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"I.M. Likhachev," given in this translation as one of the authors of the original work, is incorrect. The correct spelling is "I.M. Likharev."

TRANSLATORS' NOTE

1. Page numbers appearing in the margin of the translation correspond to those in the Russian text.
2. The section on *Boreogadies* was modified from Transl. No. 151 of the Fisheries Research Board of Canada.
3. This translation was made with support from the National Science Foundation through a grant (G-7123) to the Sears Foundation for Marine Research.
4. We are indebted to Dr. A. N. Svetovidov for his great kindness in reviewing the translation and commenting upon portions of it.

TRANSLATION EDITORS' NOTE

Readers using the morphological sections of this book are cautioned not to confuse the terms olfactory bulb and olfactory lobe, and olfactory nerve and olfactory tract.

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FOREWORD

At the present level of knowledge a detailed revision of the gadoids is extremely necessary. In this survey the entire gadoid group had to be studied as a whole, and not merely the external features; otherwise it would not have been possible to arrive at reliable, firmly based conclusions. The present work, therefore, has greater scope than that normally envisaged for the "Fauna of the U.S.S.R." series. It deals not only with species found in Soviet waters but with those from more remote regions. Thus, in this work, attention has been focused mainly on an osteologically based morphology, and not on external characteristics.

My own attention was mainly directed toward the investigation of higher systematic categories: the order, family, genus and species. I gave considerably less attention to the study of races and lower taxonomic units, mainly because I lacked technical personnel and had insufficient material collected in the proper manner for modern investigations of races. The Zoological Institute of the Academy of Sciences has an extremely rich collection of almost all the gadoid species. This and the material kindly sent to me by people and institutions, both in the U.S.S.R. and from abroad, were instrumental in enabling me to complete this work.

The geographical distribution of this group of fish needed elucidation, too. This in itself made necessary the summary of the available information in this field. Distribution maps must, of course, be compiled with the utmost accuracy. Since this, unhappily, was not always possible, the maps presented must be regarded as having orientation and schematic value only. Fairly detailed exposition on the biology of gadoids is available in well-known abstracts on fish migrations (Meek, Scheuring, Schmidt). Thus, relatively little attention has been paid to these problems in the introduction. A number of related fields have not been exhaustively treated. I did not feel myself competent to deal with commercial problems, which are, indeed, outside the scope of a book of this type; nor with otoliths, which have been described in a number of works by Frost; nor with larvae, on which a special volume of the "Fauna of the U.S.S.R." is being prepared.

I have cited only the best-known data in the literature. These were selected from the voluminous material which has been published on gadoids. In cases where books are known to me only by their titles, since I was unable to obtain the texts, I do not cite them.

I wish to thank the many people I consulted who gave their help and encouragement when I was in difficulty. It is my pleasant task to thank L. S. Berg, E. F. Gur'yanova and particularly E. K. Suvorov, who, among others, allowed me the use of unpublished material.

Almost three years have elapsed since this book was written. I have made use of only the most important works that have appeared in the interval, and those not always fully.

September 1940.

The publication of this work, which had been completed and set in type by the end of the summer of 1941, was delayed by the war. Later, during the Leningrad blockade, the proofs were lost. I was able to use, though not to their full extent, the most important works published during the war which were accessible to me. I was unable to make use of them in the sections dealing with biology and economic importance of gadoids; the data on the latter subject remain almost unchanged.

April 1947.

TAXONOMIC INDEX OF SPECIES AND SUBSPECIES

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INTRODUCTION

A Brief Historical Outline of the Classification of the Order

Within the order Anacanthini, J. Müller (1846:177), who was first to establish this order, placed those fishes having fins without spinous rays, ventral fins, if present, jugular or thoracic, and air swimbladder, if present, without pneumatic duct. The entire broad assemblage of fishes thus united into one order by these characters was divided by J. Müller thus (l.c. :202):-

Ordo Anacanthini

Subordo I. Anacanthini subbrachii

Fam. 1. Gadoidei

2. Pleuronectides

Subordo II. Anacanthini apodes

Fam. 1. Ophidini

Accordingly, the order Anacanthini, as indicated by J. Müller (l.c. : 177, 199), consists partially (Anacanthini subbrachii) of Malacopterygii subbrachii and partially (Anacanthini apodes) of Malacopterygii apodes according to the classification of Cuvier (1817:212, 229). In its internal structure, J. Müller considered the Anacanthini very close to the Anacanthopterygii, with which they, just as with the Pleuronectidae, have been graded for a long time.

Gunther (1862:317), accepting the order Anacanthini as established by J. Müller, considered that they have spinous rays only in the vertical fins, and divided the order into two suborders somewhat differently:

Anacanthini Gadoidei. Head symmetrical. Families: Gadopsidae, Lycodidae, Gadidae, Ophidiidae (groups: Brotulina, Ophidiina, Fierasferina, Ammodytina, Congrogadina), Macruridae, Ateleopodidae.

Anacanthini Pleuronectoidei. Both sides of head asymmetrical. Family: Pleuronectidae.

Günther's system also differs by a greater subdivision within the suborders.

Cope (1872:341) defined the Anacanthini as fish, whose skull base is simple (without a myodome), posttemporal forked, scapular foramen between scapula and coracoideum; pharyngeals three, horizontal, the third being the longest; rays in dorsal fin soft; caudal fin diphycercal. According to these characters he placed in the Anacanthini, which he accepts as one of the groups of the order Percomorphi, only the families Gadidae and 12 Macruridae, separating the majority of the related families into a special group of the same order Scyphobranchii. Cope separated the flat

fishes into the distinct order Heterosomata, in which status they are accepted by almost all later classifications. Cope's classification of the Anacanthini appears to be a great step forward, inasmuch as the scope and characters established by him as the basis for his classification have been accepted by a great majority of later classifications.

Jordan and Gilbert (1883:783) indicated in a footnote that in the order Acanthopteri the families Gadidae, Macruridae, Lycodidae, Congrogadidae, Fierasferidae, and Ophidiidae constitute a separate group or suborder of the Anacanthini, or Jugulares, distinguished from the other Acanthopteri by long dorsal and anal fins, consisting entirely of soft rays. They divided the family Gadidae into the subfamilies Gadinae, Merlucciinae, Chiasmodontinae, Brotulinae, even though the latter in their keys (page 79) was separated into a distinct family.

Gill (1884:167) gives the following subdivisions of the Anacanthini, or Jugulares:

GADOIDEA. Orbito-rostral portion of cranium longer than the posterior portion, cranial cavity widely open in front, supraoccipital well developed with a crest behind, scapular foramen between the scapula and coracoideum. Families: Gadidae, Merlucciidae, Bregmacerotidae, Ranicipitidae, Macruridae.

OPHIDIOIDEA. Orbito-rostral portion of cranium contracted and shorter than the posterior, cavity closed in part in the front by the expansion and fusion of the parasphenoid with frontals, scapula with a foramen in the center. Families: Brotulidae, Brotulophididae, Ophidiidae, Fierasferidae, Congrogadidae.

LYCODOIDEA. Orbito-rostral portion of the cranium compressed and shorter than the posterior, the cranial cavity open in front but bounded laterally by the expansion of the annectant parasphenoid and frontals, supraoccipital declivous and tectiform behind, scapula with foramen in the center. Families: Lycodidae, Ammodytidae, Ateleopodidae, Xenocephalidae.

All groups of the family Ophidiidae and all genera of the families Gadidae, Ophidiidae and Ateleopodidae of Günther's system are considered by Gill as families; the family Gadopsidae and the genus Chiasmodon he considers to be families of Acanthopterygii. Most important in Gill's system appears to be the fact that as a basis of division of the order into groups he indicates new osteological characters, which are important even to the present day.

We are considerably closer to the present treatment if we accept as a basis the characters of the Gadoidea of Gill's classification, and adopt the Anacanthini of Jordan and Evermann (1898:2528), who considered them just as one of the suborders of the Acanthopterygii. To the Anacanthini they refer the families Gadidae, Merlucciidae, Macruridae. The family Ranicipitidae is not included in the suborder Anacanthini, perhaps only because it is absent from the shores of North America. The families Bregmacerotidae, Brotulidae, Ophidiidae, Lycodidae, Fierasferidae, and some others are placed in the group Ophidioidea, which is near the group Blennioidea of the suborder Xenopterygii of the order Acanthopterygii. The flat fishes are placed in a separate suborder (Heterosomata) of the order Acanthopterygii, near the Anacanthini. The family Ammodytidae is referred to the suborder Rhengopteri, near the suborder Percesoces.

Boulenger (1901:268) grouped gadoid fishes with the families Trachinidae, Callionymidae and Nototheniidae into the division Jugulares of the order Acanthopterygii because of the position of the scapular foramen between the scapula and coracoideum and the jugular position of the fins. This classification, as we shall see later on, receives no recognition because it is incorrect to group fish into one suborder solely by the position of their ventral fins and the scapular foramen between the scapula and coracoideum.

- 13 In 1903 Regan (1903:459) defined the Anacanthini as follows: parietals separated from each other by the supraoccipital; prootic and lateral occipital separated by the enlarged opisthotic; pectoral arch attached to the skull; no mesocoracoid; vertical and ventral fins without spinous rays (except the first dorsal ray of some Macruridae); ventral fins anterior in position; pelvic bones posterior to the clavicular symphysis and loosely attached to it by a ligament; gills pectinate; swimbladder without pneumatic duct.

Regan paid no special attention to the position of the scapular foramen between the scapula and the coracoideum, as in *Gadomus longifilis* of the Macruridae this foramen was found within the scapula. Likewise in *Trematomus* of the Nototheniidae, which Boulenger placed in the Anacanthini, owing to the position of the scapular foramen between the scapula and coracoideum, this foramen was actually found within the scapula.

The Gadidae, Macruridae and Muraenolepidae are referred by Regan to the Anacanthini. The genera *Merluccius* and *Raniceps*, separated by some authors into distinct families, are included by him in the family Gadidae. Regan refers the genus *Bregmaceros* also to the Gadidae because according to his investigations, the pelvic bones are loosely attached to the clavicular symphysis the caudal fin is symmetrical, and the scapular foramen is between the scapula and coracoideum, but not within the scapula, as was believed by Jordan and Evermann (1898:2526), who separated *Bregmaceros* into a distinct family and placed it near the families Brotulidae and Ophidiidae.

At present Regan's classification of the Anacanthini appears to be generally accepted. With minor changes it is also accepted by Jordan (1923:162).

Classification

Goodrich, accepting in his "Vertebrata Craniata" (1909:478) the Anacanthini, which he calls Gadiformes, within the scope of Regan's definition calls our attention to a long known (Stannius, 1854:63) but forgotten peculiarity in structure of the interorbital region and the forebrain, considering this peculiarity as the most characteristic feature of these fishes.

The cranial cavity in the Gadiformes extends forward as a narrow canal above the interorbital septum, within which lie the olfactory nerves and through which the cranial cavity appears to be brought closer to the nasal capsules. The olfactory nerves [or tracts] in the Gadiformes do not therefore pass through the orbit, and throughout their length they lie close to each

other (Figure 1, A) thus differentiating them from the majority of other Teleostei, whose olfactory nerve of each side passes through the orbit and is thus separated by the interorbital septum from the nerve on the other side (Figure 1, C). The other exceptions among the Teleostei appear to be distantly related families Galaxiidae (Swinnerton, 1903:61), Siluridae, Cyprinidae (Sagemehl, 1891:489), some Characinidae (Sagemehl, 1885:1) and Plectognathi (Diodon) (Owen, 1846:184, fig. 47), in which the interorbital region is similar in structure to the Gadiformes. Besides, the olfactory lobes in Gadiformes are far removed from the forebrain, being enclosed in the canal above the interorbital septum near the nasal capsules. The olfactory nerves in these fishes are consequently very short, and the olfactory lobes are connected with the forebrain by means of long olfactory tracts (Figure 2, A) which among other Teleostei occurs only in the Galaxiidae (Swinnerton, 1903:63), some Cypriniformes (Sagemehl, 1885:74; 1891:489) and Plectognathi (Owen, 1846:184).

FIGURE 1. Tranverse section of the interorbital region at the anterior end of the eye

A—*Gadus morhua*; B—*Physiculus japonicus*; C—*Lucioperca lucioperca*; D—*Coelorhynchus jordani*; bc—cranial cavity (canal over interorbital septum); bs—bony interorbital septum; cs—membranous interorbital septum; f—frontal; ms—membranous interorbital septum; n. olf—olfactory nerve; n. opt—optic nerve; ps—parasphenoid; tr. olf—olfactory tract.

Besides the aforementioned families and orders of fish, the olfactory nerve also does not pass through the orbit in *Liparis* and *Cyclopterus*, as pointed out by Dietz (1913:86). The cranial cavity, however, extends into the interorbital region only in *Liparis* in which it is of the same width as posteriorly and directly reaches the nasal capsules. As regards *Cyclopterus*, the cranial cavity ends anteriorly at the level

of the hind margin of the eyes, and further the olfactory nerves are separated by cartilage which fills the entire interorbital region. The olfactory nerves do not pass through the orbits in a number of other genera of the suborder Scleroparei (*Myoxocephalus*, *Cottocomephorus*, *Comephorus*, *Sebastes*, *Trigla*, *Occa*) to which both of the above mentioned fishes belong, and in some Blennioidei (*Blennius*, *Lumpenus*, *Ophidion*); but in none of them does the cranial cavity extend into the interorbital area, with the exception of *Myoxocephalus*, in which it has the form of a canal running forward to the nasal capsules. However, what appears to be most important, the olfactory lobes in all of the enumerated fishes* lie very near the forebrain and are connected to the nasal capsules by means of long olfactory nerves lying between the membrane of the interorbital septum and the bones or cartilages of the interorbital region (Figure 1, D) and thus do not pass through the orbit. The canal above the interorbital septum, with the olfactory nerves enclosed in it, is also present, as we discovered, in the family Brotulidae (*Hoplobrotula armata*), in which, just as in the family Cyprinidae, the canal is osseous but the olfactory lobes are closely adjacent to the forebrain, while the long olfactory nerves extend along the canal to the nasal capsules.

Thus the interorbital region, sometimes even within the same group of fish, is variable in structure and in some groups it cannot be accepted as an important systematic character. As regards the position of the olfactory lobes, at the nasal capsules, they are placed, so far as presently known (see Lissner, 1918:127), only in the families Galaxiidae, Cyprinidae, Siluridae, and some Characinidae, in the order Plectognathi and in the Gadiformes. Of the Cyprinidae only in *Carassius* and of the Gadidae only in *Raniceps* are the olfactory lobes arranged at some distance from the nasal capsules, approximately midway between them and the forebrain; because of the expanded cartilage in the anterior part of the canal, near the nasal capsules in these fishes, the olfactory lobes shifted from the nasal sacs. Very characteristic is the fact that the olfactory lobes in the Brotulidae lie near the forebrain regardless of the existence of the canal in the interorbital region, directly reaching to the very nasal capsules. It is possible that in those Characinidae in which the olfactory bulbs do not lie near the nasal capsules this is due to the expansion of cartilage in this region.

* Dietz's statement (1921:436) on the position of the olfactory lobes in the Cyprinidae (Figure 2) near the forebrain and in *Liparis* (Figure 5) near the nasal capsules is incorrect: as is well known in the Cyprinidae, the olfactory lobes are near the nasal capsules, while in *Liparis*, according to our examination, near the forebrain. As to the caudal fin skeleton, in the Gadiformes it is of definitely different structure than in *Cyclopterus*, *Liparis* and *Cottus*, which Dietz considers closely allied to Gadiformes on the basis of this character even though in these fishes it is somewhat less asymmetric than in the other Scleroparei. The most important character of the Gadiformes - large opisthotic with the foramen for the glossopharyngeal nerve - is not considered by Dietz.

FIGURE 2. Brain

A—*Gadus morhua*; B—*Lucioperca lucioperca*; l. olf—olfactory lobes; n. olf—olfactory nerve; tr. olf—olfactory tract.

The olfactory lobes are not, however, arranged close to the nasal capsules, in all Gadiformes. In *Macrurus cavernosus* (Pfuller, 1914:48, pl. 1-2), *Coelorhynchus jordani*, *C. coelorhynchus*, *C. japonicus*, *Trachirinchus trachirinchus*, *Coryphaenoides rupestris*, *C. altipinnis* and *Abyssicola macrochir* (our investigations) of the family *Macruridae* the olfactory lobes very closely adjoin the forebrain, the cranial cavity does not extend in the form of a canal above the interorbital septum and thus the olfactory tracts are absent and the olfactory nerves are long. Besides, in all these fishes both olfactory nerves at their origins lie close to each other between the membranous interorbital septum of the right and left sides of the skull, later becoming separated by the frontals and mesethmoid and passing to the nasal capsules between these bones and the membranous interorbital septum, thereby missing the orbit. (Figure 1, D). In the family *Gadidae* the canal above the interorbital septum is bordered with the two bony parallel crests extending along the skull on the under side of the frontals. In the family *Macruridae* the olfactory nerves are arranged on the two sides of the single unpaired crest running down the middle of the skull of the under side of the frontals. It may be presumed that the olfactory lobes and the interorbital region are similarly arranged in all other representatives of this family. Thus, in one of the most important characters, the position of the olfactory lobes and the structure of the interorbital region, the family *Macruridae* differs essen-

tially from the other families of the Gadiformes. Of the characters peculiar both to the *Macruridae* and the other families of the Gadiformes, there must be pointed out the enlarged opisthotic with the foramen for the glossopharyngeal nerve*; the other characters are likewise peculiar to many other teleostean groups.

Thus, by some characters the family *Macruridae* must be placed in the Gadiformes, by other ones it must be separated from that order, and either would be almost equally correct. However, after excluding the *Macruridae* from the Gadiformes, many other characters (position of the scapular foramen between the scapula and the coracoid, only soft rays in the unpaired fins, position of ventral fins anterior to the pectorals)

* We examined only one specimen of the *Macruridae* for this characteristic — *Coelorhynchus anatrostris* Jord. et Gilb.

not considered by Regan as diagnostic become common to all families of the order, and Gadiformes (Anacanthini) may be considered actually as soft rayed and united into an order by a greater number of other characters. Therefore, the immense family of Macruridae, apparently falling in turn into several families, should be separated into a distinct order closely related on one side to the Gadiformes and on the other side to some of the Acanthopterygii.

According to the investigations of Stannius (1844:63) and Goodrich (1909: 478), the interorbital septum and the lower part of the canal of the olfactory nerve in the Gadiformes are membranous (Figure 1,A). According to our investigations, the canal of the olfactory nerve as a whole and the interorbital septum to a considerable extent are osseous in a number of representatives of the family Gadidae (Figure 1,B). Besides, in fishes having an osseous interorbital septum and canal of the olfactory nerve the neurocranium has a very small opening in front since it is almost closed by the broadening and fusion of the parasphenoid and the descending wings of the frontals, which also form the interorbital septum. In the neurocranium of fishes having a bony interorbital septum posteriorly on either side of the foramen magnum there is a large membrane-covered fontanelle through which by means of two long hornlike processes the swimbladder is in contact with the auditory capsules (Figure 3,A and B). The connection of the swimbladder with the auditory capsules in one of the representatives of the family Gadidae - *Lotella bacchus* was discovered long ago (Parker, 1883:234) but remained little known. The fact that a similar connection of the swimbladder with the auditory capsule exists in some other gadoids as well was not known at that time and therefore this very important anatomical peculiarity was not evaluated to the full extent of its importance in classification. The entire osseous canal of the olfactory nerves, the interorbital septum which is osseous for a considerable distance, the fontanelles in the rear of the neurocranium and the contact through them of the swimbladder with the auditory capsules: all these characters are very important, and genera distinguished by them must be separated into the distinct family Moridae.

The family Moridae comprises the genera: *Mora*, *Lepidion*, *Uraleptus*, *Lotella*, *Physiculus*, *Laemonema*, *Antimora* and a number of others.

The order Gadiformes (Anacanthini) therefore consists of the families Gadidae, Moridae and Bregmacerotidae. The latter is close to the Gadidae, but through a number of characters must be placed into a distinct family. As regards the genus *Muraenolepis*, which Regan (1903:466) considers as a separate family *Muraenolepididae* and places in the order Gadiformes (Anacanthini), it does not differ from the Gadiformes by the structure of the forebrain and skull but due to the increased number of pectoral radials (not less than 10) and some other characters (gill openings narrow and not extending above basis of pectorals, scales long and arranged at angles to each other; for further details see Svetovidov 1939: 583) it occupies a somewhat separate position. The increased number of pectoral radials has an important meaning and gives basis for separating the family *Muraenolepididae* into a suborder of the Gadiformes. Thus, the order Gadiformes is divided into two suborders: 1) *Muraenolepidoidei* with one family *Muraenolepididae* and 2) *Gadoidei* with the families Moridae, Bregmacerotidae and Gadidae. The latter, most

FIGURE 3. Contact of swimbladder with auditory capsule in the family Moridae

A—*Physiculus japonicus*, lateral view; B—same from ventral aspect; m—muscle; pt—post-temporal; scl—supracleithrum.

naturally, on the basis of structure of the adult, larvae, and eggs is divided into the following subfamilies: Lotinae, Merlucciinae and Gadinae.

