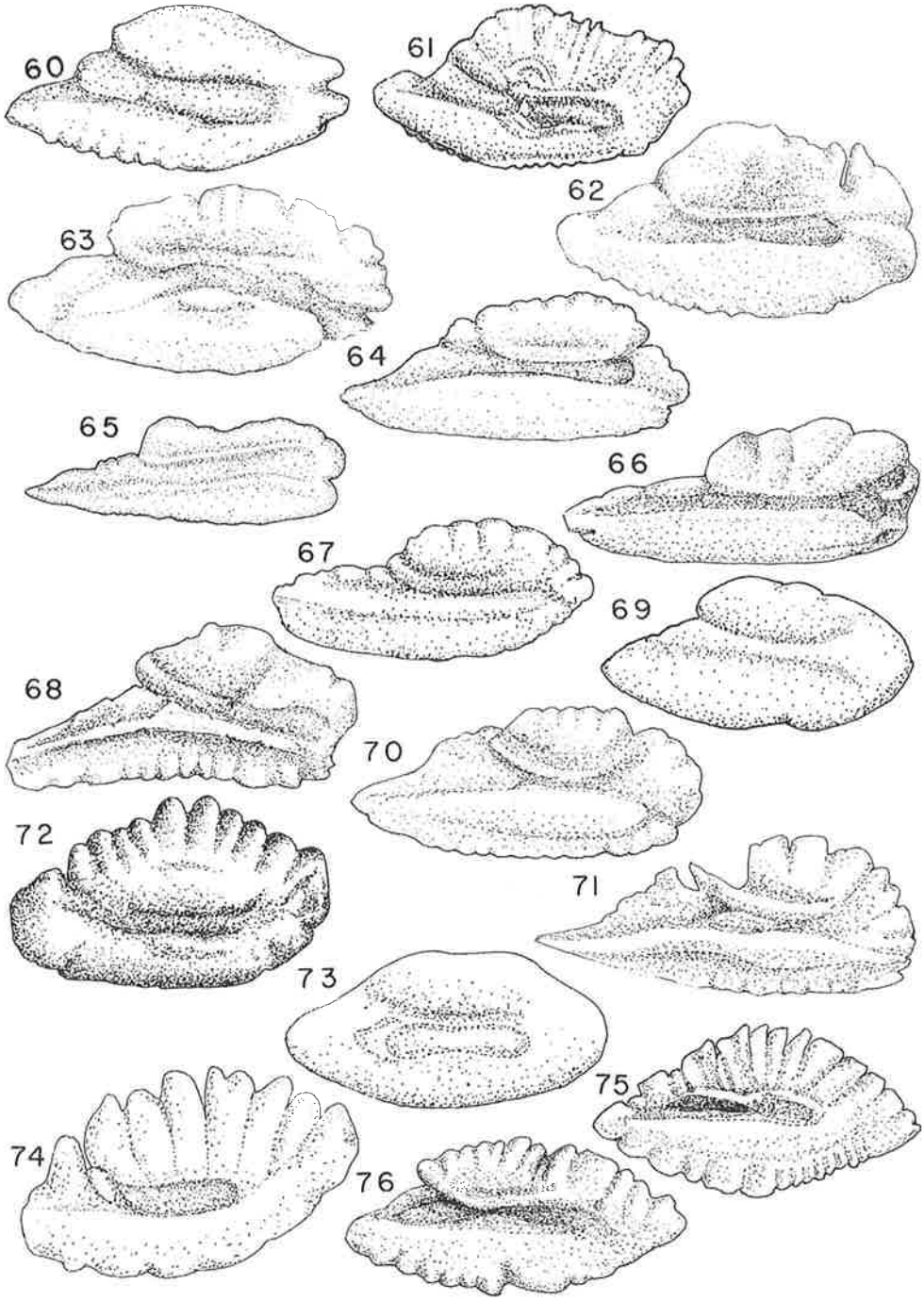


Plate VI.—Figures 60 through 76. Medial side of otoliths of Scorpaenidae, Anoplopomatidae, Hexagrammidae, and Cottidae. Figures: 60.—*Sebastes variegatus*—Harlequin rockfish. Right otolith 6.8 mm long. 61.—*Sebastes alutus*—Pacific ocean perch. Right otolith 14.2 mm long. 62.—*Sebastes aleutianus*—Rougheye rockfish. Right otolith 14.5 mm long. 63.—*Sebastes ruberrimus*—Yelloweye rockfish. Right otolith 22.0 mm long. 64.—*Erilepis zonifer*—Skilfish. Right otolith 7.5 mm long. 65.—*Anoplopoma fimbria*—Sablefish. Right otolith 10.4 mm long. 66.—*Pleurogrammus monopterygius*—Atka mackerel. Right otolith 5.0 mm long. 67.—*Ophiodon elongatus*—Ling cod. Right otolith 5.8 mm long. 68.—*Hexagrammos lagocephalus*—Rock greenling. Right otolith 5.7 mm long. 69.—*Hexagrammos stelleri*—Whitespotted greenling. Right otolith 2.2 mm long. 70.—*Hexagrammos octogrammus*—Masked greenling. Right otolith 4.5 mm long. 71.—*Hexagrammos decagrammus*—Kelp greenling. Right otolith 6.5 mm long. 72.—*Dasycottus setiger*—Spinyhead sculpin. Right otolith 8.9 mm long. 73.—*Psychrolutes paradoxus*—Tadpole sculpin. Right otolith 2.0 mm long. 74.—*Myoxocephalus quadricornis*—Fourhorn sculpin. Right otolith 8.2 mm long. 75.—*Myoxocephalus polyacanthocephalus*—Great sculpin. Right otolith 8.5 mm long. 76.—*Myoxocephalus jaok*—Plain sculpin. Right otolith 10.5 mm long.