The origin and relationship of the Gadiformes with all families and groups of fish associated with them is rather distant. The remoteness of the Gadiformes from the Pleuronectiformes (Heterosomata) has been very definitely and convincingly shown by Cope (1872:341) and Cunningham (1897:498), whose conclusions Boulenger (1902:296) and Regan (1910a:484) confirmed with new anatomical data. Regan (1903:460), who brought out a number of new characters well distinguishing the Gadiformes from the related families Blenniidae, Zoarcidae, Brotulidae, Ophiidiidae, and others, and Boulenger (1904:646, 702, 703) consider that the resemblance between these two groups of fish could be assigned to convergence rather than to close relationship. Later (1910:11) Regan expressed the suggestion of deriving the Gadiformes from the primitive Iniomi, related to the recent Aulopidae. Gregory (1933:207, 380, fig. 85), pointed out the remoteness of the Gadiformes from the Aulopidae, which have the parietals meeting and not separated by the supraoccipital and having different structure of the gill cover. Besides, it must be added that the canal above the interorbital septum in the Aulopidae is absent and the olfactory nerves pass through the orbit. But the most important distinction of the family Aulopidae, just as in all other families and

groups of fish which are near the Gadiformes, appears to be the position of the olfactory lobes near the nasal capsules. This important anatomical peculiarity of the Gadiformes, which is typical only of the distantly related Cyprinidae and Galaxiidae, indicates an early branching off from existing groups of fish of common origins. Moreover, it is necessary to point out that some characteristic morphological peculiarities, particularly the diphyccercal caudal fin* and the position of the olfactory lobes near the nasal capsules and not at the forebrain, represent secondary specializations: as it is known in young gadoids the caudal fin is homocercal and the olfactory lobes as indicated by T.S. Rass (Svetovidov, 1937:1288), are placed extremely close to the forebrain. L.S. Berg (1940:284), by placing the Gadiformes almost immediately after the Cypriniformes in his classification, and below the Perciformes, considers them to be a lowly organized order derived from forms related to the Pachycormidae. For the Gadidae he gives a somewhat different division into subfamilies than is accepted here, based only on the structure of adults. He separates into subfamilies *Eleginus* (parapophyses enlarged and containing processes of the swimbladder) and *Raniceps* (olfactory lobes somewhat removed from nasal capsules; of secondary nature in *Raniceps* and in *Carassius* see above).

The classification of the family Gadidae is very little elaborated. Even in the works specifically devoted to the Gadidae or to the order Gadiformes, the problems of the classification of the family are either untreated or given very little attention. Therefore, in treatises and compendia on fishes of these or other seas, the genera of the cods are arranged in the most varied order and sequence.

Of all efforts to classify the codfishes, the greatest attention is drawn to the classification of Jordan and Evermann (1898:2531) who, on the basis of a very important character, the structure of the dorsal fin, divide
 19 the genera of the family into 5 groups: Gadinae, Lotinae, Phycinae, Gaidropsarinae and Brosminae. Within each of these groups the genera are arranged without any system. In addition, the entire system becomes somewhat confused because in it are included genera which we separate into the family Moridae, while they accept the genus *Merluccius* as a separate family.

Efforts to classify the Gadinae, the group of the Gadidae which is richest in species and genera, actually come down to dividing these into a whole series of groups. Williamson (1909:111) proposed various groupings of the Gadinae according to many characters (position of the mouth, and that of anal fin origin, coloration of peritoneum, dimensions of the eyes, and that of the barbel, length of bases of vertical fins, dimensions and even pigmentation of fish, 20 characters in all) whereby for each one of the characters he obtained varying numbers of groups and attempted to distribute among them the genera, but because of overlap and varying functional significance of these characters the results were inconstant.

In the opinion of the author, the classification must be based upon a complex of characters functionally correlated with the most characteristic biological property of the group.

One of the morphological peculiarities of gadoids, characteristic in such a strongly pronounced and variable form and typical perhaps to them alone, is the structure of the vertical fins. There are among them species having

* Whitehouse (1935:70) considers it as homocercal also in the adults. Barrington (1935:270) proposes to name tails of this type pseudocaudal.

FIGURE 4. Structure of unpaired fins, lateral line and its branches on the head, foramina or notches for the facial nerve (a) and mucous cavity (b) on the skull

FIGURE 4 (CONT.) - Structure of unpaired fins, lateral line and its branches on the head, foramina or notches for the facial nerve (a) and mucous cavity (b) on the skull

one, two, or three dorsal and one or two anal fins. This peculiarity of the gadoids partially finds a reflection in the classification of Jordan and Evermann. A typical biological peculiarity of the gadoids no less variable than the above mentioned morphological character is their ability to inhabit various parts of the hydrosphere and their variable adaptation to movement. The predominant majority of the gadoids keep to the bottom but there are among them those which live in the middle of the water, leading a pelagic mode of life (*Micromesistius*). There are among them species living at a considerable depth (*Brosme*) as well as species which live near the shores in shallow water. Remaining near the shores, some representatives have immobile habits (*Raniceps*) others, such as *Eleginus*, are much more mobile. Along with species residing locally among the gadoids there are those which undertake extensive migrations. Undoubtedly the above mentioned morphological and biological peculiarities of the gadoids are functionally integrated.

The most perfect structure of the vertical fins, as has been shown in an experimental study by Houssay (1910:13), appears to be not continuous dorsal and anal fins but fins divided into several parts, inasmuch as such a divided structure is more adaptable for streamlining in the turbulent currents produced by the swimming movements of the fish's body. In the structure of the vertical fins all the gadoids can be arranged in series (Figure 4). From this figure it may be seen how, beginning with *Brosme* and ending with *Micromesistius*, the dorsal and anal fins become more and more differentiated. *Brosme* has one long dorsal fin and one long anal fin adjoining the caudal fin. *Gaidropsarus*, *Ciliata* and *Enchelyopus* already have two dorsal fins: the first one consists of only one normally developed ray*. In *Raniceps* the first dorsal fin is slightly larger (3 rays) and in *Phycis*, *Urophycis* and *Molva* normal size. *Merluccius*, having a notch in the posterior part of the anal and second dorsal fin, appears to be a transitional form to the gadoids having three dorsal and two anal fins. Further, in fishes having three dorsal and two anal fins, these fins at first are in contact with each other at their bases, gradually becoming separated by continuously increasing interspaces, and in *Trisopterus luscus* the anal fins are often connected by a small membrane. At the end of the series the anal fins are again somewhat closer. Therefore, we have a series of fishes having gradually differentiating unpaired fins.

Within the subfamily *Lotinae* fishes in this group are arranged according to the partitioning of at first one dorsal fin into two and the beginning of the formation of the third dorsal and second anal fins. The *Gadinae* present a continuation of this series with regard to the further separation of the dorsal fins, that is, increasing interspaces. It is quite evident that in those fishes having more than one dorsal and one anal fin, as well as in fishes with greater interspaces between these fins, the total lengths of the bases of all dorsal and both anal fins is less than in fishes having continuous fins. The main base characters in this series, as we see from the summation of the data, are the division of the fins and the size of the interspaces but not the sum of the lengths of their bases and furthermore not the total number of rays in them. Thus, for example, the total length of bases of the dorsal fins in *Trisopterus esmarkii* is approximately the same as that in the two other species of this genus, while the number of rays in these fins

* The other rays of the first dorsal fin in *Gaidropsarus mediterraneus* by their structure (Bogoljubsky, 1908:327) are not actually fin rays.

FIGURE 5. Skull in dorsal and lateral views

A—*Trisopterus luscus*; B—*Eleginus navaga*; a—orbital space; b—foramen (in *T. luscus*) and c—notch (in *E. navaga*); n.n. facialis and trigeminus; d—foramen of the glossopharyngeal nerve; e—crest above foramen for the dorsal recurrent branch of the facial nerve; f—crest above the lateral line system on the pterotic; g—lateral crest over this canal on the frontal; h—median crest of the frontal over the canal; i—mucous cavity.

in both other species is considerably greater. To a still greater degree all of the above stated will apply to the number of rays as well as to the sum of the lengths of the bases of the anal fins.

Within the series of the gadoids, arranged according to the degree of differentiation of their unpaired fins, one observes several regularities with respect to other characters, whereby each of these characters separates within the general series into two parallel series according to the two subfamilies of Gadidae: Lotinae and Gadinae; the subfamily Merluccinae occupies an intermediate position.

The facial nerve emerges from the skull together with the trigeminal nerve through a foramen or a notch of various depth in the front part of the prootic on the side of the skull (Figure 4, a and Figure 5, b,c). In *Brosme brosme* this nerve passes through the foramen (Figure 4, a), and in *Gaidropsarus mediterraneus*, the next in the series, through a deep notch in the prootic, the edges of which approach each other so closely that they almost close it anteriorly. In *Ciliata mustela* and others following it in the series, the notch becomes wider and shallower anteriorly. The notch in *Lota lota* is as deep and its edges anteriorly are narrowed almost as much as in *Gaidropsarus mediterraneus*, while in all species of *Molva* and *Merluccius* the facial nerve passes from the skull again through the foramen. The facial nerve emerges likewise through the foramen also in species of the genus *Trisopterus* which are a further continuation of the series. The width of the bony link [link separating the foramen from interorbital space]* is a little broader in *T. luscus* than in *T. minutus*, and in the latter it is wider than in *T. esmarkii*. *Odontogadus merlangus* and representatives of the family following it have a prootic notch which gradually becomes broader and less deep in front. In both forms of *Gadiculus argenteus* the notches are almost absent. Further, in species of the genera *Eleginus*, *Microgadus*, *Boreogadus*, *Arctogadus* and *Theragra* the notch gradually deepens and the edges become more approximated. *Micromesistius* 23 has a foramen on the side of the skull. Thus, by this character the general series of the gadoids, arranged according to the degree of differentiation of their unpaired fins, is divided by this character in turn into two parallel series corresponding to the division of the family into subfamilies. The same regularities can be observed in the variation of some other characters.

On the dorsal side of the skull of the gadoids, on each parietal, there is a foramen through which emerges the dorsal recurrent branch of the facial nerve (Figure 5, e and Figures B in Tables XXI-LXVII). In some of the gadoids these foramina are protected in each species by crests of varying degrees of development; in other species the crest is not developed, and the foramen is open on top. In *Brosme brosme* and *Gaidropsarus mediterraneus*, *Ciliata mustela*, *Enchelyopus cimbrius* which follow it in the series the crest protecting this foramen is present. In *Raniceps ranius* [sic] and all species of the genera *Phycis* and *Urophycis* the foramen of the dorsal recurrent branch of the facial nerve is not covered because the crest is a barely noticeable growth located somewhat posterior to the foramen. In *Lota*, and all species of *Molva* and *Merluccius* the crests are developed and cover the foramina. Within the subfamily Gadinae the parietal crests are developed more strongly.

* Added by author.

In all species of the genera *Trisopterus*, *Odontogadus*, *Pollachius*, *Gadus* and *Melanogrammus* crests are developed, their size diminishing from *Trisopterus* through *Melanogrammus*. No crests in *Gadiculus*. Further in the series crests are present and gradually increase toward the end of the series in *Eleginus*, *Microgadus*, *Boreogadus*, *Arctogadus*, *Theragra* and *Micromesistius*, while in some specimens of *Eleginus navaga* the crests are present, and in the others they are not developed.

The glossopharyngeal nerve (Stensiö, 1921:155) emerges from the skull through a small foramen in the opisthotic (Figure 5, d and Figures A in Tables XXI through LXVII). This foramen varies in size within each series following the same regularity as the previous one. In *Brosme brosme* the foramen is almost invisible. In *Gaidropsarus mediterraneus*, *Ciliata mustela*, *Enchelyopus cimbrius*, *Raniceps raninus* it is small, and in species of the genus *Phycis* and *Urophycis* it is slightly larger, in *Lota* and *Molva* it is large and in *Merluccius* it is again of small dimensions. Further, in all species of the genus *Trisopterus* this opening is hardly noticeable, its dimensions gradually increasing to *Gadus* and *Melanogrammus* and beginning with *Gadiculus* diminishing again.

The lateral lines of the gadoids form sensory (or slime) canals on either side of the head (Figure 6): Preoperculo-mandibular canal, the infraorbital canal and the supraorbital canal with a short commissure connecting the right and left canals. The lateral line of the body has on the head a supratemporal portion (L'), above which there is an ossification of 4 or 5 ossa tabularia (=supratemporal). Each canal on the head is covered from above for almost its entire length by a crest of those bones on which the canals are located (frontals, pterotics, sub- and pre-orbitals, nasals, preoperculars, tabulars). The most important of these crests is the median crest on the frontal (Figure 5, h) and the lateral crests on the frontals and pterotics (Figure 5, f and g). The supraorbital commissure of the supraorbital canal is located in a special depression in the frontals - a mucous cavity (Figure 5, i). The mucous cavity in some of the *Gadidae* is closed in front by the fused edges of the lateral and median crests over the canals on the frontals, while in others it is widely open as the edges of the lateral and median crests of the frontals are shortened and do not coalesce in front of the mucous cavity. In *Brosme brosme* the edges of the lateral and median crests of the frontals are so near to each other that they almost close the small mucous cavity in front. In *Gaidropsarus mediterraneus*, *Ciliata mustela* and *Enchelyopus cimbrius* the mucous cavity is open in front and of very minute dimensions. *Raniceps raninus* has a mucous cavity open in front. In some species of the
25 genera *Phycis* and *Urophycis* the mucous cavity is open in front, in others it is closed; both of these genera represent in this respect slight deviations from the general rule, and the reasons for this we shall discuss further. In *Lota lota* the mucous cavity is almost closed in front by the approaching edges of the lateral and median crests of the frontals, which in the species of the genus *Molva*, being fused, forms a well-locked cavity
26 The mucous cavity in all species of the genus *Merluccius* is represented by a wide depression in the center of the frontals, and it has a shape deviating somewhat from that common to the gadoids. The mucous cavity is

FIGURE 6. Distribution of sensory canals and pores on the head of *Gadus morhua* (A) and pit organs on the head of *Eleginus navaga* (B) [drawing A modified from Cole]

PM—preoperculo-mandibular canal, 1-12—its pores; JO—infraorbital canal, 1-9—its pores; SO—supraorbital canals, 1-3—its pores; SOC—supraorbital commissure with unpaired (4) pore; L—lateral canal; L'—supra-temporal portion and L''—cephalic portion of the lateral line. The dots in both figures represent pit-organs.

closed further, beginning with *Trisopterus* and ending with *Gadiculus*. In all the succeeding species of the series the mucous cavity is open in front but is closed again in the species at the end of the series, in *Theragra chalcogramma*, *Micromesistius poutassou* and *M. australis*. It should be noted that whether the mucous cavity is closed or open in front, it is generally typical for all species of any given genus of the gadoids, with the exception, as pointed out above, of the genera *Phycis*

and *Urophycis*. Besides, there is one more species, *Eleginus navaga*, in which the approximating edges of the lateral and median crests of the frontals are sometimes fused on one side, and in one of the skulls studied they are fused on both sides. Thus, this feature is in an unstable state, in the first case within the limits of the genus, and in the second within the limits of the species, each of them being in the middle of each of the two parallel series.

A similar regularity is observed in the structure of the crests above the sensory canals on the frontals. In *Brosme*, *Gaidropsarus*, *Ciliata*, *Enchelyopus*, *Molva*, *Trisopterus*, *Micromesistius*, that is, in fish which are at the beginning and the end of each series, the margins of the crests on the frontals closely adjoin to these bones and almost close over the canal. Furthermore, in some of these fishes (*Trisopterus*) the margins of these crests are in places fused with the frontals by means of bony bridges. In all the remaining gadoids arranged between them in both series the margins of the crests above the sensory canals on the frontals are usually raised. The genus *Merluccius* deviates somewhat in that the crests are developed very slightly.

Along each of the sensory canals on the head are distributed numerous groups of nerve endings (Figure 6, B) - genipores (pit-organs), or these canals open outward with a row of pores (Figure 6, A); however, few genipores are present even in that case. The lateral line on the body of gadoids extends from the head to the caudal fin in the form of a continuous or interrupted line divided by small interspaces (Figure 4). In *Brosme brosme* the lateral line extends continuously from the head to the end of the dorsal fin, becoming interrupted only on the caudal peduncle (Figure 4). In *Gaidropsarus mediterraneus*, *Ciliata mustela* and *Enchelyopus cimbrius* the lateral line is interrupted throughout its length, in *Raniceps raninus* the lateral line is apparently absent (see page 101). In species of the genera *Phycis* and *Urophycis* and in *Lota lota* the lateral line is uninterrupted almost to the end of the anal fin, and beyond that is interrupted; in species of the genus *Molva* it is interrupted posteriorly from the end of the anal fin, in those species of *Merluccius* it is uninterrupted for its entire length. In species of the genera *Trisopterus*, *Odontogadus*, *Pollachius* and *Melanogrammus* the lateral line is continuous throughout its length; in species of the genera *Gadus*, *Gadiculus** and *Microgadus* the lateral line is interrupted posteriorly from the middle or the end of the third dorsal fin; in species of the genus *Eleginus* it becomes interrupted at the rear or beginning of the second dorsal fin and in species of the genera *Boreogadus* and *Arctogadus* the lateral line is discontinuous for its entire length. Further in the series in *Theragra chalcogramma* the lateral line is interrupted behind the origin of the second dorsal fin, and in *Micromesistius poutassou* and *M. australis* it is continuous for its entire length.

- 27 A similar regularity exists in the series of the gadoids in respect of the presence on the head of pores and genipores (see dots on head, Figure 4). Genera placed at the beginning and end of the subfamilies *Lotinae* and *Gadinae* and forming two parallel series within the general one of the gadoids have pores on the head, while in genera placed in the middle of each

* Specimens of *Gadiculus* are usually without scales, and because of this it is difficult to judge the structure of the lateral line; however, it extends without interruption to the middle of the third dorsal fin.

of these parallel series (*Raniceps* and *Lota* in the first series, *Microgadus*, *Eleginus*, *Boreogadus* and *Arctogadus* in the second series) only pit-organs are found. Exceptions to this rule in the first series appear to be only *Phycis* and *Urophycis*, which are located in the middle of the *Lotinae* series, but have pores. Both of these genera likewise represent a certain exception, as was indicated above, as regards the structure of the mucous cavities. It must be noted that all species which have the mucous cavity open in the front, with the exception of some in the genera *Phycis* and *Urophycis*, have only pit-organs on their heads. All of these species, again with the exception of those of the genera *Phycis* and *Urophycis*, live in coastal regions. Many enter fresh water and even live there permanently. The genus *Merluccius*, deviating somewhat in the structure of its mucous cavity from the usual gadoid type, differs likewise from its nearby relatives in the classification of genera by the absence of mucous pores.

In the series of the gadoids arranged according to degree of the differentiation of the unpaired fins, the interspaces between the anal fins within the *Gadinae* series, as was indicated above, at first increase and at the end of the series the fins again approach each other (Figure 4). The position of the origin of the anal fin shifts accordingly: in *Trisopterus* this is placed under the first dorsal fin, farther down the series the beginning of the anal fin gradually moves backward, but commencing with *Eleginus* it again advances forward so that in both species of *Micromesistius* the anal fin begins anteriorly to the first dorsal fin.

Thus the general series of the gadoids arranged according to the degree of differentiation of their unpaired fins splits as regards all other characters, according to the division of the family into *Lotinae* and *Gadinae*, in two parallel series; the subfamily *Merlucciinae* occupies an intermediate position between them. In general the variations in all characters run parallel to each other in each of the series.

The variation in each of these characters, especially of the foramen or notch for the facial nerve on the side of the skull takes place within rather narrow limits. For example, in the cod, the notch for the facial nerve on all skulls examined and illustrated in drawings from other works varies but little. Most variable appears to be the foramen for the glossopharyngeal nerve on the opisthotic. In one skull of *Pollachius virens* the foramen on the right side is smaller than on the left side. Similarly, in the figure of the skull of *P. pollachius* (Williamson, 1902, Table VII, Figure 41) this opening is also small, and in the photograph (1,c, Table IX, Figure 28) it is of the normal size for this species. The same thing is observable in other species, studied from several or many skulls, but the general conformity with the principle of change, in this or any other feature studied, is very obvious even with the greatest degree of variability.

From ontogenetic data, it is known that in the development of larvae of any gadoid fish a gradual differentiation of the embryonic finfold* occurs. Within the continuous embryonic finfold extending along the entire body of the larvae, rays form in accordance with the locations of the caudal, dorsal and anal fins of the adult fish, whereas in *Brosme* (J. Schmidt, 1905a, 28 Table I, Figures 1-12) these rays are formed evenly along the entire back from above, and along the posterior half of the body from below, whereas

* See tables in the works of J. Schmidt (1905, 1905a, 1906, 1906a, 1907, 1907a).

in fishes having more than one dorsal or anal fin the location of the interspaces between the future fins of adults have shortened rays (if in the adult these fins are in contact with each other) or rays are entirely absent (J. Schmidt, 1905, Tables I-III). The terminal rays of two adjacent fins in the embryonic finfold in the young of all gadoids, even in *Micromesistius poutassou* larvae, in which in the adult the fins are separated by broad interspaces, touch each other or are separated by very narrow interspaces. Simultaneous with the formation of the rays in the embryonic finfold, notches appear at the places of the fin interspaces of the adults. On becoming deeper these notches gradually divide the embryonic finfold into separate fins. The dorsal and anal fins are still in contact with each other in a fully formed fry and in the fingerling, but in those species in which in the adult the fins are separated by interspaces, the fin membrane at the posterior ends of the fins gradually reduces with the growth of the fish, and thereby forming the interspaces which subsequently increase.

The structure of the lateral line canals on the head is of considerable phylogenetic importance. In the Holostei and lower Teleostei (Cyprini-formes, Clupeiformes) these canals are imbedded in bones and communicate with the outside by means of narrow openings penetrating the canal (Goodrich, 1930:294-295). In more highly organized Teleostei the dermal bones are buried more deeply under the skin, canals are less imbedded in the bones, and as in the Gadiformes, are present as a trough covered by crests and only partially imbedded in the bony cavity. The mucous cavity in fry under 60 mm in length, apparently, is not closed in front, inasmuch as in gadoid fry 60 to 65 mm in length the median and lateral crests of the frontals are connected through membrane which in fishes 85 or more mm in length becomes ossified. How the development of other characters progresses is unknown.

Thus, the series of the gadoids arranged according to these characters, to a certain extent appears to be a reflection of the phylogenetic relationships of genera and species of the family. However, we cannot assume, with Holt and Calderwood (1895:440), that all members of the series gradually evolved from *Brosme* which stands at the beginning of the series and is more generalized. Nearest to the original form of the gadoids are apparently the genera *Phycis* and *Urophycis*, which retain even in the adult stage certain features of the larval structure: the ventral fins in all species of these genera, like the larvae of *Lotinae*, are long and consist of only three rays. This suggestion is supported, as it seems to us, by the fact that of the number of features of the gadoid skull studied the mucous cavity, one of the most important in species of the genera *Phycis* and *Urophycis*, as was stated above, has a structure characteristic of all species of the family. At the same time, *Phycis* and *Urophycis* have some more specialized characters peculiar to all of the *Gadinae*: frontal bones in all species of both genera examined fuse into a single unpaired plate, thus linking the subfamilies of the gadoids.

The supposition that the genera *Phycis* and *Urophycis* are the closest to the original form of the family is likewise supported by the fact that among the gadoids there is no fish known with one dorsal fin in which there would have been a notch as observed in the posterior ends of the second dorsal and anal fins of *Merluccius*. On the contrary, in *Raniceps* and *Gaidropsarus* there appears a gradual reduction in the

posterior part of the first dorsal fin, thus separating it by an interspace from the second dorsal fin. In the young of *Raniceps* the first dorsal fin is longer and is in contact with the second, but with the growth of the young the posterior part of this fin becomes reduced and due to this a space forms between it and the second dorsal fin (Schmidt, 1907a, Table I, Figures 9-13). In young *Gaidropsarus* the first dorsal fin is of normal structure, but with growth the posterior part of the fin gradually reduces (D'Ancona, 1932, Table XIII, Figures 15-20, Table XIV, Figures 13-22), and, besides the structure of the fin in adult fish shows that this feature is secondary and produced through regression (Bogoljubsky, 1898:382). Therefore, in some gadoids the dorsal fins are subjected to further differentiation in the posterior part of the second dorsal fin the third one originates, while in the others the process of reduction is going on, the hind part of the first dorsal fin diminishes, and this fin almost disappears in the above mentioned genera.

As indicated above, the *Gadinae*, having further divided fins, lead in general a more active mode of life than the *Lotinae* with weakly differentiated fins. Corresponding to periodic changes of other characteristics in the series, the biological features of the *Gadoids* change in general in parallel manner. *Brosme brosme* and species of the genera *Molva* and *Merluccius*, standing at the beginning and at the end of the *Lotinae* series, live at considerable and even great depths. All other representatives of this subfamily appear to inhabit considerably shallower water. At greater depths live all species of the genera *Trisopterus*, *Odontogadus*, *Pollachius*, *Melanogrammus*, *Gadus*, *Theragra*, *Micromesistius*, which are located at the beginning and end of the series of *Gadinae*, while *Microgadus*, *Eleginus*, *Boreogadus*, *Arctogadus* inhabit much shallower coastal regions. Exception among the *Gadinae* are both forms of *Gadiculus argenteus*, which live at considerable depths, and partially *Pollachius virens* which keeps to the surface layers, while among the *Lotinae* some species of *Gaidropsarus* are found at depths.

Classification of eggs and larvae of the gadoids based on their adaptability to a pelagic mode of life, completely coincides with the subdivision of the family into two parallel series. The *Lotinae* and *Merlucciinae* have eggs with an oil globule (Rass, 1936:300), and in the larvae the pelvic fins are elongate and consist of only three rays. In all the *Gadinae* eggs have no oil globule and the pelvic fins in the larvae are not elongated. In the *Merlucciinae*, which occupy an intermediate position between the *Lotinae* and *Gadinae*, the pelvic fins are not as strongly elongated as in the *Lotinae*. The larvae of the subfamily *Gadinae* are mainly classified according to pigmentation and are divided into three groups: 1) *Pollachius pollachius*, *P. virens*, *Gadus morhua*, *Eleginus navaga*, *E. gracilis*, *Boreogadus saida*, 2) *Trisopterus luscus*, *T. minutus*, *T. esmarkii*, *Melanogrammus aeglefinus*, *Odontogadus merlangus*, *Micromesistius poutassou*, 3) *Gadiculus argenteus argenteus*, *G. argenteus thori*. With the above offered classification of the family *Gadidae* this classification of the larvae in the subfamily *Gadinae* agrees very little, because it is based upon entirely different characters, namely on pigmentation. Nevertheless, we must note that the first group comprises the species standing

in the middle of the series of *Gadinae*, while in the second there are primarily species located at the ends of the series.

30 Thus, the parallelism between the two series both in the morphological characters discussed and also to a considerable degree in the ecology of the gadoids is fairly complete. The above mentioned and to a certain extent some other species appear to be ecological exceptions. It must be pointed out that some morphological characters are more pronounced in the *Lotinae* (the depth of the notch in the prootic), others in the *Gadinae* (crests on the parietals above the foramen of dorsal recurrent branch of the facial nerve), and some characters (mucous cavities) in *Lotinae* have a somewhat deviating structure.

FIGURE 7. Skull of *Gadus morhua* with lateral line system canals (dots indicate pores) and branches of the facial nerve (after Cole and Goodrich partially changed).

an-angular; art-articular; bc-buccal branch of the facial nerve, innervating the infraorbital canal; d-dentary; eth, l-lateral ethmoid; f-frontal; hf-hyoid ramus of the facial nerve; hmf-hyomandibular ramus of the facial nerve innervating the preoperculo-mandibular canal; hy-hyomandibular; iop-interoperculum; ll-lateral ramus of the vagus nerve innervating the lateral line and supratemporal portion of the lateral line; mpt-meta-apterygoid; mx-maxillary; n-nasal; op-operculum; pmx-premaxillary; pop-preoperculum; porb-preorbital (equals lacrimal); pt-posttemporal; q-quadrate; rfd-the recurrent dorsal ramus of the facial nerve; rd-its branch supplying the area of the dorsal fin; rv-its branch supplying the area of the pectoral fin; so-superficial opthalmic ramus of the facial nerve supplying the supraorbital canal; soc-supraoccipital; sop-suboperculum; sorb-suborbital; s-symplectic; t-tabular (supratemporal).

As all the preceding shows, the variation in the studied characters does not proceed uniformly: one character - the structure of the unpaired fins tends throughout the series toward a gradual successive differentiation, while the variations in all other characters manifest cyclic deviations with increases and decreases just as though these characters were arranged on an ascending spiral, the axis of which would be the increasing differentiation in the structure of the unpaired fins. In such an arrangement the genus *Brosme* of the subfamily *Lotinae* would appear to be under *Trisopterus* which is at the beginning of the subfamily *Gadinae*, and the genus *Merluccius* would appear to be under *Micromesistius*. The

intermediate genera of the Lotinae would come under the analogous genera of the Gadinae. It must be pointed out that the genera arranged in the middle of each series likewise possess certain other common features: in *Boreogadus* and *Arctogadus*, on the upper part of the skull, behind the mucous cavity, there are transverse crests which are also found in *Phycis* and some species of *Urophycis*.

31 What is the common bond among these various and, at first glance, functionally unimportant characteristics?

Unpaired fins, as we have seen play a very important role in the movements of fishes. Under the crests and in the mucous cavity on the frontals the sensory canals of the lateral line are situated, by means of which, as we know, the fish orientates itself into a flow during its swimming movements. Through the foramen or notch in the prootic and the foramen in the parietal on the dorsal side of the skull emerges the branches of the facial nerve, which, as is known, innervates the branches of the lateral line on the head and also the dorsal and pectoral fins (Figure 7, bc, hmf, so, rfd). Through the foramen in the opisthotic in the gadoids issue the glossopharyngeal nerve (Stensiö, 1921:125) which is connected with the facial nerve by means of Jacobsen's anastomosis, which is a part of the palatine ramus of this nerve (Cole, 1898:148).

The complex of these characters represents the adaptation to movement in various layers of water, to perception of motion and to transmitting of these sensory perceptions to the brain by nerves emerging from the skull through foramina and notches of various forms and dimensions. Thus, all the characters that form the basis of the classification of the gadoids are in an intimate functional relation. It is possible that the structure of the brain varies similarly, as changes have been demonstrated in the structure of certain parts, associated with the mode of life and feeding (Evans, 1936: 367).

Representatives of the family Moridae can be arranged in a series similar to that of representatives of the family Gadidae, according to the structure of the unpaired fins. At the beginning of the series would stand the genus *Brosmiculus*, at the end *Tripteryphycis*. The absence of skeletons comprising if not the majority of species at least all the genera of the family Moridae does not permit us to select the characters on which we may base our classification. Judging by the small number of skulls belonging to just a few genera of the family Moridae, one may presume that there exist interrelationships in some characters similar to those of the family Gadidae. Furthermore, here we have the genera *Laemone-ma* and *Laemonemodes*, the pelvic fins of which consist of three rays as in the genera *Phycis* and *Urophycis*.

The family Muraenolepidae is the most primitive of all families of the Gadiformes. The increased number of radials in the pectoral fins is peculiar also to the families Gymnotidae and Anguillidae, and should be regarded as indicating generalization. By the structure of the skull *Muraenolepis* mostly resembles some of the Gadidae of the subfamily Lotinae, but, contrary to the opinion of Regan, its nearest relations are not with *Onos* (= *Enchelyopus*), but with *Phycis* and *Urophycis*. Besides, the family Muraenolepidae, just as the family Moridae, resembles the subfamily Lotinae also in a number of other features: their vertical fins are not as highly differentiated as in the Gadinae,

the eggs of all Moridae which have been studied in this respect have an oil globule, and the larvae have elongated pelvic fins.

The tropical family Bregmacerotidae does not differ from the Gadidae to such a great degree as does the family Moridae, and is the closest systematically to the genus Gaidropsarus, one of the most typical of the warm water representatives of the family Gadidae.

Numerous remains in the form of otoliths, referred to many genera of the family Gadidae, are found in all Tertiary formations of almost all the European countries, beginning with the upper Paleocene (Frost, 1931:105; 1934:500; Leriche, 1910:229; Koken, 1884:546; 1885:113; 1891:83; Chaîne et Duvergier, 1928:190). A great number of genera and species of gadoids were described from these otoliths but, generally speaking, it is difficult to identify not only species but even genera of the fossil gadoids based only on otoliths. The best example of this is the research of Weiler (1935:35), who referred almost all *Merluccius* known from lower Tertiary deposits to the other genus, *Nemopteryx*.

Indisputable remains in the form of impressions, by which one could state that they definitely belong to this or that extinct or recent genus of gadoid, are known only beginning with the Lower Oligocene. Remains of the family Bregmacerotidae (genus *Bregmacerosa*) are found in Eocene deposits. The fossil Moridae are known only by otoliths from the Oligocene formations of New Zealand.

FAMILY GADIDAE

Below are listed the representatives of the gadoids which are known from fossils. Species and genera of gadoids which are described from otoliths only are not mentioned.

Genus **BROSME** (CUVIER) OKEN

Brosme susedanus Kner (= *Brosmius susedanus* Kner, 1863:145; Kramberger, 1883:68 = *Brosmius* cfr. *susedanus* Erasmo, 1930:82). Upper Miocene of Croatia (Podsused).

Brosme fuchsianus Kramberger (= *Brosmius fuchsianus* Kramberger, 1883:68). Upper Miocene of Croatia (Podsused).

Brosme strossmayeri Kramberger (= *Brosmius strossmayeri* Kramberger, 1883:69). Upper Miocene (?) of Croatia (Beocin).

Brosme elongatus Kramberger (= *Brosmius elongatus* Kramberger, 1883:69; 1885:63; Lednev, 1914:3; Smirnov, 1936:27; = ? *Onobrosmius elongatus ponticus* Bogachev, 1938:38). Upper Miocene of Croatia (Dolje, Sused), Upper Miocene-Lower Pliocene Apsheron Peninsula (fish clays and coliculous marls imprints from the vicinity of Binagady, Pontic clays of the Kirov region) and the Northern Caucasus (clay slate strata from the vicinity of Dzauzhikau).

Brosme murdjadjensis Arambourg (= *Brosmius murdjadjensis* Arambourg, 1937:59). Upper Miocene (Sahelien Terrace) of Algeria (Province of Oran, Raz-el-Ain).

Brosme oligocaenicus Bogachev (*Brosmius oligocaenicus* Bogachev, 1933:27). Lower Maykop strata (Oligocene?) of the Caucasus (in the vicinity of Sumgait).

Brosme andrussovi Bogachev (*Brosmius andrussovi* Bogachev, 1933:45). Middle Miocene of Apsheron Peninsula (Spirialis strata).

Brosme sp. *Lednev* (= *Brosmius* sp. *Lednev*, 1914:5). Upper Miocene-Lower Pliocene of Apsheron Peninsula (fish clays and marl strata from the vicinity of Binagady).

Genus **PHYCIS** RÖSE

Phycis suessi Steindachner (= *Brosmius* Heckel, 1851:157 = *Pycis suessi* Steindachner, 1860:566). Lower Pliocene in the vicinity of Vienna (Inzersdorf).

Otoliths ascribed to the recent species *Urophycis tenuis* are found in Miocene deposits of eastern Germany (Chaine et Duvergier, 1928:191).

Genus **PSEUDOLOTA** BOGACHEV

Pseudolota abbreviata Bogachev (= *Lota* sp. *Lednev*, 1914:36 = *Pseudolota abbreviata* Bogachev, 1933:28). Lower Miocene of Apsheron Peninsula (Upper Maikop group deposits in the vicinity of Baku) and Shabandag.

In *Lota* sp. described by *Lednev*, *Bogachev* established from the drawings that the second dorsal and anal fins are divided in two. This impression was examined by myself and the division of the fins into two parts was not observed. In the area of the separation of the second dorsal fin as indicated by *Bogachev*, there are several rays pressed to the back, and these fin rays are covered over by some rock with the result that in the drawing the fin appears to be divided; these rays cannot be the posterior rays of the fin, as they are very thin and hardly noticeable in the impressions. The anal fin at the sixth ray cannot be divided in two because the fifth, sixth, and seventh rays in the impression are the longest. The interspace between the fifth and sixth rays is slightly greater than that between the others as both rays are somewhat more spread apart; almost the same interspace is seen farther back between the seventh and eighth rays.

To the description of this impression by *Lednev*, we must add that the pectoral fins on the impression are very long, extending beyond the anal fin; the pelvic fins are shorter, and their tips are very poorly preserved. The neural spines of the first 12 to 15 vertebrae are expanded at the base, are in contact, short and not strongly inclined backward. The structure of the neural spines is more reminiscent of *Molva* than of *Lota*. From the recent species of the genus *Molva* this fish differs by the considerably lower (45) number of vertebrae (63-65 in *M. molva*, 82-84 in *M. dipterygia elongata*).

Genus **LOTA** (CUVIER) OKEN

Lota hulai Pietschmann (1934:48). Lower Pliocene, vicinity of Vienna. Sole representative of fossil gadoids, found in fresh or brackish water deposits (Congerien-Tegeln).

Genus **NEMOPTERYX** AGASSIZ

Close to genus *Merluccius*, from which it differs in having narrow parapophyses, which are normal for the gadoids, neural spines not in contact at the bases, pectoral fins extremely elongate; two dorsal and one anal fin with notches in the posterior portion of the second dorsal and anal fins. Extinct genus.

Nemopteryx crassus Agassiz (= *N. crassus* Agassiz, 1842:75 = *N. elongatus* Agassiz, 1842:76 = *Palaeogadus troschelii* v. Rath, 1859:126 = *Palaeobrosomius elongatus* v. Rath, 1859:130 = *N. troschelii* Wettstein, 1886:59 = *N. elongatus* Rychlycki, 1909:760 = *Gobius elongatus* Rychlycki, 1909:759). Lower-Middle Oligocene of Switzerland (Canton Glarus) and lower layers of Middle Oligocene of the Galician Carpathians.

Nemopteryx emarginatus (Koken) [= *Otolitus* (*Merluccius*) *emarginatus* Koken, 1884:547 = *Merluccius emarginatus* Weiler, 1928:50 = *N. emarginatus* Weiler, 1935:34]. Middle Oligocene of Germany (the Mainz Basin).

Nemopteryx baschkaensis (Kramberger) (= *Megalolepis baschkaensis* Kramberger, 1879:61 = *Merluccius baschkaensis* Kramberger, 1882:111 = *N. baschkaensis* Weiler, 1935:34). Lower strata of Middle Oligocene (Baschka, Krakowiza).

Nemopteryx latus (Kramberger) (= *Megalolepis latus* Kramberger, 1879:62 = *Merluccius latus* Kramberger, 1882:11 = *N. latus* Weiler, 1935:34). Lower strata of Middle Oligocene of Carpathians (Baschka).

Nemopteryx leptosomus (Kramberger) (*Gobius leptosomus* Kramberger, 1879:63 = *N. leptosomus* Weiler, 1935:34). Apparently identical to *N. baschkaensis*. Lower Oligocene of Carpathians (Baschka).

Nemopteryx athanasiui Pauča (Pauča, 1932:149; 1934:639; Weiler, 1933:20). Lower strata of the Middle Oligocene of Carpathians (Dukla, Jaslo, Krosno, Suslanesti), Moravia (Nikoltschitz) and Hungary (Eger).

Nemopteryx elongatus (Simonescu) (= *Gobius elongatus* Simonescu, 1905:120 = *N. elongatus* Pauča, 1934:641 = *N. elongatus* Weiler, 1935:34). Lower strata of the Middle Oligocene of Carpathians (vicinity of Piatra, Moldavia).

Nemopteryx kubackskai Weiler (Weiler, 1935:28). Oligocene of Hungary (Budapest).

Nemopteryx sp. Weiler (= *Merluccius* sp. Weiler, 1928:77 = *N. sp.* Weiler, 1935:34). Lower strata of the Middle Oligocene of Moldavia (Blatt Mainest, Jud. Bacau).

Nemopteryx sp. Bogachev (Bogachev, 1933:28). Oligocene - Lower Pliocene of the Northern Caucasus (Upper Maikop group near Perkichkuhl).

Besides the Lower and Middle Oligocene, *Nemopteryx* possibly is found also in Upper Oligocene, and perhaps in Miocene where otoliths were found resembling the otoliths of *Nemopteryx* (Weiler, 1935:39).

Genus **MERLUCCIUS** RAFINESQUE

Merluccius macroactus (Kramberger) (= *Gobius macroactus* Kramberger, 1879:64, pl. XVI, Figure 5 = *Merluccius macroactus* Weiler, 1935:34). Lower strata of Middle Oligocene of Carpathians (Wola radziszowska).

Merluccius lednevi Bogachev (Bogachev, 1933:35). Oligocene - Lower Miocene of Apsheron Peninsula (Upper Maikop group in the vicinity of Sumgait).

Merluccius maicopicus Bogachev (Bogachev, 1933:26). Lower Maikop group in the vicinity of Sumgait (Oligocene? of the Caucasus).

Merluccius errans (Smirnov) (= *Spinogadus errans* Smirnov, 1936:68 = *M. maeoticus* Bogachev, 1942:89*). Oligocene-Lower Miocene of the Northern Caucasus (upper Maikop deposits in the vicinity of Dzaudzhikau and the Meotic ones of the 'Taman' Peninsula).

- 35 After detailed study almost all fossil species of the genus *Merluccius* from Central Europe were found to belong to the genus *Nemopteryx*. Similarly the study of the otoliths of both genera has shown that all Paleocene, Eocene, and the majority of Oligocene otoliths on which a number of species of the genus *Merluccius* have been described proved to be of the genus *Nemopteryx*; to the genus *Merluccius* belong only otoliths from the Upper Tertiary deposits of Central Europe (Weiler, 1935:35).

Genus **GADUS** L. (s. lat.)

Recent gadoids, formerly referred to the genus *Gadus*, at present are divided into several independent genera. It is difficult to identify exactly fossil gadoids, described mainly from incomplete remains, and therefore, in the following they are all referred to the genus *Gadus* s. l.

Gadus jonas (De Bosniaski) (in: Sauvage, 1880:12 = *G. jonas* Erasmo, 1930:78). Upper Miocene of Apennine Peninsula (Gabbro, Province of Livorno).

* The identity of *M. maeoticus* is established by P.G. Danilchenko, to whom the author is very grateful for this information. *Merluccius* sp. Lednev (1914:37) was synonymized by Bogachev (1933:35) with *M. lednevi*. As indicated by P.G. Danilchenko, it is closer to *M. errans*.

Gadus aeglefinoides (Kner et Steindachner) (= *Morrhua aeglefinoides* Kner et Steindachner, 1863:34; Kramberger, 1883:65). Upper Miocene of Croatia (Podsused).

Gadus extensus (Kramberger) (= *Morrhua extensa* Kramberger, 1885:51; 1886:135). Upper Miocene of Siebenburgen (Szakadat).

Gadus lanceolatus (Kramberger) (= *Morrhua lanceolata* Kramberger, 1883:67). Upper Miocene of Croatia (Podsused).

Gadus macropterygius (Kramberger) (= *Morrhua macropterygia* Kramberger, 1883:65 = *Gadus* sp. ? aff. *aeglefinoides* Bogachev, 1928:38 = *Gadus macropterygius* Bogachev, 1933:33). Upper Miocene of Croatia (Dolje) and Apsheron Peninsula (diatomaceous clays from the vicinity of Binagady).

Gadus minimus (Kramberger) (= *Morrhua minima* Kramberger, 1885:63; 1891:104). Upper Miocene of Croatia (Sused).

Gadus szagadatensis (Steindachner) (= *Morrhua szagadaten-sis* Steindachner, 1863:139). Upper Miocene of Siebenburgen (Szakadat).

Gadus atropatanus Bogachev (Bogachev, 1933:37). Middle Miocene of Apsheron Peninsula (*spiralis strata*).

Gadus kiplingi Bogachev (Bogachev, 1928:36; 1933:40). Upper Miocene of Apsheron Peninsula (diatomaceous clays from the vicinity of Binagady).

Gadus caspius Bogachev (Bogachev, 1928:36; 1933:41). Upper Miocene of the Apsheron Peninsula (diatomaceous clays from the vicinity of Binagady).

Gadus kwitkae Bogachev (Bogachev, 1933:43; 1938:40). Lower Pliocene of Apsheron Peninsula (Pontic clays from the vicinity of Binagady and Kirov region).