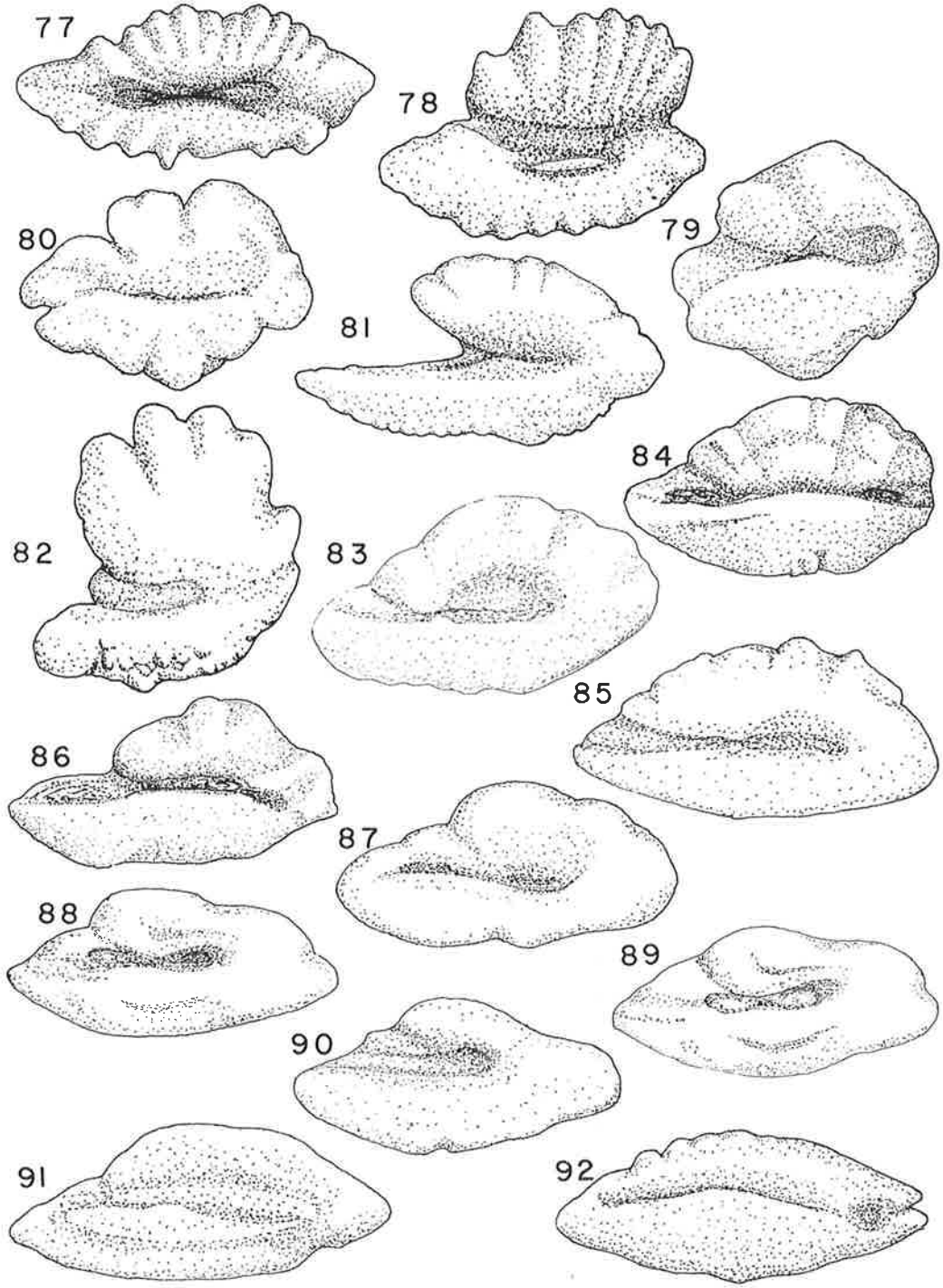


Plate VII.—Figures 77 through 92. Medial side of otoliths of Cottidae. Figures: 77.—*Myoxocephalus scorpius*—Shorthorn sculpin. Right otolith 8.6 mm long. 78.—*Malacocottus kincaidi*—Blackfin sculpin. Right otolith 8.5 mm long. 79.—*Nautichthys robustus*—No common name. Right otolith 1.4 mm long. 80.—*Blepsias bilobus*—Crested sculpin. Right otolith 1.8 mm long. 81.—*Blepsias cirrhosus*—Silverspotted sculpin. Right otolith 1.9 mm long. 82.—*Hemitripterus bolini*—Bigmouth sculpin. Right otolith 4.5 mm long. 83.—*Icelus spiniger*—No common name. Right otolith 4.7 mm long. 84.—*Icelus canaliculatus*—No common name. Right otolith 6.5 mm long. 85.—*Radulinus asprellus*—Slim sculpin. Right otolith 4.4 mm long. 86.—*Gymnocanthus galeatus*—Armorhead sculpin. Right otolith 8.5 mm long. 87.—*Icelus spatula*—Spatulate sculpin. Right otolith 4.3 mm long. 88.—*Icelinus borealis*—Northern sculpin. Right otolith 3.8 mm long. 89.—*Gymnocanthus tricuspis*—Arctic staghorn sculpin. Right otolith 3.8 mm long. 90.—*Rhamphocottus richardsoni*—Grunt sculpin. Right otolith 2.0 mm long. 91.—*Artedius harringtoni*—Scalyhead sculpin. Right otolith 2.7 mm long. 92.—*Artedius fenestralis*—Padded sculpin. Right otolith 4.6 mm long.