Gadus spoliatus Bogachev, (Bogachev, 1938:41). Lower Pliocene of Apsheron Peninsula (Pontic marls of the Kirov region).

Gadus iniistius (Jordan et Gilbert) (= *Arnoldina iniistia* Jordan et Gilbert, 1919:63 = *Arnoldina iniistia* Jordan, 1921:262 = *Arnoldites iniistia* Jordan, 1923:164). Pliocene of southern California. Known only from one imprint with both the rear dorsal and anal fins unpreserved. Jordan and Gilbert separated it into a distinct genus to *Theragra* or *Pollachius*.

Gadus sp. (Pauca, 1935:103). Pliocene (Pontic strata of Oltenie).

Gadus sp. (Pauca, 1935a:228). Miocene of Siebenburgen (Gemeinde Desmir, Bezirk Cojocna).

- 36 Some of the above listed species are identical. Some of them are known from poor remains. Besides, remains of the genus *Gadus* s. l. are known from fragments of skeletons from the Upper Pliocene of southern Great Britain, and small specimens from glacial and post-glacial clays of Norway (Woodward, 1901:599). In glacial clays of Sweden near Lund bones were found identical to bones of presently living *Boreogadus saida* (Smitt, 1893:484), and in glacial clays near Karlsborg (near Lake Vettern) - bones identical to those of *Melanogrammus aeglefinus* (Munthe, 1910:1). *Eclipses veternus* Jordan et Gilbert (= *Merriamina ectens* Jord. et Gilb.), *E. manni* Jordan et Gilbert, *E. extensus* Jord., referred by Jordan (1921:260) to the family Gadidae it is difficult to say to what family they refer.

Thus, the Gadidae in the Oligocene and Miocene were represented by the same genera as at present. Of all the fossil gadoids only *Megapteryx* is not found today.

Family **BREGMACEROTIDAE**

The only existing genus, *Bregmaceros*, is known in the fossil state.

Genus **BREGMACEROS THOMPSON**

Bregmaceros albyi (Sauvage) (= *Podopteryx albyi* Sauvage, 1880:17 = *P. bosnjaski* Sauvage, 1881:19 = *Erethmophorus* sp. Stefano, 1918:85 = *B. albyi* Arambourg, 1925:25; Erasmo, 1930:51). Upper Miocene of Appenine Peninsula, Sicily (Licata) and Algeria (Sidi-Brahim, Raz-el-Ain).

Bregmaceros filamentosus (Priem) (= *Problennius filamentosus* Priem, 1908:17 = *Bregmaceros filamentosus* Arambourg, 1925:58). Eocene of Iran (Pouchet-e-Kuuh).

Family **MORIDAE**

Fossil representatives of this family in the form of impressions are unknown.

Strinsia alata Steindachner (1859:771) cannot be referred to this family inasmuch as the genus *Strinsia* is excluded from present faunistic works. In the upper Oligocene (Hutchinsonian beds) of New Zealand otoliths were found which Frost (1933:129) assigns to *Physiculus* [*G. (Physiculus) terakohensis*].

Thus, from the beginning of the Tertiary period the families Gadidae and Bregmacerotidae, as can be judged by fossil remains, were sufficiently well differentiated. Many recent genera of the subfamilies Lotinae (*Brosme*, *Lota*, *Merluccius*) were also well differentiated. How sharply the present day Gadinae genera were differentiated in the Miocene is difficult to judge by fossil remains.

The geographical distribution of each family of the order Gadiformes is distinguished by essential peculiarities mainly depending on the ecological differences of the families. Representatives of the family Moridae in-

FIGURE 8. Distribution of the family Gadidae

1—about 20 species; 2—about 15 species; 3—about 10 species; 4—about 5 species (3-5); 5—1-2 species. The white line marks the southern border of the distribution of the genus *Lota*.

habiting considerable depths, just as the entire basic mass of the deep water fauna appear to be cosmopolitan; they are sufficiently evenly distributed throughout almost all deep seas (Table 1).

Distribution of the family Moridae.

Table 1

Numer- ical order	Genera	Total number of species	North Atlantic Ocean and Adjacent Seas	North Pacific Ocean and Adjacent Seas	Southern Atlantic and Pacific Oceans
1	* Brosmiculus*	2	1	-	1
2	* Melanonus	3	2	-	1
3	* Algoa	1	-	-	1
4	Uraleptus	1	1	-	-
5	* Austrophycis	1	-	-	1
6	Physiculus	20	3	9	8**
7	Lotella	8	1	2	5
8	* Salilota	2	-	-	2
9	Lepidion	10	3	4	3†
10	* Hypsirhynchus	1	1	-	-
11	* Microlepidium	2	-	2	-
12	Laemonema	9	4	4	1
13	* Laemonemodes	1	-	-	1
14	Antimora	5	1	2	2
15	* Halargyreus	3	2	-	1
16	Mora	1	1	-	-
17	* Tripterophycis	1	-	-	1
Total Species		71	20	23	28

* The genera marked with an asterisk have not been examined osteologically and are only presumably referred to the family Moridae.

** Including three species from the Indian Ocean.

† Including two species from the Indian Ocean.

The distribution of the warm-water-loving members of the family Bregmacerotidae is limited to tropical and subtropical seas.

Distribution of the family Gadidae, being more cold-water-loving than the family Bregmacerotidae, and found at much lesser depths than the family Moridae, is limited basically to the northern hemisphere, with the exception of some species of Gaidropsarus, Urophycis, Merlucius, and Micromesistius, which occur off the coasts of New Zealand, at the southern tip of Africa and at South America (Table 2 and Figure 8).

In tropical regions at depths where only single specimens of some species of the genera *Merluccius* and *Urophycis* are found (perhaps there are also *Gaidropsarus*), the representatives of the family *Gadidae* as a rule are absent. Not all of the *Gadidae* have a similar distribution within the general area of the family: some are found only in Arctic seas, the majority in temperate ones, and a few in subtropical seas.

Table 2.

Distribution of the family *Gadidae*.

	Genera	Total number of species	North Atlantic Ocean and Adjacent Seas	North Pacific Ocean and Adjacent Seas	Arctic Seas	Southern Atlantic and Pacific Oceans
1	<i>Brosme</i>	1 ^{3a}	1	—	—	—
2	<i>Gaidropsarus</i>	13*	10	1(?)	—	2
3	<i>Ciliata</i>	2	2	—	—	—
4	<i>Enchelyopus</i>	1	1	—	—	—
5	<i>Raniceps</i>	1	1	—	—	—
6	<i>Phycis</i>	3	3	—	—	—
7	<i>Urophycis</i>	7	6	—	—	—
8	<i>Lota</i>	1(1)**	1	(1)	—	—
9	<i>Molva</i>	2(1)	2(1)	—	—	—
10	<i>Merluccius</i>	7	2	1	—	4
11	<i>Trisopterus</i>	3(1)	3(1)	—	—	—
12	<i>Odontogadus</i>	1(1)	1(1)	—	—	—
13	<i>Pollachius</i>	2	2	—	—	—
14	<i>Melanogrammus</i>	1	1	—	—	—
15	<i>Gadus</i>	1(3)	1	(1)	(2)	2
16	<i>Gadiculus</i>	1(1)	1(1)	—	—	—
17	<i>Microgadus</i>	2	1	1	—	—
18	<i>Eleginus</i>	2	—	1	1	—
19	<i>Boreogadus</i>	2	—	—	2 ³	—
20	<i>Arctogadus</i>	2	—	—	2	—
21	<i>Theragra</i>	2(1) ^{3b}	1 ^{3b}	1(1)	—	—
22	<i>Micromesistius</i>	2	1	—	—	1
Total number of species		58(9)	40(4)	5(3)	5(2)	8

* The majority of these species are undoubtedly only subspecies.
 ** The number of subspecies are shown in parentheses.
 3 *B. saida* is found in the most northern part of the Bering Sea, mainly being distributed throughout the Arctic seas.
 3a Corrected figures given by the author due to misprints in the original text.
 3b Figure corrected by author with the following note: A second species (*Th. finmarchica*) was recently described from the North Atlantic (Koefoed, Fiskeridirektor Skr., ser. Havunders., XI, 5, 1956; Svetovidov, Univ. Bergen Arbok, Naturvid. rek, Nr. 11, 1959).

The present distribution of genera and species of the family *Gadidae* within the general area occupied by them as well as the distribution of the families within the order, besides having historical reasons, depends mainly on temperature. All the *Gadidae* can be divided into several groups in accordance with the zoogeographical subdivisions of Ortmann (1896):

I. Arctic-circumpolar subregion: *Arctogadus borisovi*, *A. pearyi*, *Boreogadus agilis*, *B. saida*, *Eleginus navaga*, *Gadus morhua ogac*, *G. morhua maris-albi*, *G. morhua morhua n. hiemalis*. To these also may be referred, evidently, *G. morhua kildensis* from Mogil'noe Lake on Kil'din Island, as well as a local coastal Murmansk race of *G. morhua morhua*.

II. Atlantic-boreal subregion: *Brosme brosme**, *Gaidropsarus mediterraneus***, *Ciliata septentrionalis*, *C. mustela*, *Enchelyopus cimbrius*, *Raniceps raninus*, *Phycis phycis*, *Ph. blennoides*, *Ph. chesteri*, *Urophycis regius*, *U. tenuis*, *U. Chuss*, *U. floridanus*, *U. earlii*, *U. cirratus*, *Lota lota lota*, *L. lota leptura*, *L. lota maculosa* (fresh water), *Molva molva**, *M. dipterygia dipterygia**, *M. dipterygia elongata**, *Merluccius merluccius**, *M. bilinearis**, *Trisopterus luscus**, *T. minutus minutus*, *T. minutus capelanus*, *T. esmarkii*, *Odontogadus merlangus merlangus*, *O. merlangus euxinus*, *Pollachius pollachius*, *P. virens*, *Melanogrammus aeglefinus*, *Gadus morhua mor-*
40 *hua*, *Gadiculus argenteus argenteus**, *G. argenteus thori**, *Microgadus tomcod*, *Micromesistius poutassou** [*Theragra finmarchica* must be added].

III. Pacific-boreal subregion: *Gaidropsarus pasificus*, *Merluccius productus**, *Gadus morhua macrocephalus*, *Eleginus gracilis*, *Theragra chalcogramma chalcogramma*, *Th. chalcogramma chalcogramma n. fucensis*, *Microgadus proximus*.

IV. Antarctic (temperate) region: *Gaidropsarus capensis*, *G. novae-zealandiae*, *Urophycis brasiliensis*, *Merluccius capensis**, *M. gayi**, *M. australis**, *M. hubbsi**, *Micromesistius australis**.

The first group comprises forms whose distribution coincides with the range of the Arctic-circumpolar subregion of Ortmann; all of these forms, with the exception of the subspecies of *G. morhua* and possibly also *A. pearyi* and *B. agilis*, are to a considerable extent euryhaline. The southern limit of distribution of this group (*B. saida*, *E. navaga*) in the Atlantic Ocean coincides more with that of the Arctic region after Broch (1933:17) than with Ortmann's limits. Some of the species of the Arctic region (*Arctogadus*, *B. agilis*) inhabit the coldest seas and can be called high-Arctic (Hofsten, 1915:209). A comparatively small number of species found here as well as in other subregions, does not permit us to divide them further.

The distribution of the second group corresponds with the Atlantic boreal subregion of Ortmann, with the only difference being that within it we must include the Mediterranean and the Black Seas, thus making its southern limits at the eastern coasts of the Atlantic extend slightly farther south, approximately to 15° N., coinciding closely with the southern limits of

* Forms marked with an asterisk live at considerable depths.

** The other doubtful *Gaidropsarus* species are not mentioned.

the distribution of the Mediterranean-Atlantic fauna of S. Eckmann (1935:113). At the coasts of North America the limit of distribution of this group of gadoids almost coincides with the southern limit of the Atlantic-boreal sub-region of Ortmann. To be more precise, as Eckmann properly remarks, (1935:144), and this particularly refers to the gadoids, these are not boundaries but rather transitional areas, as some species penetrate very far into the Arctic regions along the Gulf Stream branches, according to seasonal variations in temperature. With favorable conditions, a number of species, especially those living at considerable depths, range much further south of their indicated boundaries. The same refers to the boundaries of other regions.

There is no reason for separating the Mediterranean gadoids, with those of the adjoining part of the Atlantic, into a special Mediterranean-Atlantic fauna (Eckmann, 1935:113) inasmuch as many Mediterranean gadoids (*M. poutassou*, *Ph. blennoides*, *T. luscus*) with singular exceptions (*O. merlangus euxinus* and *T. minutus capelanus*) are distributed in the Atlantic Ocean far to the north - to the boundaries with the Arctic fauna and appear to be more common here than in the Mediterranean. Besides, the spawning grounds of all species of gadoids are found within the limits of the regions typical of them, while all Mediterranean gadoids, with the exception of the above mentioned two subspecies, spawn primarily in the Atlantic Ocean, not only in the Mediterranean. The most important peculiarity of the Mediterranean-Atlantic fauna - relationship with the Indo-West Pacific - is foreign to the gadoid fauna. However, there are some indications of a minor segregation of the gadoids in this region such as: the areas of some forms (*M. dipterygia elongata*, *Ph. phycis*, *G. argenteus argenteus*) to a certain degree coincide with the boundaries of the Mediterranean-Atlantic fauna. Besides, the southern range

41 of some North Atlantic species (*G. morhua morhua*, *M. aeglefinus*, *P. virens*, *M. molva*, *M. dipterygia dipterygia* and others) coincide closely with the northern boundaries of Eckmann's Mediterranean-Atlantic fauna.

The third group of gadoids must be referred to the Pacific-boreal sub-region of Ortmann, the boundary of which with the Arctic Circumpolar subregion in the gadoids in the Bering Sea extends approximately from the Chuckchi Peninsula to Cape Nome in Alaska. To the north of this boundary enter cod (*Gadus morhua macrocephalus*) and vachnya (*Eleginus gracilis*), and to the south saika (*Boreogadus saida*). The southern boundaries of the distribution of this group of gadoids closely coincides with Ortmann's boundaries: central California on the coast of North America and central Japan in the Pacific Ocean. Only single species of gadoids penetrate south of this boundary - to the Yellow Sea and the Gulf of California.

A characteristic peculiarity of this subregion appears to be that, in spite of the low temperature of the water of some of its seas, the gadoid fauna bears a partial boreal character. The species of the Arctic genus *Eleginus* - *E. gracilis* here appears as a warmer water species, occurring even in the Yellow Sea. In comparison with the Atlantic-boreal subregion the gadoid fauna of the Pacific-boreal subregion is much poorer.

In the southern hemisphere the gadoid fauna is still poorer; here we find five species (or perhaps they are subspecies) of the genera *Gaidropsarus*

and *Merluccius* closely related to the boreal forms, and one each of the genera *Urophycis* and *Micromesistius*.

Thus, the fauna of the gadoids in the Atlantic-boreal subregion is much richer, having the greatest number of endemic genera. The gadoid species which are largest in size and most abundant in number are met with here. Next in a quantitative comparison of endemic genera and species is the Arctic Circumpolar subregion. The Pacific-boreal subregion is still poorer in gadoids. There is only one endemic genus (*Theragra*). The Antarctic (temperate) region has not a single endemic genus.

Such a distribution of the gadoids shows little agreement with Eckmann's zoogeographical regions (1935) primarily because there is no sufficient reason to separate gadoids into a special Mediterranean-Atlantic region. Besides, the gadoids of the Bering and Okhotsk Seas have more reason to be included in the Pacific boreal region than in the Arctic region. And, finally, the poor and uniform gadoid fauna of the southern hemisphere is more correctly considered as one without subdividing it into South African, South Australian, New Zealand and Peruvian-North Chilean regions.

With regard to almost all groups of marine animals, and particularly fishes, many authors (Günther, 1880:176; Smitt, 1904:394; Berg, 1918: 1835; Broch, 1935:42, and others) have noted that the fauna of the North Pacific Ocean shows great similarity to the fauna of the North Atlantic, and is much richer in species and genera and even families. The fauna of the North Atlantic Ocean, as well as that of the Arctic Seas, appears in the main to be an impoverished fauna of the North Pacific Ocean from which it is mainly derived.

Among fishes the gadoids are almost the only exception to this general rule since this family is represented in the northern parts of the Atlantic Ocean by a greater number of species and genera. The reasons for such a peculiar distribution of the gadoids, which is contrary to the distribution of other fishes, and which was noted simultaneously with the discovery of the similarity of the fauna of the North Atlantic and North Pacific Oceans and the fact that the latter is much richer (Günther, 1880:180; Smitt, 1904: 402), however, remains unexplained. After the separation of the family Gadidae from the family Moridae, the predominantly Atlantic distribution of the gadoids becomes still more marked (see Tables 1 and 2 and Figure 8) as deep water fishes are cosmopolitan.

The numerical predominance of gadoid species and genera in the North Atlantic, the presence there of a number of endemic genera (*Brosme*, *Raniceps*, *Phycis*, *Urophycis*, *Molva* and others), the absence of endemism in the Pacific gadoid fauna, and its obvious genetic dependence on the Atlantic, doubtless points to the derivation of the Pacific gadoids from the Atlantic. The opinion is being accepted in recent years by many authors (Scheuring, 1930:197; Zenkevich, 1933:21; Smitt, 1936:175). It is clear that the present gadoid fauna of the Atlantic and Pacific Oceans and of the Arctic Seas has had a somewhat different origin than the rest of the ichthyofauna of both oceans.

In the opinion of L. A. Zenkevich, the wealth of species and genera of gadoids in the Atlantic is a phenomenon which developed in the Atlantic Ocean itself and began after the separation of the two oceans at the end of the Pliocene (l. c.:21), but this opinion contradicts the paleontological data since gadoid remains were found in much earlier strata, in the Oligocene

and Miocene, and otoliths beginning with the upper Paleocene. To this we must add that the evolution of the gadoids did not occur so rapidly since already in the Oligocene and Miocene deposits of western Europe and the Caucasus, the gadoids, especially in the subfamily Lotinae, are represented by the same genera as at present; many of these genera are represented by a few species, while in the glacial clays of Scandinavia a skeleton was found of a small gadoid completely identical with the skeleton of the present day *Boreogadus saida*. Some authors (Schmit, 1936:175) consider that the main basin in which the gadoids developed during the Tertiary were seas that covered the area of the present North Atlantic Ocean and farther north.

In discussing the problem of the origin of the gadoids, in addition to the fauna and the present day geographical distribution, it is also necessary to consider the following: 1) definite and fairly marked preference for cold water associated with the eurythermal habits of the family as a whole, 2) time and places of fossil remains, and 3) geological history of localities of the fossil remains of the gadoids.

The predominant cold water habits of gadoids have attracted the attention of almost all authors (Günther, 1880:177; Zenkevich, 1933:21; S. Ekman, 1935:235), who pointed out the peculiar distribution of the family. Actually, both the geographical distribution (primarily in considerably high latitudes of the northern hemisphere) and, most important, the spawning time, which in the great majority of species occurs in the cold season of the year, doubtless explains the cold water preference of the gadoids. As noted by Appellöf (1912:303), requirements for reproduction may be an indirect indication of the origin, thus reproduction in the cold season of the year is
43 indicative of an Arctic origin. In species which prefer warm water and those which are distributed farther south the spawning time occurs in the warmest time of the year. *Scomber scombrus* (L.), in the same latitudes as the cod off the coast of Norway spawns in June-July (McIntosh a. Masterman, 1897:160), *Mullus barbatus* L. and *M. surmuletus* L. at the coasts of Great Britain spawn in June-July (Meek, 1916:304). In more southerly latitudes spawning of these fishes takes place earlier, Spawning time in the flat fishes, among which there are also boreal and almost Arctic groups as well as tropical fishes, differs according to their distribution: tropical flat fishes spawn in the warm time of the year, and breeding in flounders with a more normal northerly distribution tends to be in the colder part of the year; but even among these there are some, the subfamily Pleuronectidae, found at much higher latitudes which spawn at the coldest time of the year. Within the gadoids species with the most southerly distribution breed in warmer seasons of the year than do species distributed farther to the north (J. Schmidt, 1909:155).

Indisputable fossil remains of the gadoids - as imprints of skeletons - are known from Central Europe, the Caucasus and a few from California*. The first to appear in the Lower Oligocene is *Nemopteryx* which disappears toward the end of Middle Oligocene. In Middle and Upper Oligocene deposits deep water gadoids - *Brosme* and *Merluccius* - appear. Gadoids of the *Gadus* s.l. type appear for the first time in much later deposits, as singular specimens in the Middle Miocene and abundantly in the Upper Miocene beds. *Phycis* and *Lota* are known from Lower Pliocene deposits.

* See the chapter on fossil gadoids.

Judging from otoliths which have been found, gadoids were found even earlier - in the Eocene and even the Upper Paleocene, but as was noted above it is difficult to identify them exactly even though they were referred to many genera and even species of the present day gadoids. All of these fossils were found in deposits of central Europe and the Caucasus. From the Pacific region (southern California) fossil gadoids are known only from Pliocene deposits.

At the time to which are referred the earliest known remains of gadoids - Paleocene and earlier, in place of the present Mediterranean in southern and central Europe, as we know, was the Tethys Sea extending farther westward into the central part of the present Atlantic Ocean and southeastward where it was connected with the Indian Ocean. The northern boundary of the Tethys in Europe extended along the northern boundaries of the Carpathians and the Alps which rose in the form of flat islands; southward the boundary of Tethys passed approximately through northern Africa. The northern part of the present Atlantic Ocean was crossed by a bridge connecting Europe with North America through Iceland and Greenland (Jhering, 1927:35).

The Paleocene fauna of the Tethys was tropical, extremely rich and in the opinion of Ekman (1934:359) gave rise to the existing littoral fauna of tropical seas. The Paleocene, Eocene and Oligocene fish of the Tethys and the Anglo-Paris and Belgian epicontinental basins adjoining it were similarly tropical (Leriche, 1902:47; 1905:49; 1910:231); and present day gadoids were absent. Only from the middle and end of the Oligocene in the Tethys
44 do present day deep water *Merluccius* appear, and in the northeastern part of it (Apsheron Peninsula) *Brosme*; for gadoids which keep to lesser depths such as *Gadus* s.l. the climate was apparently still a little too warm. *Nemopteryx* which is found here only in Oligocene deposits apparently preferred slightly warmer water than present day gadoids and perhaps lived at depths, because its remains are mainly recorded from Tethys deep water deposits. Only *N. emarginatus* has been found also in shallower deposits of the Mainz Basin.

From the middle of the Tertiary (during Miocene) the Tethys greatly diminished, a number of islands emerged from the sea, its northeastern portion separated and consequently became greatly freshened; the strait across the Pyrenean Peninsula disappeared, giving room to a narrow strait in the area of the Guadalquivir River; the Tethys lost its communication with the Indian Ocean. As a result of the cooling of the climate the European portion of the Tethys lost its tropical fauna.

Thus, at the end of the Tertiary period a gradual cooling of the climate occurred, under which influence the Paleocene tropical fauna of the Tethys disappeared and in its place came a more cold water fauna originating along the northern parts of the Pacific Ocean. The migration of this fauna into the Atlantic Ocean became possible for the first time, as was shown by Berg (1918:1835), only during the Pliocene, when simultaneously with the marine submergence in the region of the Bering Strait there was a warmer climate. The gadoids, as pointed out above, appeared in those seas which were in regions of the Atlantic Ocean and Europe considerably earlier. Already from the Middle Miocene deposits of the Caucasus the genus *Gadus* s.l. (*Gadus atropatanus*) is known and from Upper Miocene deposits many species of this genus are known from Central Europe as well as from the Caucasus. The upper Miocene deposits of Central Europe and Algeria also

contain *Brosme*, previously known from the Oligocene beds of the Caucasus. In the Pacific the gadoids appear only in the Pliocene (California), that is apparently after transgression of the area of the Bering Strait.

All of the above stated facts: the present distribution of the gadoids, their ecology, localities and age in the fossil state, and the Tertiary history of the seas in which the deposits have been found, all these facts indicate that with cooling of the climate in the Upper Tertiary the gadoids migrated to the seas which covered regions of present day Central Europe and the Caucasus, from much colder basins to the north. Present day knowledge of the history of the northern seas only allows us to guess and to suggest in which of these basins the gadoid fauna developed and where they were in the early Tertiary. It is, nevertheless, possible to assert that the gadoid fauna did not originate in those epicontinental marine basins which covered present day western Europe (Anglo-Parisian, Belgian, etc.), even though otoliths were found in deposits of these seas belonging, if not to the assigned genera then undoubtedly to the gadoids because the climate, flora (Köppen-Wegener, 1924: 104) and fauna of these localities, marine as well as terrestrial (Leriche, 1902:47; 1905:49; 1906:125; 1910:231; White, 1931:36) were tropical. It is obvious that the gadoids in the early Tertiary frequented cold water basins and only the deep water forms admixed into the tropical fauna. This occurred in localities perhaps within the sphere of influence of some cold stream upwellings from the bottom water layers of the basin where gadoids
45 are usually found. Such a basin could be the Polar and the adjacent Scandinavian and other basins but, to our regret, the Tertiary history of the Polar Basin has remained unexplored to this day although it is shown in all (46-62) of Arldt's paleogeographic charts of the Tertiary, Chalk, Urski, and Triassic periods. The tetrahedral theory of the structure of the earth, according to which there had always been a sea around the North Pole (Arldt, 1919:1196), has been the only evidence for the great age of the Polar Basin. According to the most recent studies of D. G. Panov (1946), the formation of the Polar Basin and the establishment of the marine regime can be placed in the Mesozoic. The deepening and formation of the present basin commenced from the very beginning of the Tertiary period.

The above assumptions on the origin of the gadoids is strongly supported by the distribution of some crustaceans. Thus, for example, besides the considerable number of species of various groups of marine animals (see Eckman, 1935:245) there are several genera of amphipods in which the distribution is almost or even exclusively High Arctic - "High Arctic autochthonous forms" as they are called by Gurjanova* (1935:566). To their number belong the genus *Onisimus* with 11 purely Arctic species, of which only three descended into the northern part of the Atlantic Ocean; in the northern part of the Far Eastern Seas this genus is not found (Gurjanova, 1932:159). All the three species of the genus *Acanthostepheia* appear to be pure Arctic (Gurjanova, 1929:288; 1932:159). Of the six species of the genus *Pseudolibrotus* four appear to be exclusively Arctic, hardly ever extending south of the Arctic Circle into the northern part of the Atlantic Ocean and absent from the Pacific Ocean; two species are found in the Caspian Sea (Gurjanova, 1932:163). Among the isopods the genus *Mesidothea* is purely Arctic, only one (*M. entomon*) of its four species has subspecies in the Baltic, Bering, Okhotsk and Caspian Seas and in some fresh water basins of northern Europe and North America (Gurjanova,

* [Also known in literature as Gur'yanova]

1932:175). The number of endemic crustaceans for the Polar Basin is extremely high: among the amphipods 41%, among isopods 34% (Gurjanova, 1939:681).

The distribution of the above mentioned crustaceans has great similarity to the distribution of the gadoids: a very small proportion of them (*M. entomon orientalis*), proportionately much less than in gadoids, occur in the northern parts of the Far Eastern Seas, being mainly distributed throughout the Arctic Seas and in the North Atlantic Ocean, while the only Pacific representative of these species has its origin in the Arctic, just as the Pacific gadoids have their origin in the Atlantic. However, in addition to the similarities in distribution of the gadoids and crustaceans there are also some differences: a great part of the crustaceans inhabit the Arctic seas, hardly penetrating into the North Atlantic Ocean and almost completely absent from Far Eastern Seas, while the gadoids are more numerous and range much farther south in both the Atlantic and Pacific Oceans and, more important, they are represented by a greater number of species in the North Atlantic than in the Arctic seas.

46 The reason for this similarity, which we may presume, was still greater in the Early Tertiary period, is undoubtedly conditioned by the fact that the gadoids and the above named crustaceans apparently evolved in one and the same basin, evidently the Polar Basin. Differences in their distribution patterns developed later and appear to have resulted from cooling of climate during the Upper Tertiary and in the greater mobility of gadoids. As indicated above, the climate and the fauna of the Tethys and the epicontinental basins which lay to the north of it were tropical. Undoubtedly, the climate in the region of the Polar Basin was much warmer than at present as the early Tertiary flora of Greenland, Iceland and Spitzbergen was of somewhat more southern type than the flora of present day Norway; here were found two species of birch, linden and pine and others (here, cited by Koppen-Wegener, 1924:106). With cooling climate, gadoids began to move out of the Polar Basin and finding more suitable conditions farther south concentrated here in all their great variety, leaving in the Arctic seas elements which were better suited to lower temperatures. However, the crustaceans we referred to previously, being less mobile and undoubtedly better adapted to cold than were the main mass of the gadoids, remained in the Arctic Seas. Because of the earlier connection of the Polar Basin with the Atlantic than with the Pacific, gadoids could move into the northern part of the Atlantic with the cooling climate, and not into the Pacific. Apparently, the same will explain the greater penetration of the crustaceans referred to above into the northern part of the Atlantic and not of the Pacific. As is known, the faunal exchange between the Pacific and the Arctic Seas, and through the latter also with the Atlantic Ocean, first became possible only in the Pliocene. Connection of the Polar Basin with the Tethys began much earlier. From the very beginning of the Tertiary period and up to the close of the Oligocene (Archangelsky*, 1935:119; Obruchev, 1935:9, 11) a wide sea passage to the northeast of the Tethys extended from the present day Caucasus toward the mouths of the Ob' and Yenesei - and the Oligocene representatives of the genera *Brosme* and *Merluccius* which were found in the Lower Maikop deposits of the Caucasus possibly had penetrated southward along this passage. In the Eocene this sea was shallow, in the Oligocene, quite deep, and at the end of that period it became broken up into lagoons and lakes (Obruchev, 1935:8-9). The bridge connecting Europe

* [Also known in literature as Arkhangel'skii]

and North America through Britain, Iceland and Greenland, in the opinion of the majority of paleogeographers, did not exist continuously (see Arldt, 1919:406-423) and apparently at times was covered by the sea which formed bays and straits across it thus connecting the Polar Basin with the Tethys and adjacent seas. It is most probable that this was the route along which the gadoids, otoliths of which are known from early Tertiary deposits of western Europe, had penetrated into these seas. Apparently, as noted by Davies (1920:311), the Anglo-Parisian-Belgian basin was subjected in the Paleocene (Landenian layer) to influences from the north and from the south (Tethys), but from the latter apparently to a lesser extent. This resulted in a mixture of warm and cold water faunas and explains the occurrence of gadoid otoliths. But generally the prevailing climatic conditions during Palaeogene, together with the partial isolation of the Polar Basin were cause enough for the concentration of the gadoids in higher latitudes in the Paleocene. The main migration of the gadoids from the Polar basin into the middle latitudes apparently took place in the Upper Miocene when the land connection between Europe and North America had disappeared and the climate became similar to that of the present day. At this time, as indicated above, a great number of representatives of *Gadus* s.l. and a considerably larger number of those of other gadoid genera appeared in the deposits of Central Europe and the Caucasus in much greater numbers than in the Oligocene.

The basic patterns of present distribution of the gadoids just as of all the fauna and flora had developed in the beginning of the Quaternary period under the influence of lower temperatures and heavy glaciation. The gadoids
 47 best adapted to cold concentrated in the high Arctic regions while the more warm-water-loving species were forced to retreat to the south. Meanwhile, due to periodic decreases and increases in salinity which occurred at this time in the Polar basin, Zenkevitch (1933:22) showed that only those gadoids adapted to cold which could tolerate freshening (genera *Arctogadus*, *Boreogadus*, *Eleginus*) survived in the high Arctic regions. A number of other cold water loving gadoids, being intolerant of low salinity (genera *Gadiculus*, *Brosme* and others) were forced, together with some more warm-water-loving fishes to retreat to more southerly latitudes, but at depths.

The concentration in different regions of different ecological groups of gadoids apparently did not require them to be completely isolated from each other during that period as there was a continuous bridge between Europe and North America. A glacial cooling and even a small reduction in salinity* following it, which is possible without complete isolation of the Arctic Seas from the Atlantic Ocean, would have been sufficient for this. The adaptation to a fresh water existence in the burbot apparently occurred over a long period of time and in various parts of its range. Even though in the fossil state a burbot is known from fresh water or brackish water deposits in the vicinities of Vienna in the Lower Pliocene, apparently the burbot entered fresh water during the glacial period and from the

 * We must, however, indicate that to judge by all information at hand a complete freshening of the Polar Basin never occurred since in that case the enumerated gadoids which propagate only in sea water, as well as the crustaceans listed above (for this see also Gurjanova, 1939:679) would never have survived.

Polar Basin. This assumption is supported by the present day circum-polar distribution of *Lota* and by its absence from the Neogene (Pliocene) deposits of Siberia (Schtilko, 1934:74).

As shown above, gadoids could have penetrated (see Berg, 1918; 1838; 1934:69) into the Pacific during the Pliocene and then during the marine postglacial transgression, when the climate was warmer than today (Berg, 1911:73; Smith, 1919:167). Indisputable remains of gadoids are known from Pliocene deposits of California. Apparently during the Pliocene, *Theragra** appeared in the Pacific and evolved to a distinct genus. It is more difficult to state when the other gadoids migrated into the Pacific. In this regard there are just two points of view. According to one point of view (Schmitt, 1936:175), cod and navaga migrated into the Pacific during the Pliocene, while according to the other point of view (Schmidt, 1936:136), the migration took place before or during glacial cooling. The first opinion seems to be supported by present distributions in the Pacific Ocean extending southwards to and including the Yellow Sea, where it seems they could have gone only under the influence of dropping temperatures. However, this could not have occurred because, owing to rising of land at the onset of the Quaternary Period, the Yellow Sea itself at that time was dry land, and the Sea of Japan a land-locked basin. The gadoids could not have been present either in that land-locked basin or in the adjoining parts of the Pacific, for the climate there was much warmer than now, as is shown by the occurrence in those localities of tropical fauna (molluscs and coral in the Tokyo Bay during the Name facies (Krishtofovich, 1932:293). After penetrating into the Pacific Ocean post-glacially, cod and navaga could have entered the Yellow Sea and Sea of Japan, because it is known, for example, that migratory
48 forms of cod can appear in a very short time where they have been unknown before in times of change in thermal conditions. Thus in recent years, when there was a general warming there, cod were discovered in the Kara Sea (Berg, 1935:73). Thus it appears most likely that cod and navaga penetrated into the North Pacific Ocean during the postglacial period. The White Sea cod (*G. morhua maris-albi*), which settled in the White Sea during the post-glacial period (Derjugin, 1932:443) is only a subspecies, the same as is the Pacific cod. This becomes even more probable because navaga and that form of cod from which the Pacific cod was derived are cold water loving. It is possible that *Microgadus proximus* and *Merluccius productus* which have very closely related species in the Atlantic Ocean entered the Pacific Ocean simultaneously with cod and navaga. On the other hand, they are more warm water loving than are cod and navaga and that might indicate that their distribution could have occurred also at another time and, in the case of *Merluccius*, through other ways (see below). Considerably later, apparently at the end of the warm post-glacial period, saika (*B. saida*) appeared in the Bering Sea, keeping to its most northerly parts; the reason for its slow dispersal southward, and particularly into the Sea of Okhotsk where it could have found favorable conditions, is apparently the absence of floating ice, with which this fish is generally closely associated, south of Cape Lopatka along the eastern coast of Kamchatka and at the Aleutian Islands. The most cold water loving of the gadoid genera, *Arctogadus*, is confined to the coldest Arctic Seas.

* [This suggestion now must change as the Atlantic species of *Theragra* (*Th. finmarchica*) has recently been found.]

The existing distribution of Pacific gadoids and closely related Arctic and Atlantic species and subspecies shows the routes along which they migrated into the Pacific Ocean. The distribution of *Eleginus navaga* along the northern coasts of Europe and Siberia and *E. gracilis* in the Far Eastern Seas indicates the migration of the latter into the Pacific along the coasts of Asia. *Microgadus proximus* (closely related to the species *M. tomcod* which occurs along the Atlantic coast of North America) undoubtedly entered the Pacific Ocean around the North American continent. That the same route was followed by *G. morhua macrocephalus*, is substantiated not so much by the number of vertebrae (Schmidt, 1936:64) as by its cranial as well as ecological affinities with *G. morhua ogac*, found at the shores of Greenland. *G. morhua ogac* and *G. morhua macrocephalus*, distinguished craniologically by a broad head and also ecologically by the fact that they do not undertake extensive migrations as does the narrow-headed *G. morhua morhua*, in pre-glacial times were apparently represented by one form which occupied one broad common range (present distribution, see Figure 26). With the disappearance of the land connection between North America and Europe the continuous range of this coastal form appeared to be interrupted by the deep sea which appeared in place of the land and thus along the northern parts of both coasts of the newly formed Atlantic Ocean there appeared two forms; at first isolated geographically they later acquired morphological distinction. The form isolated along the northern shores of Europe apparently played some role in the formation of *G. morhua maris-albi* (about this see further on page 173). The form found along the coast of North America penetrated into the Pacific Ocean and gave rise to *G. morhua macrocephalus* which spread widely to the south and developed into a warmer water race than the original form. The narrow-headed form of cod - *G. morhua morhua* which ranged farther south and was adapted to warmer temperatures did not enter the Pacific Ocean with the broad-headed cod and *navaga* apparently because the climate at that time along the northern tip of North America appeared to be too severe for it. It is unlikely this route was followed by *Merluccius productus* in penetrating the Pacific; as for deep-water fish the other route seems most likely - along the coast of South America, which is partly confirmed by its absence from the coasts of Asia, and its present bipolar distribution. *Boreogadus saida*, found in Arctic seas at the coasts of Asia and North America, also inhabits the northernmost part of the Bering Sea along both shores. Thus, judging by the present distribution, the dispersal of gadoids into the Pacific Ocean apparently occurred chiefly around the coast of North America, i.e., coinciding with the dispersal routes of the majority of representatives of other groups of marine animals which migrated primarily in the opposite direction from the northern part of the Pacific Ocean into the northern part of the Atlantic.

The dispersal of gadoids in the southern hemisphere where they are represented by close but not identical species and subspecies of the genera *Gaidropsarus* (*G. capensis*, *G. novae-zealandiae*) and *Merluccius* (*M. capensis*, *M. hubbsi*, *M. australis*, *M. gayi*) and by the single species of the genera *Micromesistius* (*M. australis*) and *Urophycis* (*U. brasiliensis*) at the southern tips of Africa and South America and at New Zealand could have occurred during the glacial

cooling period, and is perhaps even taking place at the present time. As is known, in tropical regions the surface water layer with the highest temperature is latitudinally the narrowest and the bottom water layer with a minimal temperature is latitudinally the broadest in the Atlantic Ocean along the western shores of Africa (Schott, 1926:134, tables IX, XIV, and XV) and in the Pacific Ocean along the western shores of America (Schott, 1935:150, 181, tables XX-XXIII and XXXI-XXXII). Due to this the transition from tropical to temperate fauna is least pronounced here (Ekman, 1935:88) and because of this, we have here the most favorable conditions for the exchange of faunas between the northern and southern hemispheres. Thus, for example, separate representatives of the bipolar distributed family Triglidae (Svetovidov, 1936:8) sometimes were recorded in the tropical area off the western coasts of Africa (Regan, 1915:129). As indicated above, some gadoids (*Merluccius gayi*) are also found in the tropical areas of the Pacific Ocean off the western coasts of America at depths. Thus, the bottom water layer of a tropical area does not represent an insurmountable barrier to the southward dispersal of more warmth loving gadoids (some species of the genus *Gaidropsarus*) and deep-water ones (genera *Merluccius* and *Micromesistius*) even at the present time in the indicated places, but for the majority of them this dispersal occurred mainly during glacial cooling. In general, species which have penetrated into the southern hemisphere are either the most warm-loving and more southern in distribution (*Gaidropsarus*, *Urophycis*) or those living at great depths and leading a bathypelagic mode of life (*Merluccius*, *Micromesistius*).

Ecological peculiarities of the families of the gadiformes and the distribution according to climatic zones, depending on those peculiarities, have remained unchanged from the very beginning of the Tertiary. The family Bregmacerotidae which was tropical in the Eocene (*B. filamentosus*, Eocene of Iran) remained approximately the same through the Miocene (*B. albyi*, Upper Miocene of Algeria, Miocene of Algeria and Sicily); in tropical areas they survive to this day. The Miocene climatic cooling caused the migration of colder water gadoids to the middle latitudes of the northern hemisphere where they were not known previously. Judging by otoliths referred to the genus *Physiculus* and found in Upper Oligocene deposits of New Zealand (Frost, 1933:129), the family Moridae has had a wide distribution also from the very beginning of the Tertiary.

Biology*

All gadiforme fishes, with the exception of one species, are marine; in particular this applies to the families Moridae and Bregmacerotidae, representatives of which as a rule are absent even from brackish areas around river mouths. As to the family Gadidae, among its representatives there is one species, the burbot, with three subspecies (*Lota lota lota*, *L. lota leptura*, *L. lota maculosa*), living and reproducing in fresh water. A number of species of the family Gadidae, being

* Compiled from data from the systematic section and the works of Hjort (1909), Damas (1909), J. Schmidt (1909) and some other authors cited in the text.

basically marine fish, enter into greatly freshened and sometimes quite fresh water, and some travel considerable distances up rivers within the sphere of influence of tides and ebbs. To this group of species belong *Eleginus navaga*, *E. gracilis*, *Microgadus tomcod* and perhaps *M. proximus*, *Boreogadus saida*, *Arctogadus borisovi* and some others. From the number of exclusively marine species of the family some (for instance *Gadus morhua* and particularly some of its forms) can tolerate somewhat lower salinity even during the spawning season, and occasionally may enter quite fresh water (three specimens of cod caught in the Luga River, one kilometer from the mouth). A number of species of the family (*Molva molva*, *M. dipterygia dipterygia*, *M. dipterygia elongata*, *Gadiculus argenteus argenteus*, *G. argenteus thori*, *Micromesistius poutassou* and some others) live and reproduce in marine water, at a salinity no less than normal oceanic.

With regard to temperature each family of the order has its own characteristic requirements. The family Gadidae is the most varied in this respect. Basically this family is quite cold-loving. A group of species (*Arctogadus borisovi*, *Boreogadus saida*, *B. agilis*, *Eleginus navaga*, and to a lesser degree *E. gracilis* and some others) lives and, what is more important, breeds at temperatures close to zero and even lower. On the other hand, a group of species requires for its existence much higher temperatures. The most warm-loving of the Gadidae are *Trisopterus luscus*, *T. minutus minutus*, *T. minutus capellanus*, *Molva dipterygia elongata* and some others. The family Bregmacerotidae, in contrast with the family Gadidae, is more warm-loving because species are found in tropical parts of all oceans where they live at great depths as well as in the surface layers. Species of the family Moridae appear to be fishes which are quite cold-loving and adapted to living in cold waters close to the bottom, living at great depths at the border or beyond the borders of the continental shelf.

In vertical distribution each of the families of the Gadiformes also has its own characteristics. The Gadidae are most varied in this respect. Almost all species of this family, to some extent, live only at the bottom with the exception of *Micromesistius poutassou*, partially *Merluccius* and some others, living over great depths and leading a pelagic mode of life at a sometimes considerable depth from the surface or in the very surface layers. Some of the gadoid species live along the very shores and at shallow depths, for instance *Raniceps raninus*, *Eleginus navaga*, *E. gracilis*, *Microgadus tomcod*, *M. proximus* and perhaps *Arctogadus borisovi*, or among floating ice as *Boreogadus saida*. A group of other species belonging to the family Gadidae, as for example *Gadus morhua morhua*, *Melanogrammus aeglefinus* and many others, live at considerable depths—to 200 meters and deeper. Finally, some species of the family live at great depths, down to 1,000 meters. Deepest dwelling species are *Brosme brosme*, *Molva dipterygia dipterygia*, *M. dipterygia elongata*, *Gadiculus argenteus argenteus*, *G. argenteus thori* and others; some of these remain at great depths, perhaps not at the very bottom but in intermediate layers. All representatives of the family Moridae, as a rule, live at great depths of several hundred meters and some more than a thousand meters and generally are not found in coastal areas. Species of the family Bregmacerotidae lead a pelagic mode of life. The ecology and

biology of representatives of the families Moridae and Bregmacerotidae have been little studied and information regarding them is very limited.