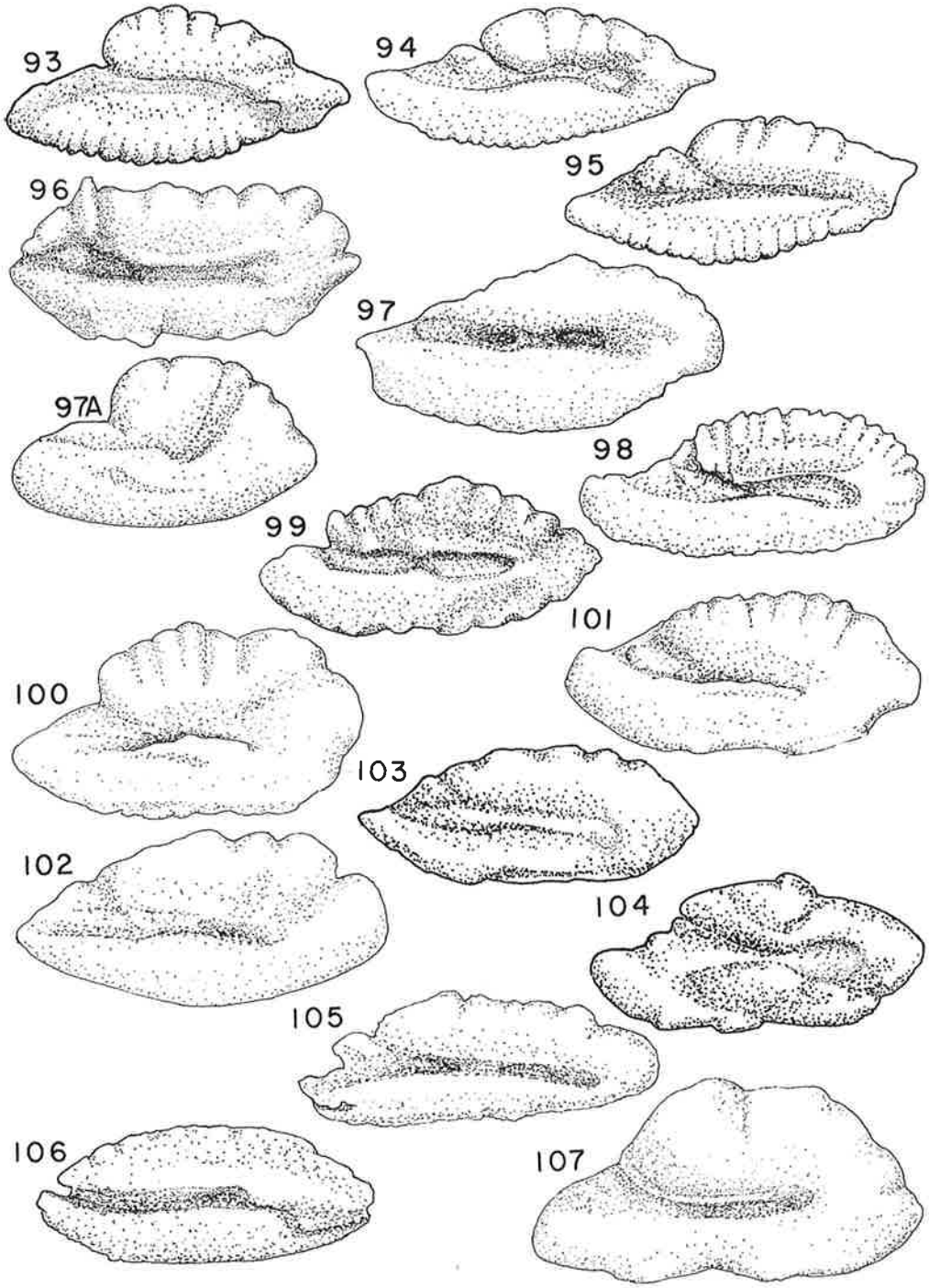


Plate VIII.—Figures 93 through 107. Medial side of otoliths of Cottidae and Agonidae. Figures: 93.—*Hemilepidotus hemilepidotus*—Red Irish lord. Right otolith 6.0 mm long. 94.—*Hemilepidotus jordani*—Yellow Irish lord. Right otolith 4.0 mm long. 95.—*Hemilepidotus spinosus*—Brown Irish lord. Right otolith 9.0 mm long. 96.—*Enophrys diceraus*—Antlered sculpin. Right otolith 9.5 mm long. 97.—*Enophrys bison*—Buffalo sculpin. Right otolith 9.5 mm long. 97A.—*Enophrys* sp. Right otolith 3.4 mm long. 98.—*Leptocottus armatus*—Pacific staghorn sculpin. Right otolith 9.5 mm long. 99.—*Megalocottus platycephalus*—Belligerent sculpin. Right otolith 7.2 mm long. 100.—*Triglops scepticus*—Spectacled sculpin. Right otolith 7.0 mm long. 101.—*Triglops forficata*—Scissortail sculpin. Right otolith 5.8 mm long. 102.—*Triglops pingeli*—Ribbed sculpin. Right otolith 4.3 mm long. 103.—*Triglops macellus*—Roughspine sculpin. Right otolith 6.8 mm long. 104.—*Agonus acipenserinus*—Sturgeon poacher. Right otolith 3.5 mm long. 105.—*Occella dodecaedron*—Bering poacher. Right otolith 4.8 mm long. 106.—*Occella verrucosa*—Warty poacher. Right otolith 3.9 mm long. 107.—*Bathyagonus nigripinnis*—Blackfin poacher. Right otolith 4.9 mm long.