So far as known, almost all Gadiformes undertake migration. The families Moridae and Bregmacerotidae have not been studied at all in this respect, but as far as the family Gadidae is concerned, the migrations of its representatives as well as other questions of their biology and ecology have been much more fully studied. Some gadoids undertake limited migrations dependent upon changes of temperature from the shores to somewhat greater depths and back, or within the limits of a quite restricted portion of their range. To those fishes which are more or less sedentary and undertake only local limited migrations, belong species of the genera *Gaidropsarus*, *Enchelyopus*, *cimbrius* and some others. Somewhat more mobile but undertaking migrations only within limited portions of their ranges are *Eleginus navaga*, *E. gracilis*, *Microgadus tomcod* and, perhaps *M. proximus*. *Boreogadus saida* seems not to undertake large migrations but it is apparently carried great distances with drifting ice. But particularly extensive migrations are undertaken by the oceanic form of cod, *Gadus morhua morhua*, and by the haddock—*Melanogrammus aeglefinus*, which travel in summer from the coasts of Norway almost to the shores of Novaya Zemlya, making in a short period of time a trip of 1,500 to 2,000 kilometers. Similar extensive migrations are undertaken by cod moving between Greenland and Iceland.

Migration of gadoids, as with all fishes, is closely related to feeding and reproduction, and to a great degree it depends upon currents and seasonal changes in temperature. Cod, whose migration has been studied most, after losing a great deal of weight during spawning in spring, travel northward along the North Atlantic current from the breeding grounds off the Lofoten Islands in pursuit of food or in search of food. This spring migration of hungry cod northward is closely related to the rising water temperature. With the approach of fall and a drop in water temperature the Lofoten cod gradually leave the eastern portions of the Barents Sea and during winter only part of the population remains in the western regions of the Barents Sea. For the purpose of feeding and in close accordance with the changing temperature, the haddock (*Melanogrammus aeglefinus*) as well as pollack (*Pollachius virens*) undertake migrations almost as extensive; 52 *Micromesistius poutassou* and some others undertake migrations of lesser distances and not in such masses as the two preceding species. Under the influence of seasonal changes in temperature and for the purpose of finding food those gadoids which move only between great depths and coastal waters also migrate.

Each species of the family out of the spawning season lives over a wider range and is subjected to greater extremes in temperature, salinity, depth than during the spawning season. During the spawning season fully adult gadoids gather in places which are quite fixed and familiar to each species, where each species spawns within specific environmental limits which are more restricted than the usual ranges of variation in temperature, salinity and depth. The ecological characteristics of each species of the gadoids during the spawning period are more specific than are those outside the spawning season, and on this basis some authors (Hjort, 1909:58; Damas, 1909:223; J. Schmidt, 1909:178) offered a division of the gadoids into several biological groups.

Even closely related species have distinctly different conditions, locations and times of spawning, the best example of which is the genus *Molva*. *M. molva* lays eggs at a temperature of 6-10° C., a salinity of 35.2 parts per thousands, at a depth averaging about 200 meters; *M. dipterygia*—at a temperature of 5-8° C., a salinity of 35.2 parts per thousand, at a depth averaging about 1,000 meters; *M. dipterygia elongata*—at a temperature of 8-9° C., a salinity of 35.5 parts per thousand, at a depth averaging 1,000 meters. The spawning characteristics of each species differ greatly, the spawning grounds being found in various places: in *M. molva* closer to shore, in both subspecies of *M. dipterygia* at depths, while in *M. dipterygia dipterygia* spawning grounds are distributed north of Ireland, and in *M. dipterygia elongata*—southward. Such vicarious species and forms among the gadoids exist not only as regards spawning grounds but spawning season as well.

The main spawning season of the gadoids is the latter half of winter and early spring; in some species spawning takes place in summer, while in species of lesser size it may occur almost the whole year round. Time of spawning for the same species is greatly dependent upon the geographical latitude—in the southern portion of the range spawning occurs earlier than in the more northerly portions.

The fecundity of the gadoids is extremely large [*Molva molva* produce up to 60 million eggs (Fulton, 1891:234), *Gadus morhua* 4 to 6, sometimes up to 9 million eggs, though its eggs do not all mature at once and apparently all are not laid at one time as in a mature ovary several stages in the development of eggs were distinguished]. Number of eggs depends upon the size of the fish; gadoids of large size have a greater number of eggs, smaller individuals considerably fewer; *navaga*, for example, has only 6 to 90 thousand eggs.

Eggs, larvae and young of almost all gadoids lead a pelagic or in some cases (*Micromesistius*, *Gadiculus*) bathypelagic mode of life, while the young of many species (*Gadus morhua*, *Melanogrammus aeglefinus*, *Eleginus navaga*, *E. gracilis*, *Odontogadus merlangus* and some others) hide under jelly fish (*Cyanea*) and the young which already lead a bottom mode of life (*Urophycis chuss*)—within the shells of mollusks (*Pecten magellanicus*). Some species of gadoids (for instance, *Eleginus navaga*) have demersal eggs, and in *Lota lota* eggs are laid on the bottom or remain in a suspended state at the very bottom. Incubation period continues from one week to a month, and in Arctic species is much longer than in boreal species.

53 During development of eggs into young several stages are distinguished (Rass, 1933:12): 1) eggs, 2) larvae characterized by presence of the yolk sac, 3) incompletely formed young which extend from full resorption of the yolk sac to the appearance of rays in the unpaired fins, 4) a formed young, having rays in the unpaired fins but without scales, and 5) juvenile or yearlings—fully formed fish with scales.

During the pelagic period of life the egg, larvae and young are carried by currents from the spawning places sometimes to very great distances. In the gadoids which spawn at Lofoten Islands the young toward the end of the pelagic stage are carried by the North Atlantic current from the spawning grounds for hundreds of kilometers along and away from the shores. In the egg and young of the cod spawning along the southern and western shores

of Iceland a circular current circulating here carried them to the northern shores of the island.

Thus, even in the egg, larval and young stages the dispersal of gadoids away from the spawning grounds takes place. The dispersal of gadoids in their pelagic stages of development does not go beyond the limits of the currents circulating through the spawning grounds. Active migration of the adults greatly broadens the limits of distribution of each species. However, the distributional range of each species of gadoid is determined not only by the migration and ecology of the adult but to a great extent also by the reproductive ecology, which occurs as shown above within narrower limits than those within which a given species could exist outside of the spawning season. The adult stage of many species of gadoid can find suitable conditions for life at great distances from the spawning grounds, but cannot find favorable conditions for breeding and thus are often immediately forced to return for spawning to places which are restricted spatially in comparison with the general range, and after spawning depart again on distant migrations. Examples of this might be *Micromesistius poutassou*, which in the adult stage penetrates into the western part of the Barents Sea, but for breeding is forced to return to a comparatively small area which extends in a narrow strip along the 1,000 meter isobath from Iceland to the Bay of Biscay. It is seen from this example that the broadening of the range of the species from its spawning ground, which we should take as its center, occurs along the paths of currents. Expansion of the range with change in external conditions is generally accompanied by the expansion also in this direction of the spawning grounds. Since the second half of the last century the cod was never found in commercial abundance at the shores of Greenland but during recent years, due to a general warming of the climate and a northward displacement of life zones, the cod began to be caught in great numbers and now stays here the whole year. It is established at present that the spawning of the cod occurs at the western shores of Greenland. Saithe (*Pollachius virens*), which for a long time was never found along the shores of Greenland, appeared during recent years and apparently began to spawn there.

Upon reaching a certain size which varies for each species from a few to 15 cm, the young and yearlings gradually descend to the bottom and, now actively swimming, approach the shores. The length of the pelagic young stage is different for each species and varies from several weeks to several months; in cod, for example, it lasts for an average of 3 months and longer
54 in northern latitudes. The longest this period lasts is in deep-water fishes, although this is not a general rule. The pelagic juvenile phase of one and the same species is much longer in northern breeding regions than in southern.

The young of almost all species of gadoids spend the first years of life along shores at shallow depths. The depth and distance from shore of the place of habitat of the young is different for each species and actually has almost no relation to the depth of the spawning grounds. During the first few years of bottom life the young undertake only limited migrations under the influence of seasonal changes in temperature and in search of food. As they grow the migratory movements of the young ones lengthen, and at the time of attainment of full maturity the extent of the migrations becomes of the normal length for the species.

The time as well as size of attainment of full maturity differs in different species of gadoids. Small species reach sexual maturity fastest—*Eleginus navaga*, *Boreogadus saida* begin to spawn at from two to four years of age. Larger species of gadoids—*Pollachius virens*, *Melanogrammus aeglefinus*, *Gadus morhua*—grow much faster, but reach sexual maturity at much later ages. *Pollachius virens* first begins to spawn at from five to six years of age; *Melanogrammus aeglefinus* at from four to five years of age; different races of *Gadus morhua* at ages from four to fifteen years.

Young gadoids feed on small invertebrate animals. Food of adult gadoids is most varied. Smaller species (*Eleginus navaga*, *Boreogadus saida*) feed on small planktonic and benthic crustaceans and less often on young fish. Larger species of gadoids (*Gadus morhua*, *Melanogrammus aeglefinus*, *Pollachius virens*) feed on echinoderms, mollusks, large crustaceans and fish. The main food of some species (*Gadus morhua*, *Pollachius virens*, and others) is fish.

Commercial Importance

Of all families in the order only the Gadidae are of commercial importance*; the other families have no importance for industry. The gadoids by their role in catches of international fisheries are in the first place after herring. Annual catch of all the gadoid species in recent years reaches on the average over 17,500 thousand metric centners [kilograms]. Not included in this figure is the gadoid catch of the southern hemisphere and the number of species caught in small quantities and not included in the statistics. Our trawling industry during 1934-1938 had caught from 772 to 2,132 thousand metric centners.

Cod has the greatest importance of all species of gadoids, the catch of which in the Atlantic Ocean along the coasts of Europe, Greenland and Newfoundland in recent years exceeds 10 million metric centners (about 10.7 million metric centners in 1933 and 10.4 million metric centners in 1934 not counting the catch of the USSR). Besides, during recent years 1.5 to 2 million metric centners of cod was taken from the Pacific Ocean annually. Thus, cod constitutes on the average about 60-70 % of the total catch of all the gadoids.

55 Second place in the catch belongs to the haddock of which about 2 million metric centners are taken out of the sea annually (about 2.13 million metric centners in 1933 and about 1.8 million metric centners in 1934). Saithe has very great importance, with an annual catch which exceeds 1 million metric centners (about 1.11 million metric centners in 1933 and about 1.2 million metric centners in 1934).

The Pacific species—mintay (*Theragra chalcogramma*) the stock of which is not being sufficiently exploited, is still produced in considerable quantities: in Japan over 900 thousand metric centners are caught.

* Numerical data herein quoted are taken from Bull. Statistique des Pêches Marit. XXII (1933), 1935-XXIV (1934), 1936, Pacific Fisherman (1936) and Canadian Fisheries Manual 1931. Data on catches for the USSR are quoted from information given in the works of N. A. Maslov (1939, 1944) which could not have been used here more fully for reasons indicated in the foreword. The catch of *Theragra* is given according to the data of E. K. Suvorov.

The merlang (*Odontogadus merlangus merlangus*) also has quite an important role in the catch of gadoids. Of this species about 700 thousand metric centners (about 730 thousand metric centners in 1933 and over 715 thousand metric centners in 1934) are caught annually. And finally *Merluccius merluccius* and *Molva molva*, though not playing any role in our economy, as does merlang, hold an important position in the catch of western European countries. Over 400 thousand metric centners (over 445 thousand metric centners in 1933 and about 407 thousand metric centners in 1934) of *M. Merluccius* are caught annually; over 300 thousand metric centners (over 300 thousand metric centners in 1933 and over 350 metric centners in 1934) of *M. molva*.

All other species of gadoids have no appreciable importance in economy and international statistics do not consider them.

Codfishing played an important role in the economy of countries of north-western Europe from very early times. It is known that the cod was the object of fishing even to prehistoric man. At first fishing was done along the shores in places where cod were concentrated at certain times of the year. Trawling originated in western Europe at the end of the 19th century and already in the beginning of this century it was very greatly developed. Russian coastal cod fishing in the Barents Sea began in the 15th century. The only instrument used in cod fishing along the coast until almost recent times was the long-line. The hand-line, which was used in western Murman, was almost unknown in the eastern areas. Cod nets began to come into use only after the October Revolution. Coastal fishing is conducted during spring and summer, a period when the cod come closer to shore. The possibility of trawling cod and haddock in our waters was established by the explorations of the Murman Scientific Fishery Expedition; however, this type of fishing was not adopted by the Russian fishermen. Only hand-lines were widely used along the coast. Results of the investigation of the Murman Scientific Fishery Expedition were utilized by foreigners, at first the English and Germans (Knipovich, 1914:35; Maslov, 1944:18,19). The Russian trawling industry, until the October Revolution, was nonexistent in the Barents Sea, if we do not include several separate experiments in trawling. The Soviet trawling industry originated after the end of the Civil War, and in 1919-1924 the number of trawlers reached 11, catching primarily along the Kanin shores and along the shores near the Murman coast. In 1925, with the transfer of the trawling base from Arkhangel'sk to Murmansk, Soviet trawlers began to fish the year round, their number increasing to 17, and by 1933 to 60, and the extent of the industry had extended to all industrial regions of the Barents Sea. Cod appears to be the main object of the Soviet trawling industry (46-78% of trawling catch in 1922-1933). British and German trawlers in the Barents Sea during this period were catching a somewhat smaller number of cod than of haddock. From 1925 the catch of the Soviet trawlers exceeded the catch of British trawlers in the Barents Sea, excluding the catches of the latter on the Bear Island-Spitzbergen Bank; from 1937 the catch of Soviet trawlers exceeded British catches in the Barents Sea, also including the catches on these forementioned banks. Catches of German trawlers in the Barents Sea, together with the catches from the Bear Island-Spitzbergen Banks, became less than the Soviet ones beginning in 1932. In the Far Eastern seas our trawl catch began in 1929. The trawler fleet of the USSR in the period from 1934 to 1938

had fished from the Barents Sea from 772 (1934) to 2,132 (1937) thousand metric centners. The bulk of this catch (87.2 to 95.0%) was cod and haddock. In our fishery, as in international fisheries, in first place by catch is cod, which in the Barents Sea from 1930 to 1938 constituted from 47.5 to 85.1% of the total catch of the trawling fleet. The total catch of the cod in the period of time from 1934 to 1938 varied from 558 (1934) to 1,750 (1937) thousand metric centners. In second place in our gadoid fishery is haddock which during the period 1930 to 1938 represented 6.3 to 37% of the total catch of the trawling fleet. The total catch of haddock from 1934 to 1938 was from 84 (1935) to 770 (1938) thousand metric centners (Maslov, 1939). The saithe was caught in our waters in lesser quantities. The Alaskan pollock, caught in considerably great quantities in Japan, is hardly ever used by our fisheries.

Both species of navaga have somewhat greater industrial importance. The catch of navaga from 1936 to 1941 varied from 11.6 (1920) to 24.0 (1930) thousand metric centners. The Far Eastern catch of navaga (vahrga) was over 16,000 metric centners. The catch of burbot during these years varied from 16.7 (1941) to 18.76 (1937) metric centners.

To the gadoids which are totally unused in industry but which are found in considerable numbers we may refer the Polar cod or saika (*Boreogadus saida*) which plays an important role in feeding of marine mammals.

From by-products of the gadoid industry we must first indicate cod liver oil which, because of the high vitamin content, has great application in medicine. Cod heads are used in the preparation of fish meal. The skin is also removed from large fishes and processed.

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SYSTEMATIC PART

Order GADIFORMES (*ANACANTHINI* ex parte)

Olfactory nerves short, olfactory lobes lying close to nasal capsules (except in *Raniceps*, which has olfactory nerves slightly elongate and, owing to this, olfactory lobes lie between the nasal capsules and the fore-brain), connecting with the forebrain by means of long olfactory tracts. Olfactory nerves and tracts are arranged in a special canal - a continuation of the cranial cavity over the interorbital septum and are thus separated from the optic nerves. Orbitorostral portion of skull longer than or equal (in some *Moridae*) to the rear portion. Basisphenoid and orbitosphenoid absent. Myodome absent. Opisthotic exceptionally well-developed, pierced by foramen for the glossopharyngeal nerve, its rear end partially encroach on the foramen of the vagus nerve, and beneath it contacts the basioccipital separating the prootic from the exoccipital. Supraoccipital well-developed with a longitudinal crest along its entire length or over the posterior portion only, in contact with frontals separating the right and left parietals. The pectoral girdle is attached to the skull; mesocoracoid absent; scapular foramen between scapula and coracoid, pectoral radials 4-13. Pelvic bone behind pectoral symphysis, loosely attached to it by a ligament. Vertebrae numerous, first two without parapophyses, ribs and epipleurals, the rest 2-4 also without parapophyses, but with sessile ribs and epipleurals; all the remaining precaudal vertebrae with well-developed parapophyses to which are attached ribs and epipleurals, with the exception of *Merluccius* in which the first 5-6 vertebrae are similar to those in all other gadoids, but the next one with rudimentary parapophyses, ribs and epipleuralia, and all the remaining precaudal vertebrae with greatly expanded parapophyses, but without ribs and with epipleurals only on the anterior 3-4 vertebrae. A neural spine of the first vertebra is firmly attached to the supraoccipital crest. Four gills, a slit behind the fourth, pseudobranchiae absent, gill opening wide, gill membranes free or narrowly attached to the isthmus; 6-8 branchiostegal rays. All fins spineless, 1-3 dorsal fins, 1-2 anal fins - caudal fin separated from dorsal and anal, rarely partially or completely fused (in *Muraenolepidae*) to them, diphycercal*, pelvic fins anterior to pectorals. Body and part of the head covered with small cycloid scales. Chin usually with a barbel. Swimbladder without a pneumatic duct, sometimes rudimentary. Puloric caeca numerous, seldom singular or absent.

* To be more correct pseudocaudal (see page 7).

The order is more sharply defined after separating off the family Macruridae, and consists of the families Muraenolepidae, Moridae, Bregmacerotidae, Gadidae.

Measurements of representatives of the order Gadiformes were taken according to the generally accepted method used by V. S. Mukhin for cod, in which not all measurements were taken but just the following (fig. 9): a-b - total length; a-c - length of body to the end of the scale cover; a-d - anteanal distance; a-e - antedorsal distance; f-f' - length of pectoral fin; g-g' - length of pelvic fin; e-e' - length of base of first dorsal fin; h-h' - length of base of second dorsal fin; i-i' - length of base of third dorsal fin; d-d' - length of base of first anal fin; j-j' - length of base of second anal fin; k-k' height of first dorsal fin; l-l' - height of first anal fin; m-c - length of caudal peduncle; a-o - length of head; a-p - length of snout; p-p' - horizontal diameter of eye; q-q' - length of upper jaw; r-r' - length of lower jaw; s-s' - length of barbel. In addition considerable importance is attached to the distance between the first and second dorsal fins (e'-h), the second and third dorsals (h'-i) and between both anal fins (d'-j).

The body depth is important but highly unreliable as a character in the gadoids, depending to a great degree on the fullness of stomach, and therefore it has not been measured.

The body depth beyond the pelvic fins is more independent of the degree of fullness of stomach, as indicated by N. B. Evropeitseva. Almost equally the distances from pectoral and pelvic fins to the anal fin are dependent upon the degree

FIGURE 9. Scheme of measurements of the gadoid fishes. Explanations in the text.

of fullness of the stomach and maturity of the sexual products. These measurements were also excluded from this study. In species with less complicated fins, the measurements are considerably simplified.

In view of the fact that misunderstandings often arise due to differences in measurements it is necessary here to clarify some of them. The length of the body was measured from the tip of the snout (if lower jaw projects then the measurement was taken from its tip) to a line connecting the tips of the lobes of the caudal fin when the rays are pressed straight back. This length is considered basic and if body length is mentioned then this particular measurement is meant. The length of the pectoral fin was measured from the base of its first ray to the tip of the fin. As for the length of the pelvic fin it is taken from the base of the first ray to its tip. In some cases it is very important to measure, in addition to the length of the pelvic fin, the distance to the tip of the longest ray (second ray); but the length of the pelvic fin is always taken to be the length to the end of the first ray and in such cases where it is not particularly specified, this length is meant. The height of the first dorsal and first anal fins were taken at the longest ray, with the exception of cases where this ray in the dorsal fin (in some species of *Phycis* and *Urophycis*) is very elongated like a thread. In such cases the height of the fin is accepted as the length of the longest ray which is not threadlike and the elongate ray was measured separately. For length of caudal peduncle the distance from the posterior end of the last dorsal or anal fin to the end of the scale cover (the end of scale cover in cod is distinctly visible) is accepted. For the depth of caudal peduncle the least depth of that part of the body (in *Lotinae*) of the depth of the caudal peduncle at the end of the last dorsal or anal fin is accepted. The head length was measured from the tip of the snout (if lower jaw is projecting forward, then from its tip) to the spinelike end of the operculum. The membrane, which embraces the gill cover, was not taken into consideration. Width of the interorbital space is taken as the least bony width of the skull in the interorbital area while the fleshy covers were not measured. N. B. Evropeitseva recommends measuring in addition to those above, the length of the caudal portion of the body from the vertical of the posterior end of the first anal fin to the end of the scale cover.

All body measurements are expressed as percentage of length of body* (to ends of the lobes of the caudal fin), and those of the head - as percentage of head length.

In counting the number of rays in all unpaired fins with the exception of the first dorsal, the membrane at the base of the beginning and end of each fin must be cut, as otherwise a few rays concealed in the membrane and skin cover will remain uncounted. Gill-rakers were counted in the outer row of the first gill arch and all gill-rakers were counted including rudiments. All vertebrae were counted including the last, to which the middle rays of the caudal fin are directly connected.

For the explanation of parts of the skull mentioned in descriptions, see Figure 5 and pages 22-26 of the introduction. The processes of the hyomandibular were named here as follows (Figure 10): the articular process by which

* It would have been more correct and exact to express these measurements in terms of percentage of body length to end of scale cover, as M. E. Markun does for the burbot, but as long as everyone accepts the percentages of total length of the body, we feel that we should not upset this generally accepted rule.

this bone is joined to the skull; the opercular process to which is joined the operculum; the preopercular process to which is attached the praeoperculum; the lower process to which are attached from beneath the symplectic and stylohyale. The pores of the canals of the lateral line system distributed on the head and having very important systematic significance are described in the diagnoses for the preoperculo-mandibular canal, infraorbital canal, commissure and supraorbital canal. The number of pores in the supratemporal portion and cephalic portion of the lateral line are constant and therefore 65 were not counted.

FIGURE 10. Processes of the hyomandibular of *Gadus morhua*.

a-articular; b-opercular; c-preopercular; d-lower.

At present there are a great number of papers with detailed descriptions of the skull of various species of gadoids and there is no need to give a general description of the skull of the Gadidae. Therefore, attention was directed chiefly to those characteristics of skull structure which have significance in the classification or distinction between genera and species of gadoids. With the same point in view there were selected and here briefly described several bones of the visceral skeleton, gill cover and girdle of the paired fins, drawings of which could be of great help in studying the feeding of fish. However, one must bear in mind that almost all of the bones of the visceral skeleton vary within considerably broad limits. The drawings of the vertebral columns may be useful in studying fossil fishes where great importance is attached to the neural spines, and transverse processes and haemal arches, the dimensions and forms of which sharply distinguish the species and genera of gadoids. Ribs and epipleuralia are not indicated in these drawings as they are weakly attached to the vertebrae and usually fall off when the muscles are removed.

The osteology of some species (*Melanogrammus aeglefinus*, *Eleginus navaga*, *E. gracilis*, *Boreogadus saida* and especially *Gadus morhua morhua*) have been studied from several tens of skeletons. A number of species (*Gaidropsarus mediterraneus*, *Raniceps raninus*, *Phycis phycis*, *Urophycis regius*, *U. brasiliensis*, *Lota lota lota*, *Molva molva*, *M. dipterygia elongata*, *Merluccius merluccius*, *Trisopterus minutus*, *capellanus*, *Odontogadus merlangus euxinus*, *Gadus morhua morhua n. hiemalis*, *G. morhua maris-albi*, *G. morhua macrocephalus*) were studied from 2, 3, 4 or more skeletons. The remaining scarcer species were studied from one skeleton.

The number of specimens studied is indicated in parentheses after the description of each species; such indications are absent if the number of specimens examined was more than ten.

Key to the Families

- 1 (2). Caudal fin connected with dorsal and anal fins. Pectoral radials no less than 10. (Suborder Muraenolepidoidei) 1. Muraenolepidae
- 2 (1). Caudal fin separated from dorsal and anal fins, rarely partially connected. Pectoral radials 4-6. (Suborder Gadoidei)
- 66 3 (4). Swimbladder in contact with the auditory capsules through the fontanelles in the lateral occipitals at the rear of the skull*. Neurocranium almost closed anteriorly, olfactory canal and partly the interorbital septum are bony. The head of the vomer often toothless. , Deepwater fishes. 2. Moridae
- 4 (3). No fontanelles behind the skull in the lateral occipitals, the swimbladder not in contact with the auditory capsules. Neurocranium widely open anteriorly, interorbital septum and canal of the olfactory nerve membranous. The head of the vomer is always toothed. Fish of usually moderate depths.
- 5 (6). First dorsal fin at the nape consisting of only one long slender ray. Orbitorostral portion of skull equal to the rear portion. Olfactory nerve canal wide, almost equal in width to the neurocranium. 3. Bregmacerotidae
- 6 (5). First dorsal fin posterior to head, generally of normal structure, seldom consisting of one ray. Orbitorostral portion of skull much longer than posterior portion. Olfactory nerve canal narrow. 4. Gadidae

Suborder ***MURAENOLEPIDOIDEI***

Pectoral radials 10-13. Gill openings narrow, extending upwards only to the level of the pectoral bases. Scales oblong and arranged at angles to each other. Caudal fin connected with a second dorsal and anal.

1. Family ***MURAENOLEPIDAE***

Muraenolepidae Regan, Ann. Mag. Nat. Hist., (7), XI, 1903: 460; Svetovidov, Dokl. Akad. Nauk, XXIII, 6, 1939: 583.

Orbitorostral portion of skull longer than rear portion. Lower portion of canal for olfactory nerves, and interorbital septum membranous. Neurocranium widely open anteriorly, without fontanelles in the auditory region of the

 * This is very easy to discover when one lifts the gill cover and makes a lateral incision above the gills along the base of the skull. A horn-like process of the swimbladder is seen in the Moridae, and if this is lifted up a fontanelle can be seen. Continuing the incision forward, under the eye, it can be established whether there is bone or membrane in the lower part of the canal over the interorbital septum.

skull in the lateral occipitals. Swimbladder small, thick-walled, arranged in the rear of the body cavity beginning approximately in the middle and lacking any horn-like processes anteriorly, not being in contact with the auditory capsules. Basioccipital lacking facets for attachment of muscles on the underside. Head of vomer without teeth. Frontals fused into a single unpaired bone. Pyloric caeca absent. Two dorsal fins and one anal fin, first dorsal fin consisting of only one ray. A barbel on the chin.

Genus *Muraenolepis* with 3 marine species in the southern hemisphere.

Suborder *GADOIDEI*

Pectoral radials 4-6. Gill openings wide, extending above the base of the pectoral fins. Scales normal. Caudal fin separate from dorsal and anal fins, seldom partially fused.

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2. Family **MORIDAE**

Gadidae (ex parte) auctorum. - Gadidae (ex parte) Erethmophoridae Jordan, *Classif. fish.*, 1923:163. - Moridae Svetovidov, *Izv. Akad. Nauk SSSR, biol.*, 4, 1937:1286.

Orbito-rostral portion of skull somewhat longer than or equal to the posterior portion. Neurocranium opens in front only with a narrow opening, almost closed by the enlargement and fusion of the parasphenoid with the frontals. Canal of the olfactory nerves and partly the interorbital septum bony. A large membrane-covered fontanelle in the neurocranium posteriorly in the lateral occipitals on each side of the foramen magnum. The swimbladder in contact with auditory capsules (Figure 3) by means of two long horn-like processes with thickened tips which are tightly pressed against the fontanelle membranes in the lateral occipitals. Posterior part of swimbladder tightly embraced by the ribs. Each of the swimbladder horns has a muscle fastened to a special process on the lower part of the basioccipital and to the supracleithrum. Head of vomer toothless or with minute teeth, rather broad and flat, on the underside. 1-2, more seldom 3, dorsal fins and 1, or more seldom 2, anal fins. Deep-water fishes.

About 17 widely distributed deep-water genera: *Brosmiculus* (2 species), *Melanonus* (3 species), *Algoa* (1 species), *Uraleptus* (1 species), *Austrophycis* (1 species), *Physiculus* (20 species), *Lottela* (8 species), *Salilota* (2 species), *Hypsirhynchus* (1 species), *Lepidion* (=Haloporphyrus) (10 species), *Microlepidium* (2 species), *Laemonema* (9 species), *Laemonemodes* (1 species), *Antimora* (5 species), *Halargyreus* (3 species), *Mora* (1 species), *Tripterygion* (1 species).

At present within the limits of the USSR only one species each of the genera *Laemonema* and *Antimora* is found.

COMPARATIVE NOTES. Genera and species of the family Moridae have been little studied, owing mainly to their rare occurrence. Some species are known only from one specimen, very few from several, and only a few from many specimens. Because of this the osteology not only of most species but even of all the genera of the family is unstudied. At present we may say with assurance that only the following genera belong to the family Moridae: *Uraleptus* (*U. maraldi* Risso studied in detail*), *Physiculus* — (*Ph. japonicus* studied in detail and *Ph. dalwigkii* Kaup in part**), *Lotella* (*L. phycis* Temminck and Schlegel was studied in detail and *L. maximowiczii* Herzenstein in part), *Lepidion* (*L. inosimae* Günther and *L. schmidtii* Svetovidov studied in detail), *Laemonema* (*L. longipes* P. Schmidt studied in detail), *Mora* (*M. mediterranea* Risso was partially studied from a specimen and also from photographs of the skull), *Antimora* (*A. microlepis* Bean studied in part). Undisputed membership in the family Moridae has not yet been established for the genera *Brosmiculus*, *Melanonus*, *Algoa*, *Salilota*, *Microlepidium*, *Laemonemodes*, *Halargyreus*, *Tripterophycis* and *Hypsirhynchus*. These genera resemble those genera which undoubtedly belong to the family Moridae in their broad almost cosmopolitan distribution. The genus *Algoa*, known only from a single specimen, was very poorly described and never again found by anyone else; the species *A. viridis* Castelnau, 1861 (mouth of Zwartkops River, Algoa Bay, South Africa) is doubtful and possibly does not belong to the Gadiformes. The genus *Strinsia* (*S. tinca* Rafinesque, 1880 [1810], Sicily) described very inadequately from a badly preserved specimen, and perhaps erroneously, has not been found since its description and is never mentioned by modern faunistic workers. The following are referred to the genus *Physiculus* (in table 1), following Norman's (Discovery Reports XVI, 1937), *Leptophycis filifer* Garman (= *Physiculus rastrelliger* Gilbert), *Pseudophycis peregrinus* Günther (= *Physiculus peregrinus*), *Lotella marginata* Günther (= *Physiculus marginatus*). *Physiculus rhacinus* Forst, following Norman, is referred to the genus *Lotella*. The genus *Eretmophorus* (*E. kleinenbergi* Giglioli, 1889, Messina) turned out to be the young of *Lepidion lepidion* (Risso) (D'Ancona, Arch. Zool. Ital, XV, 1930:297). The genus *Melanosoma* Barnard (Ann. S. Afr. Mus., XXI, 1925:331), is considered identical with *Melanonus*, while some authors (Jordan, Gilbert and Hubbs and others) referred the latter to the family Gadidae, and others (Regan) to the family Macruridae. The genus *Pteridium*, usually Gadidae, should be placed in the family Macruridae because the olfactory lobes are placed near the forebrain and opisthotic is greatly enlarged.

Key to the Genera

- 1 (2). Ventral fins consist of only two elongated rays and of one rudimentary ray 1. *Laemonema* Günther
- 2 (1). Pelvic fins of normal structure, consisting of approximately 6 rays 2. *Antimora* Günther

* The skeleton and the structure of the swimbladder were studied.

** In partially studied species of which only single specimens are in the collection of the Zoological Institute of the Academy of Sciences, the presence of the fontanelles in the posterior portion of the skull and the connection of the swimbladder with the auditory capsules was ascertained.

1. Genus **LAEMONEMA** GÜNTHER

Laemonema Günther, Cat. fish., IV, 1862:356 (Type: *Phycis yarrellii* Lowe).

Two dorsal and one anal fin, second dorsal and anal long, with no fewer than 40 to 50 rays; rays of middle part of both fins are sometimes shortened to form a notch. Each pelvic fin consists of two long thread-like rays and one rudimentary ray. The mental barbel present or absent. Teeth on premaxillary, on dentary and weak on the head of vomer. Lateral line slightly curved, continuous to the caudal peduncle and apparently beyond. Pores are present on the head.

Nine species at depths of the Pacific and Atlantic Oceans. In our waters one species.

*1. *Laemonema longipes* P. Schmidt (Table XX).

Laemonema longipes P. Schmidt, Dokl., Akad. Nauk, Nov. Ser. XIX, 8, 1938:653 (Okhotsk Sea).

69 I D 6, II D 50-52, A 45-46, gill-rakers 19-20. Lower jaw slightly projecting. Pelvic fins long, reaching beyond the beginning of the anal fin, extending posteriorly approximately one-third of its length. In percentage of body length: anteanal distance 31.1-33.5, antedorsal distance 22.1-22.7, length of pectoral fin 18.5-18.6, length of pelvic fin 30.6-33.6, length of base of first dorsal 4.6-4.9, length of base of second dorsal 55.9-58.2, length of base of anal fin 51.4-53.2, height of first dorsal fin 6.1-6.3, depth of caudal peduncle 1.1-1.3, its length 5.3-6.3, the length of head 19.8-20.1. In percent of head length: length of snout 32.9-36.0, diameter of eye 19.1-19.8, length of upper jaw 43.5-44.0, length of lower jaw 52.4-55.1, interorbital space 19.3-21.2. Coloration of upper part of body brownish; head, sides of body and belly silvery (3 specimens).

It is distinguished from the nearby allied *L. gracilipes* Garman by larger scales, smaller eyes, much longer pectoral and pelvic fins and smaller number of rays in the second dorsal and anal fins.

DISTRIBUTION. Sea of Okhotsk. Known only from a few specimens (4 specimens from two nearby localities: 55° 42' north latitude, 143° 34' east longitude, depth 542 meters; 55° 13' 30" north latitude, 146° 34' east longitude, depth 592 meters; two specimens from the western shores of Kamchatka).

BIOLOGY unknown.

2. Genus **ANTIMORA** GÜNTHER

Antimora Günther, Ann. Mag. Nat. Hist. (5), II, 1876:2 (Type: *A. rostrata* Günther)

Two dorsal and one anal fin, second dorsal long, with more than 50 rays, anal fin with more than 40 rays, both with a deep notch in the middle, first ray of first dorsal fin elongated, thread-like. Pelvic fins of normal structure, containing about six rays. A well-developed barbel on the chin. Snout

flattened, projecting forward above the jaws. Teeth on premaxillary and dentary, small patch of weak teeth on vomer. Lateral line slightly curved, continuous for almost its entire length, interrupted only beyond the middle of the anal fin. There are pores on the head.

Five species from the depths of the Atlantic and Pacific Oceans. In our waters only one species.

*1. *Antimora microlepis* Bean (Table XVIII).

Antimora microlepis Bean, Proc. U. S. Nat. Mus., XIII (1890), 1891: 38 (51°00'23" N, 130°34'W); Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898: 2545 (distribution); Franz, Abh. Math.-phys. Cl. Bayer. Akad. Wiss., Suppl. Bd. IV, 1910: 29 (Misaki); Gilbert a. Burke, Fish. Bering Sea a. Kamchatka, (1910), 1912: 90 (Avachin Lip); Schmidt, Trans. Pacif. Committ., II, 1931: 151 (Misaki).

ID 4, II D 52, A 41, gill-rakers 15. Percentages of body length: ante-anal distance 58.8, antedorsal 21.1, length of pectoral fin 16.7, length of base of first dorsal 3.3, length of base of second dorsal 57.5, length of base of anal 31.5, elongate ray of first dorsal fin 26.4, depth of caudal peduncle 2.7, its length 7.3, head length 23.2. Percentages of head length: length of snout 30.0, diameter of eye 25.6, length of upper jaw 42.4, length of lower jaw 49.8, interorbital space 20.7, length of mental barbel 10.8 (1 specimen).

DISTRIBUTION. The Pacific Ocean off the coast of North America from Queen Charlotte Island to California, along the Asiatic coasts from Avachinsky Bay, at the shores of Japan (Misaki).

BIOLOGY not studied. All known specimens were caught at great depths.

3. Family **BREGMACEROTIDAE**

Bregmacerotidae auctorum.

70 Orbito-rostral part of skull equal to the posterior part. Neurocranium broadly open in front, without fontanelles posteriorly in the lateral occipitals. Interorbital septum and canal of olfactory nerves are membranous below, canal of olfactory nerves broad, slightly narrower than the cranial cavity and much broader than in the Gadidae. Sacculus of large dimensions. Swimbladder of small size, thin walled, not in contact with the auditory capsules. Basioccipitals lacking ventral processes for attachment of muscles. Vomer with few teeth. Two dorsal fins and one long anal fin: First dorsal fin consists only of one elongated and slender ray arranged on the supraoccipital, second dorsal and anal fins with a large notch in the middle almost separating each into two fins. Pelvic fins elongate, consisting of five rays. Pyloric caeca few in number. No barbel below the chin. Small fishes of tropical seas, leading a pelagic mode of life on the surface, and apparently reaching great depths (500 meters and deeper).

The genus *Bregmaceros* Thompson (= *Calloptilum* Rich. = *Asthenurus* Tickell) with 2 or 3 species in tropical parts of the Atlantic, Indian and Pacific Oceans. The genus *Auchenoceros* Günther apparently belongs to the same family.

4. Family **GADIDAE** - CODS

Gadidae (ex parte) + Merlucciidae Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898:2528, 2531. — Gadidae (ex parte) Regan, Ann. Mag. Nat. Hist., (7), XI, 1903:460. — Gadidae (ex parte) + Gaidropsaridae + Merlucciidae Jordan, Classif. Fish., 1923:163. — Gadidae Svetovidov, Izv. Akad. Nauk SSSR, Biol., 4, 1937:1286; Berg, Classification of Fishes, 1940:285.

Orbito-rostral part of skull much longer than the posterior part. Canal of the olfactory nerves and interorbital septum membranous. Neurocranium broadly open in front, without fontanelles in the auditory region in the rear of the skull and in the exoccipitals. Swimbladder with short horn-like processes anteriorly, not in contact with the auditory capsules through fontanelles. Basioccipital lacks ventral processes for muscle attachments. Head of vomer always with teeth. One-three dorsal and one-two anal fins.

Twenty-two genera in Arctic and boreal parts of the northern hemisphere, some species in the southern hemisphere.

This family, according to certain important structural characteristics of the adults, larvae and eggs, is divided most naturally into three subfamilies: Lotinae, Merluccinae and Gadinae.

COMPARATIVE NOTES. The subfamily Lotinae in many morphological characteristics appears to be more primitive than the subfamily Gadinae. Many genera of this subfamily are separated from each other much more distinctly than those genera of the subfamily Gadinae. Within the subfamily Lotinae several groups of morphologically related genera can be indicated:

1) Brosme, 2) Gaidropsarus, Ciliata, Enchelyopus, 3) Raniceps, 4) Phycis, Urophycis, 5) Lota, Molva. Some authors consider these groups or part of them as subfamilies or even families. Of all groups in the subfamily Lotinae, the most divergent is Raniceps, in which the olfactory lobes are somewhat shifted from the nasal capsules to the forebrain, and the olfactory nerves are elongated owing to the lateral expansion of the skull and formation of cartilage in the anterior part of the canal above the interorbital septum. In addition, the upper expanded part of the post-cleithrum is a separate bone. In all other respects Raniceps does not differ from the other Lotinae, and therefore there is no reason to separate it as an independent family or even a family. And there is still less reason for segregating as an independent family or even subfamily the genera Gaidropsarus, Ciliata, and Enchelyopus, which have no noteworthy distinctions whatsoever.

Most naturally, according to the morphological peculiarities of the adults as well as the larvae and eggs, the Gadidae falls into the subfamilies Lotinae and Gadinae. The subfamily Merlucciinae appears to be in the main one of the groups of the subfamily Lotinae but distinctly diverges in some characters (the structure of the mucous canals on the head, absence of pores and genipores) which place it near the family Macruridae; in a number of characters this subfamily appears to be transitional between the subfamilies Lotinae and Gadinae.

Key to the Genera

- 1 (20). One or two dorsal fins and one anal fin. Frontals paired in all with the exception of *Phycis* and *Urophycis*.
- 2 (19). Parapophyses not widened, bearing ribs and epipleurals. Mucous cavities and crests over the lateral line canals on top of the head are normal. Barbel below the chin present. (Subfamily *Lotinae*).
- 3 (4). One dorsal fin, long, partially fused with the caudal and anal fins 1. *Brosme* (Cuvier) Oken
- 4 (3). Two dorsal fins.
- 5 (10). First dorsal fin consisting of only one ray, in the rear of which are placed numerous short and slender soft rays in a groove. Besides the barbel on the chin, there are several barbels on the snout.
- 6 (9). No more than three barbels on snout. Skull narrow, its width contained about twice in length.
- 7 (8). Two barbels on snout. Head of vomer considerably enlarged, pointed anteriorly. 2. *Gaidropsarus* Rafinesque
- 8 (7). Three barbels on snout, one at each nostril and one at the tip of the snout. Head of vomer small, its apex rounded 4. *Enchelyopus* Bloch et Schneider
- 9 (6). No less than 4 barbels on snout. Skull broad, its width no more than 1.5 times in its length
- 10 (5). First dorsal fin with more than one ray, no furrow with free filamentous rays posterior to the fin. No barbels on snout.
- 11 (12). First dorsal fin of only three rays. Head and body strongly depressed from top to bottom. Skull broad, almost as wide as long. 5. *Raniceps* (Cuvier) Oken
- 12 (11). First dorsal fin with more than 3 rays. Body not depressed dorso-ventrally.
- 13 (16). Pelvic fins of only two greatly elongated rays and one rudimentary ray. Head of vomer of normal size.
- 14 (15). Opisthotic with a large process posteriorly for the articulation of the pectoral girdle; posttemporals and supracleithrum normally* developed 6. *Phycis* Rose
- 15 (14). The processes posterior to the opisthotic for the articulation of the pectoral girdle not developed, the posttemporals and supracleithrum minute. 7. *Urophycis* Gill
- 16 (13). Pelvic fins of normal structure, consisting of more than three rays, and not greatly elongated. Head of vomer greatly enlarged, ends extending out in horseshoe shape.
- 17 (18). Teeth in jaws and head of vomer feeble, bristle-like. A short barbel on each side at the anterior nostrils. A deep notch for the facial nerve on the side of the skull. Freshwater. 8. *Lota* (Cuvier) Oken
- 18 (17). Teeth in jaws and head of vomer strong, canine. No barbels at the anterior nostrils. A foramen on side of head for the facial nerve. Marine. 9. *Molva* Fleming

 * This can be established by removing the skin covering and muscles from one side of the body immediately behind the head on top.