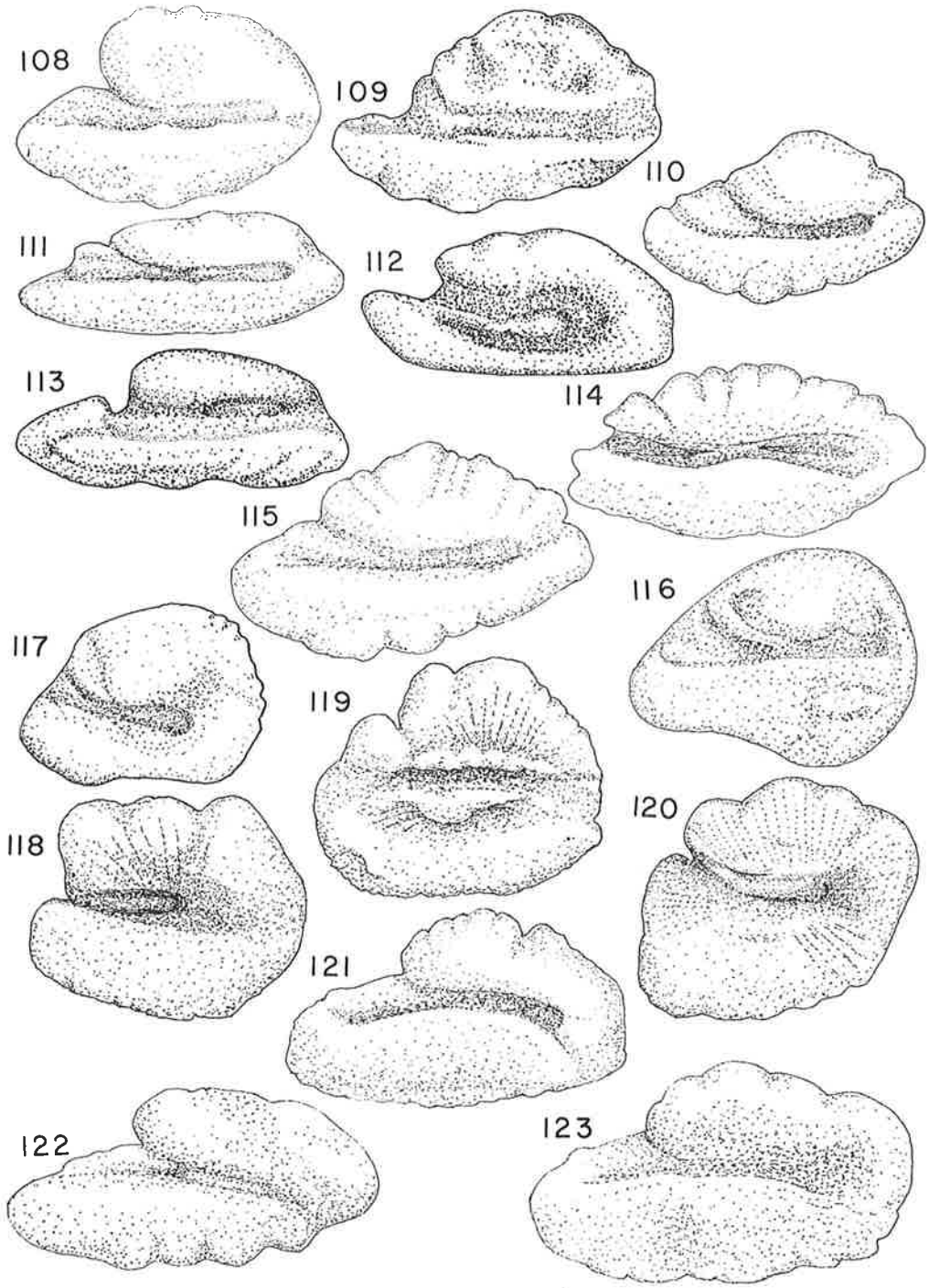


Plate IX.—Figures 108 through 123. Medial side of otoliths of Agonidae and Cyclopteridae. Figures: 108.—*Bathyagonus pentacanthus*—Bigeye poacher. Right otolith 3.7 mm long. 109.—*Bathyagonus infraspinatus*—Spinycheek starsnout. Right otolith 3.4 mm long. 110.—*Bathyagonus alascanus*—Gray starsnout. Right otolith 3.2 mm long. 111.—*Anoplagonus inermis*—Smooth alligatorfish. Right otolith 2.8 mm long. 112.—*Pallasina barbata*—Tubenose poacher. Right otolith 1.5 mm long. 113.—*Hypsagonus quadricornis*—Fourhorn poacher. Right otolith 2.2 mm long. 114.—*Sarritor frenatus*—Sawback poacher. Right otolith 7.1 mm long. 115.—*Sarritor leptorhynchus*—Longnose poacher. Right otolith 5.7 mm long. 116.—*Eumicrotremus orbis*—Pacific spiny lumpsucker. Right otolith 1.2 mm long. 117.—*Nectoliparis pelagicus*—Tadpole snailfish. Right otolith 0.7 mm long. 118.—*Careproctus* sp. Right otolith 2.9 mm long. 119.—*Careproctus furcellus*—No common name. Right otolith 4.0 mm long. 120.—*Careproctus melanurus*—Blacktail snailfish. Right otolith 3.5 mm long. 121.—*Liparis pulchellus*—Showy snailfish. Right otolith 3.0 mm long. 122.—*Liparis dennyi*—Marbled snailfish. Right otolith 2.9 mm long. 123.—*Liparis liparis*—Striped seasnail. Right otolith 4.1 mm long.

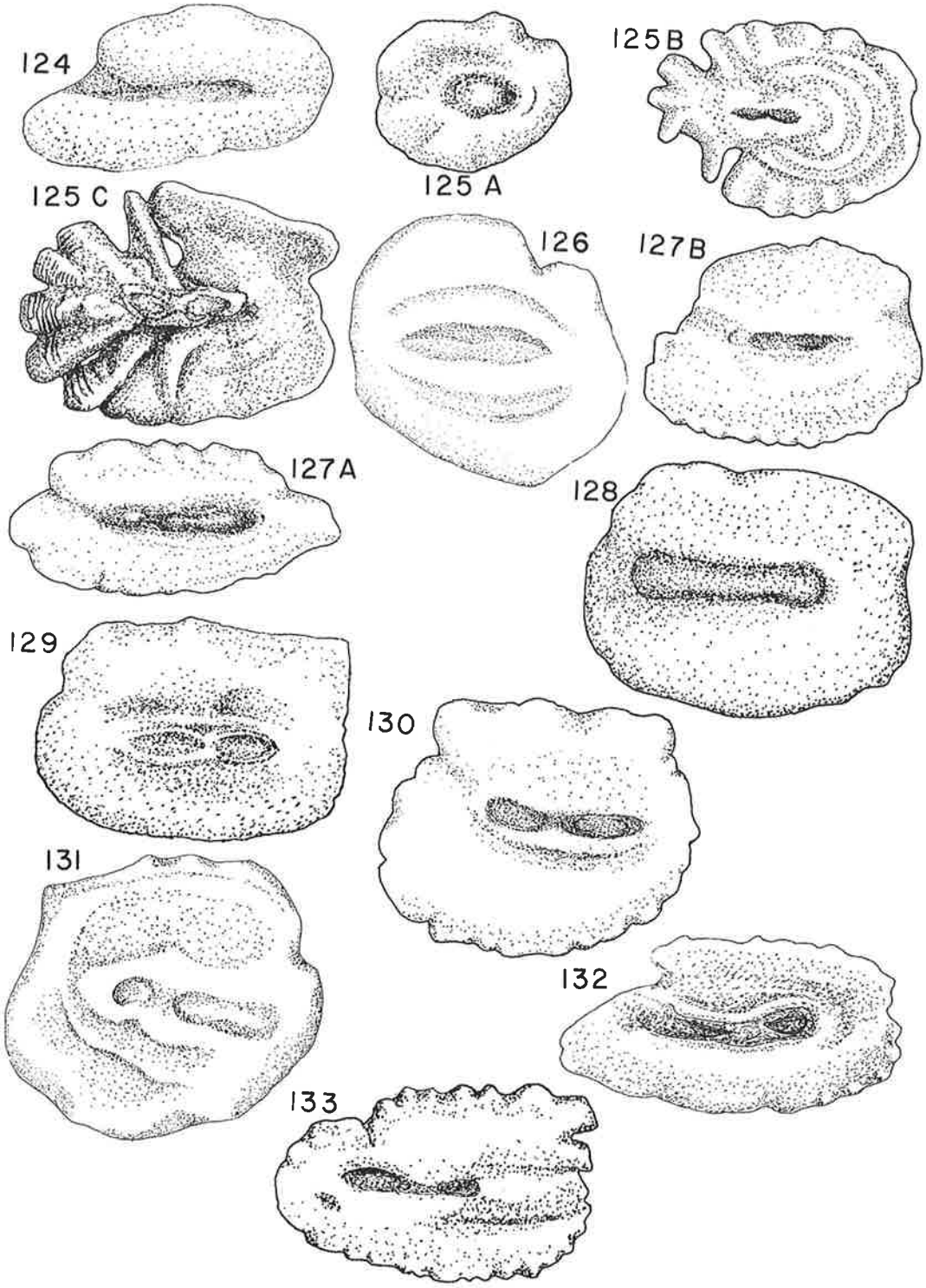


Plate X.—Figures 124 through 133. Medial side of otoliths of Cyclopteridae, Bothidae, and Pleuronectidae. Figures: 124.—*Liparis gibbus*— No common name. Right otolith 2.2 mm long. 125.—*Reinhardtius hippoglossoides*—Greenland halibut. A. Left otolith 2.4 mm long. B. Right otolith 4.5 mm long. C. Right otolith 6.5 mm long. 126.—*Citharichthys sordidus*—Pacific sanddab. Right otolith 8.2 mm long. 127.—*Liopsetta glacialis*—Arctic flounder. A. Left otolith 6.8 mm long. B. Right otolith 4.7 mm long. 128.—*Hippoglossoides robustus*—Bering flounder. Right otolith 5.0 mm long. 129.—*Isopsetta isolepis*—Butter sole. Right otolith 5.8 mm long. 130.—*Limanda proboscidea*—Longhead dab. Left otolith 4.2 mm long. 131.—*Glyptocephalus zachirus*—Rex sole. Left otolith 4.9 mm long. 132.—*Hippoglossus stenolepis*—Pacific halibut. Right otolith 6.4 mm long. 133.—*Platichthys stellatus*—Starry flounder. Right otolith 7.2 mm long.

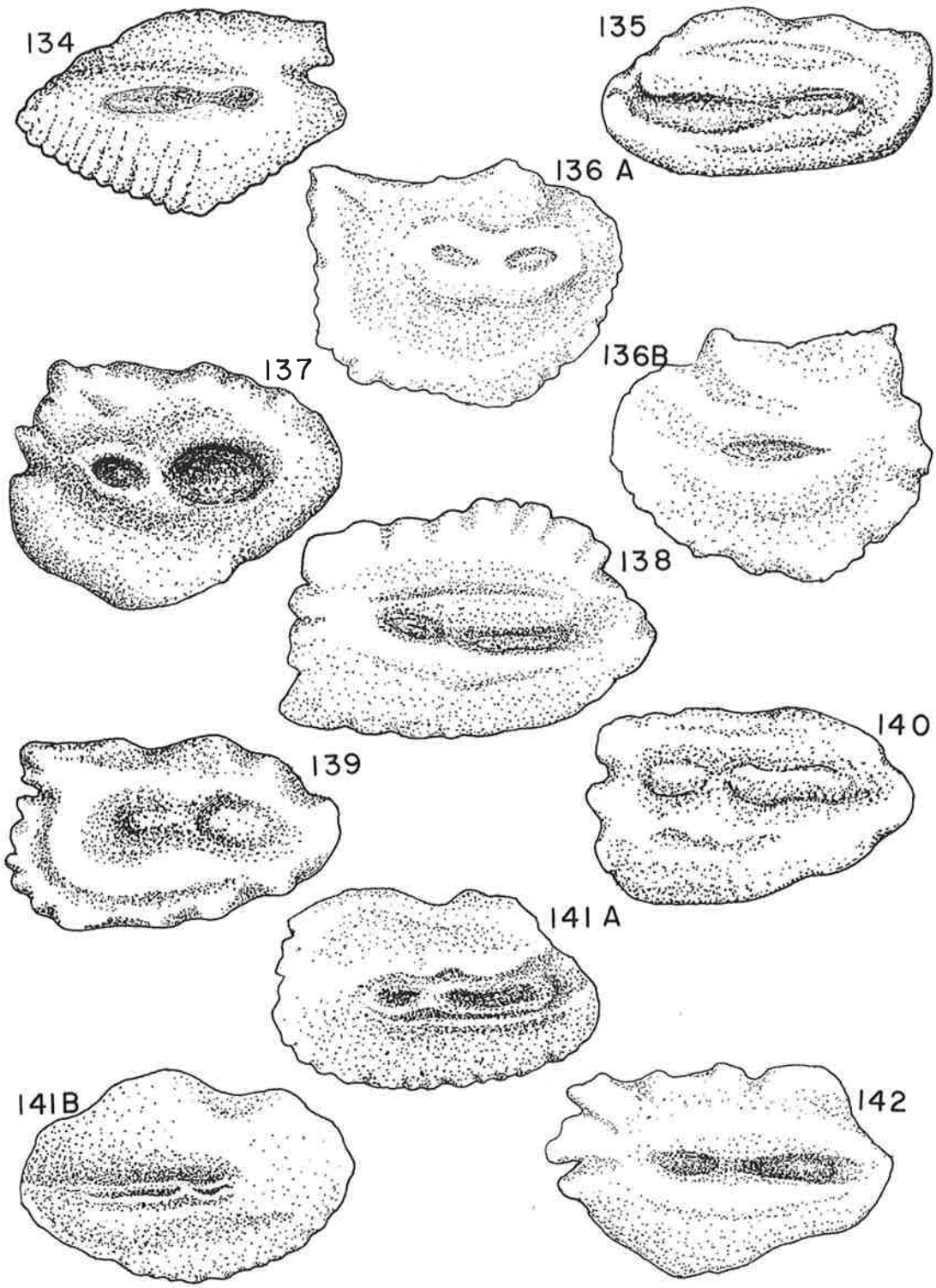


Plate XI.—Figures 134 through 142. Medial side of otoliths of Pleuronectidae. Figures: 134.—*Atheresthes stomias*—Arrowtooth flounder. Right otolith 8.0 mm long. 135.—*Microstomus pacificus*—Dover sole. Right otolith 6.5 mm long. 136.—*Pleuronectes quadrituberculatus*—Alaska plaice. A. Left otolith 8.0 mm long. B. Right otolith 8.0 mm long. 137.—*Hippoglossoides elassodon*—Flathead sole. Left otolith 7.7 mm long. 138.—*Psettichthys melanostictus*—Sand sole. Left otolith 5.0 mm long. 139.—*Limanda aspera*—Yellowfin sole. Left otolith 7.3 mm long. 140.—*Lepidopsetta bilineata*—Rock sole. Left otolith 6.1 mm long. 141.—*Parophrys vetulus*—English sole. A. Left otolith 5.9 mm long. B. Right otolith 5.8 mm long. 142.—*Eopsetta jordani*—Petrale sole. Left otolith 7.0 mm long.

388. Proceedings of the first U.S.-Japan meeting on aquaculture at Tokyo, Japan, October 18-19, 1971. William N. Shaw (editor). (18 papers, 14 authors.) February 1974, iii + 133 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

389. Marine flora and fauna of the northeastern United States. Crustacea: Decapoda. By Austin B. Williams. April 1974, iii + 50 p., 111 figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

390. Fishery publications, calendar year 1973: Lists and indexes. By Mary Ellen Engett and Lee C. Thorson. September 1974, iv + 14 p., 1 fig. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

391. Calanoid copepods of the genera *Spinocalanus* and *Mimocalanus* from the central Arctic Ocean, with a review of the Spinocalanidae. By David M. Damkaer. June 1975, x + 88 p., 225 figs., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

392. Fishery publications, calendar year 1974: Lists and indexes. By Lee C. Thorson and Mary Ellen Engett. June 1975, iv + 27 p., 1 fig.

393. Cooperative Gulf of Mexico estuarine inventory and study—Texas: Area description. By Richard A. Diener. September 1975, vi + 129 p., 55 figs., 26 tables.

394. Marine Flora and Fauna of the Northeastern United States. Tardigrada. By Leland W. Pollock. May 1976, iii + 25 p., figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

395. Report of a colloquium on larval fish mortality studies and their relation to fishery research, January 1975. By John R. Hunter. May 1976, iii + 5 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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