- 19 (2). Parapophyses expanded. A large triangular recess on top of skull bordered with crests which diverge from the longitudinal crest of the posterior part of the supraoccipital. Second dorsal and anal fins with a notch posteriorly. No barbel on chin. (Subfamily Merlucciinae) 10. *Merluccius* Rafinesque
- 20 (1). Three dorsal and two anal fins. Frontals fused into one unpaired plate. (Subfamily Gadinae).
- 21 (27). First anal fin long, beginning under first dorsal or even anterior to it, its length considerably more than half of the anteanal distance.
- 22 (42). Origin of first anal fin under the first dorsal. Interspaces between dorsal fins less than the diameter of the eye.
- 23 (26). Anal fins usually in contact. A black spot at the base of the pectoral fin, sometimes very faint in alcohol-preserved specimens.
- 24 (25). Dorsal fins in contact, less frequently separated by narrow interspaces. Barbel below the chin well developed, its length no less than half the diameter of the pupil. A foramen at the side of the skull for facial nerve 11. *Trisopterus* Rafinesque
- 25 (24). Dorsal fins with narrow interspaces. Mental barbel rudimentary or absent. Notch on side of skull for facial nerve
. 12. *Odontogadus* Gill
- 26 (23). Dorsal and anal fins with small interspaces. No black spot at base of pectoral fin 13. *Pollachius* (Nilsson) Bonaparte
- 27 (21). First anal fin short, no more than half of the anteanal distance*, its origin posterior to the first dorsal fin.
- 28 (34). Mucous cavity on skull closed in front**. Pores on head along the lateral line canals.
- 29 (32). Upper jaw projecting.
- 30 (31). Lateral line dark, extends without interruption to the caudal fin, a large dark spot across it beneath the first dorsal. Jaws shortened, length of lower jaw no more than twice the caudal peduncle depth. Bones of pectoral girdle swollen and ivory-like.
. 14. *Melanogrammus* Gill
- 31 (30). Lateral line light, continuous to the middle or end of the third dorsal fin, discontinuous beyond; no dark spot on side of body. Length of lower jaw more than twice the depth of the caudal peduncle. Bones of pectoral girdle normal. 15. *Gadus* Linne
- 32 (29). Lower jaw projecting. Barbel below the chin scarcely developed or absent.
- 33 (41). Barbel below the chin not developed. Large, broad, open mucous cavities† on the head. Suboperculum and postcleithrum not swollen and ivory-like. Small fish
. 16. *Gadiculus* Guichenot
- 34 (28). Mucous cavity on skull not closed in front. Pit organs on the head only.

* With the exception of *Microgadus proximus*, in which the length of the first anal fin equals or slightly exceeds half of the anteanal distance, the origin of first anal fin is slightly behind or under the end of the first dorsal.

** This can be established by touch or slightly removing the skin covering.

† On intact specimens of *Gadiculus*, as in a group of other species, there are pores on the head. However, uninjured specimens of *Gadiculus* are seldom caught, usually at the raising of the trawl from the depths the skin cover of the head tears, opening the mucous cavities

- 73 35 (38). Lower jaw not projecting, caudal fin truncate or slightly forked. Lateral line continuous to the beginning of the second or the end of the third dorsal fin, interrupted beyond. No transverse crests on the skull behind the mucous cavity.
- 36 (37). Lateral line continuous to the end of the third dorsal fin, parapophyses not swollen at their tips 17. *Microgadus* Gill
- 37 (36). Lateral line continuous only to the origin of second dorsal. Parapophyses swollen at their tips* . . . 18. *Eleginus* G. Fischer
- 38 (35). Lower jaw projecting or as long as upper jaw. Caudal fin strongly forked. Lateral line continuous throughout entire length. Small transverse crest on skull behind mucous cavity on each side.
- 39 (40). No palatine teeth. Mental barbel hardly developed, its length less than diameter of pupil 19. *Boreogadus* Günther
- 40 (39). Strong teeth on palatine. Mental barbel no less than diameter of pupil 20. *Arctogadus* Drjagin
- 41 (33). Mental barbel weak but present. Normal mucous pores on the head. Suboperculum and postcleithrum greatly swollen and ivory-like. Large fish 21. *Theragra* Lucas
- 42 (22). Beginning of first anal fin in advance of first dorsal fin. Interspace between first and second dorsal fins no less than diameter of eye, interspace between second and third dorsal fins exceeds the base of the first dorsal 22. *Micromesistius* Gill

1. Subfamily **LOTINAE**

One or two dorsal fins and one anal fin, second dorsal long. Caudal fin rounded, generally in contact with the anal and dorsal, less frequently separated by a narrow space or partly fused. Frontals paired in all with the exception of *Phycis* and *Urophycis*. Parapophyses not enlarged, ribs and epipleurals present. Pelvic fins in the larvae consist of only three rays and in the majority greatly elongated. Eggs in all with an oil droplet.

1. Genus **BROSME** (CUVIER) OKEN

"*Les brosmes*" Cuvier, *Règne animal*, ed. I, II, 1817:216 (Type: *Gadus brosmæ* Müller). — *Brosme* Oken, "*Isis*," 1817:1182 (Type: *B. brosmæ*, secundum Cuvier). — *Brosmus* Stark, *Elem. Nat. Hist.*, I, 1828:425 (Type: *B. brosmæ*). — *Brosmius* Cuvier, *Règne animal*, ed. II, II, 1829:334 (Type: *B. brosmæ*).

* This is noticeable on the sides of the body by touch.

One long dorsal and one anal fin, partly fused with the caudal fin, lower jaw equal to upper. A well-developed barbel on chin approximately equal
74 in length to diameter of eye. Well-developed teeth in several rows on pre-maxillaries, dentaries and on the entire well-developed head of the vomer. Lateral line in anterior part of the body nearer the dorsum, in the form of a gently arched curve, beyond the middle of the body straight for its entire length, discontinuous only on the caudal peduncle. On the head, 12 pores in the preoperculo-mandibular canal, 9 pores in the infraorbital canal, 1 pore in the commissure and 3 pores in the supra-orbital canal. Mucous cavity small and almost closed in front. Facial nerve passes through the foramen on the side of the skull.

Skeleton. Skull not high (A)* its height contained slightly more than three times in its base. Lower surface of bones of the base of the skull in a straight line, from which protrudes down the well-developed head of the vomer. Upper profile of skull straight with a slight curvature in the middle. The crest on the frontal and on the anterior part of the supraoccipital between the parietals is absent, developed only in the posterior part of the supraoccipital above the lateral occipitals, extending back farther than the posterior end of the basioccipital. Anterior edge of mesethmoid straight, without a notch, descending steeply, placed at a sharp angle to the upper edge. Orbital space not too high, less than 3 times in its base. Facial nerve emerges from the skull through a foramen limited in front by the processes of the parasphenoid, frontal and prootic. Foramen of the glossopharyngeal nerve on the opisthotic is hardly developed. Skull from above (B) quite broad, the greatest width is contained almost twice in its base. Lateral edges of skull present wavy lines gradually converging forward. Lateral edges of pterotics rounded at ends with a slight concavity in the middle. Edges of the frontals serrate in the middle, without noticeable notches in the interorbital region. Lateral ethmoids about as long as they are wide, extending considerably laterally from under the forward edges of the frontals and extending to a greater degree in front. Anterior edge of vomer extends considerably from beneath the anterior edge of the mesethmoid. The crests above the canals of the lateral line on the pterotic and frontal are not too wide, and are tightly adherent to these bones. Mucous cavity shallow, almost closed in front by the lateral and median crests of the frontals which are in contact to form a canal that is almost closed over from above anteriorly and which lies alongside the median crest. The parietals on each side have a small laterally expanded crest beneath the posterior end of which is placed the foramen of the recurrent dorsal branch of the facial nerve. The anterior edge of the head of the vomer (C) extends downward, and has a horseshoe-like appearance from beneath, with well-developed and irregularly arranged teeth, the ends of the horseshoe greatly extending back and somewhat laterally. The parasphenoid from beneath along its entire length is flattened. In the rear of the skull (D) the supraoccipital crest just barely fails to extend over the upper edge of the supraoccipital and epiotic, and it is wide and flattened from above. The auditory region of the skull is almost without lateral swellings. Lateral walls of the skull are limited by almost straight lines, arranged at approximately right angles to each other.

* A--see side view of skull, B--from above, C--from below, D--from behind. The corresponding description follows.

75 The opercular and preopercular processes of the hyomandibular are closely approximated and the former is directed downward, the latter somewhat elevated and in the shape of a crest continues anteriorly across the lower process, both a little longer than the lower process; the articular process is scarcely developed. Upper fork of the posttemporal long, the lower processes less than half of the upper. Postcleithrum thin, slightly bent and widened at the upper end. Pelvic bone of normal form but considerably larger than in the other genera. Opercle with a small notch on the lower edge and a projection at the upper end of posterior edge. Urohyale elongate and narrow, along its lower edge from each side a crest is formed. Parapophyses quite broad, long.

Description given from one skeleton.

FIGURE 11. Distribution of *Brosme brosme*.

DISTRIBUTION. One species along both coasts of the northern parts of the Atlantic Ocean and in the western part of the Barents Sea (Figure 11). Fossil remains known from the Oligocene (?) Middle and Upper Miocene.

*1. *Brosme brosme* (Müller)—Menek (Tables I, XXI, LXVIII)

Gadus brosme Müller, Zool. Dan. prodr., 1776:41 (coasts of Denmark). — *Gadus torsk* Bonnatere, Tabl. encycl. meth., 1788:51. — *Gadus lubb* Euphrasen, Vet. Akad. Handling., 1794:223, tabl. 8 (off the Coasts of Bohuslan province). — *Gadus brosme* Lacepede, Hist. nat. poiss., II, 1800:368, 450 (shores of Greenland, Europe). — *Blennius torsk* Lacepede, l. c.:460, 508 (Greenland). — *Enchelyopus brosme* et E. lubb Bloch ed. Schneider, Syst. ichth., 1801:51. — *Brosmius flavescens* LeSueur, Mem. Mus. Hist. Nat. Paris, V, 1819:158 (Newfoundland Bank). — *Brosmius vulagris* Fleming, Hist. brit. animals,

1828:194. — *Brosmius scotica* Swainson, Nat. hist. classific. fish., II, 1838:301. — *Brosmius flavescens* et *B. brosme* Günther, Cat. fish., IV, 1862:369. — *Brosmius americanus* et *B. brosme* Gill, Proc. Acad. Nat. Sci. Phila., 1863:242. — *Brosmius brosme* Goode a. Bean, Proc. U. S. Nat. Mus., I, (1878), 1879:362; Smitt, Scand. fish., I, 1893:562, pl. XXV, f. 4 (synonymy, biology).

DISTRIBUTION, BIOLOGY. Malm, Göteb. Bohusl. Fauna, 1877:499 (Kattegat to Vingo Island); Knipowitsch, Ann. Mus. Zool. Acad. Sci. St.-Petersb., II, 1897:151 (Murman coast); Hjort, Rapp. Procès-Verb., X, 1909:66, f. 19 (spawning grounds); Damas, ibid.:207 (spawning grounds); J. Schmidt, ibid.:110-147 (spawning grounds); Bigelow a. Welsh, Fish. Gulf Maine, 1925:462, f. 230-232 (North American coast, biology); Saemundsson, Synops. fish. Iceland, 1927:32 (around Iceland, biology); Rass, Dokl. first session gos. oceanogr. inst., 5, 1933:8 (spawning grounds in Motovsky Bay); Karelo-Murmansky Kray, 1934, 3-4:58 (spawning grounds); Rass, Int. Rev. ges. Hydrob. u. Hydrogr., Bd. 33, 1936:265 (spawning grounds).

D 93-101, A 62-75, gill rakers 11-13, vertebrae 64*. Gill rakers in the form of broad tubercles with a few weak bristle-like spines at the ends. Pectoral fin wide and rounded, pelvic fins without elongate rays, dorsal and anal fins confluent at the base with the caudal fin through a small membrane. In percent of body length: anteanal distance 46.2-48.8, antedorsal distance 25.4-26.8, length of pectoral fin 10.4-11.5, length of pelvic fin 10.2-11.2, base of dorsal fin 62.2-67.0, base of anal fin 38.5-43.0, head 20.9-22.7. In percent of head length: snout length 31.4-34.3, horizontal diameter of eye 18.5-23.5, length of upper jaw 45.0-46.7, length of lower jaw 58.0-60.9, width of interorbital 16.0-20.3, length of barbel 15.8-23.3. Coloration light grey with brownish tint, paler on the sides changing to grayish-white on the belly. Unpaired fins at the base, of the same color as the back, the very tips white or yellowish, a black line extends along the fins slightly below the top. Pectoral fins yellowish pelvic fins blackish toward the tip. Length most often near 40 cm, occasionally to 110 cm.

DISTRIBUTION. Atlantic Ocean. At the coasts of Europe north to the western part of the Barents Sea off the Murman Coast**, generally at the southern shores of Iceland, less frequently along its northern shores, to the east in Skagerrak and adjacent parts of Kattegat (to Vingo Island), southward in the North Sea to the coasts of Yorkshire, off the northwestern shores of Ireland. Along the coast of North America southward to New Jersey, common at Cape Cod, north to Newfoundland, occasionally at Labrador. Very seldom at the coast of Greenland.

BIOLOGY. Sedentary fish, generally remaining in the same region, undertaking apparently only local migrations from greater depths to lesser. Found alone or in small schools, not forming large concentrations such as other gadoids. Generally keeps far from shore, at the bottom, at depths of 100 to 1,000 meters, never found near the coasts or at depths of less than 20-30 meters. Spawning takes place at considerable depths, from 50 to 400 meters, but generally at depths of about 200 meters. Spawning grounds are distributed practically throughout the entire range. At the coasts of Europe spawns in the vicinity of some banks along the coast of Norway northward to the Lofoten Islands, small numbers along the western Coast of Murman, in the northern parts of North Sea between the 100 and 200 meter isobaths, at the southern and southwestern coasts of Iceland, southward between Iceland and the Faroe Islands, at Faroe Islands off the northern and northwestern coasts of Scotland and Ireland. Major spawning grounds are between

* According to J. Schmidt, 64-65 vertebrae.

** In the collections of the Zoological Institute, Academy of Sciences, are specimens from Teriberka (No. 6372) and from Gavrilovo (No. 10664).

Scotland and Iceland. Less is known of the places and conditions of spawning along the American coast than in Europe. Spawning apparently takes place here at slightly lesser depths. Spawning time - spring - beginning of summer, from the beginning of April to July, earlier or later depending upon locality. Conditions of spawning: temperature 5.5-6.0 to 9.0°C, and on the average about 7°C, salinity about 32.2 parts per thousand. Number of eggs over two million from fish of average size. Sexual maturity is reached at a length of about 50 cm upon reaching 8-10 years. Feeds on
77 crustaceans, mollusks.

Not commercially important in some parts of its range. Along our shores it is rare and cannot be considered a commercial fish. At the shores of Norway and particularly of Iceland, Scotland and in some places along the coasts of North America, it is caught in considerable quantities but is never entirely taken into consideration by catch statistics.

COMPARATIVE NOTES. *B. flavescens* LeSueur has two barbels on the chin. Specimens with two barbels on the chin were found by us among the cod (*G. morhua callarias*) as well. *B. flavescens* and *B. americanus* are identical with *B. brosme* which had been established by Goode and Bean (1. c.).

2. Genus **GAIDROPSARUS** RAFINESQUE

Gaidropsarus Rafinesque, Ind. ittiol. Sic., II, 1810:11, 51 (Type: *G. mustellaris* Raf. = *G. mediterraneus*). - "Les musteles" Cuvier, Règne animal, ed. I, II, 1817:215 (Type: *G. tricirratus* Bloch = *G. mediterraneus*). - *Mustela* Oken, "Isis," 1817:1182 (Type: *G. mediterraneus* L., secundum Cuvier, nomen praeoccupatum). - Onos Risso, Hist. nat. Eur. merid., III, 1826:214 (Type: *O. mustella* Risso = *G. mediterraneus*). - *Motella* Cuvier, Règne animal, ed. II, II, 1829:334 (Type: *G. tricirratus* Bloch = *G. mediterraneus*). - *Onogadus* De Buen Bol. Soc. Esp. Hist. Nat., XXXIV, 1934:500 (Type: *G. ensis*).

Two dorsal and one anal fin, second dorsal of 45-70 rays. First dorsal consists of only one ray behind which, in a groove, are numerous short filamentous rays. Swimbladder rudimentary, thin-walled and of small size. Lower jaw shorter than upper. Three barbels on the head, one on chin and one each at anterior nostrils. Teeth small, in several rows on the premaxillary, dentary and on the head of vomer. Head of vomer rather large, its apex angular. Skull narrow, its length more than twice its width. Crests on the pterotic and on frontals above the canals of the lateral line system are tightly fixed to the bone and almost closing the canal. Mucous cavity small, open in front, central crests of the frontals not developed. Lateral line with a sharp bend above the beginning of the anal, discontinuous for its entire length. Pores along the canals of the lateral line on the head, 13 in preoperculo-mandibular canal, 12 in infraorbital canal, 4 in supraorbital canal (2 pores in front and 2 pores behind nostrils), one pore in the infraorbital commissure, one pore on each side in the supratemporal portion of the lateral line and one unpaired pore on the back of the skull. Facial nerve emerges from the skull through a deep notch with an almost closed front edge.

SKELETON. Skull low (A), slightly higher posteriorly than in front, its greatest height almost one-fourth of the length of the base. Lower edge of

vomer and parasphenoid straight, basioccipital bending downward somewhat. Upper profile of skull straight for almost its entire length. Supraoccipital crest extends a little behind the posterior end of the basioccipital, with a sharp notch on its upper edge, developed only in the posterior part of the supraoccipital over the lateral occipitals; crest on the anterior part of supraoccipital between the parietals and the frontals is absent. The anterior edge of the mesethmoid with a small bulge, placed perpendicular to the longitudinal axis of the skull and to its upper edge. Orbital space small, rather high with regard to its length. Facial nerve emerges from the skull through a deep notch in the anterior part of the prootic, with the forward edge almost closed. The foramen of the glossopharyngeal nerve on the opisthotic hardly developed, and discerned with difficulty. Skull from above (B) quite narrow, especially in the interorbital region, its greatest width contained twice in the length of the base of the skull. Lateral edges of the pterotic rounded, convex, with deep notches in their anterior edges and at the rear of the sphenotic. Lateral edges of the frontals rounded, sharply narrowed toward the interorbital region, with a slight broadening at the anterior end of the frontals. Lateral ethmoids greatly elongated in latitudinal and longitudinal directions of the axis of the skull, scarcely emerging anterior to the frontals from the underside. Anterior end of vomer beneath the beginning of the mesethmoid. Edges of the crests above the canals of the lateral line of pterotic and frontals are close to the bones, almost closing the canals on the sides. Mucous cavity above is closed by enlarged edges of the central and lateral crests of the frontal bones. The foramen of the recurrent dorsal branch of the facial nerve is covered from above by a small triangular crest-like growth of the parietal. Underneath the skull (C) along the anterior edge of the head of the vomer is a horseshoe-like elevation with 2-3 rows of irregularly distributed small teeth. Lower surface of parasphenoid broad, sharp anteriorly, flat in the middle, slightly rounded posteriorly. Sphenotic greatly elongated anteriorly over the frontals. In back of the skull (D) the supraoccipital crest hardly extends above the supraoccipital and epiotic. Prootic convex, lateral walls of skull somewhat inflated. The opercular process of the hyomandibular thin and long, longer than the lower process; the preopercular process of the hyomandibular is in the shape of a small projection from the rear end of the broad lower process; the articular process is broad and short. Posttemporal small, the lower fork much shorter than the upper. Postcleithrum thin, curved, not broadened at its upper end. Pelvic bone large, much larger than in any other gadoids, with a long process below. Opercle with a deep notch in its lower edge, the posterior end of which is in the form of a spine. Preoperculum broad, with a large process in front. Uruhyal somewhat elongated, and comparatively narrow. Parapophyses short and broad.

Description of the skull refers only to *G. mediterraneus*. Judging from the width of the interorbital region, an approximately similar shape skull is found in the other species of the genus.

DISTRIBUTION. One of the most widely distributed genera of the family (Figure 12). The majority of forms described as distinct species are found in the northern part of the Atlantic Ocean off the coasts of Europe, some along the coasts of Greenland and North America, one from off South Africa, one form off New Zealand, and one form off Japan.

FIGURE 12. Distribution of the genus *Gaidropsarus*.

COMPARATIVE NOTES. As it is seen from the keys to species, taken without any modification from Collett (1892) and De Buen (l. c.), distinctions between the species of the genus are based on the number of rays in the pectoral and pelvic fins and the relation of the measurements of the eye, inter-orbital space, head and the first dorsal fin ray. However, if the number of rays in the dorsal and anal fins are taken into consideration, the distinction between the two most widely distributed species of the genus — *G. mediterraneus* and *G. vulgaris* — is somewhat different. In the following the number of rays in the dorsal (D), anal (A), pectoral (P) and pelvic (V) fins of the two species are given according to our data* and the data of other authors.

Following Collett and taking as the basis of the distinction between these two species the number of rays only in the pectoral and pelvic fins, it must be considered that Yarrell was dealing with *G. vulgaris*. But if the number of rays in the dorsal and anal fins are taken into consideration, it is clear that Lütken's and Collett's specimens differ considerably from Yarrell's, and resemble more closely the specimens of *G. mediterraneus*. Thus it would have been more proper for one of the species (*G. mediterraneus*) to accept II D (52) 54–58, A 44–49 (50), P (15–16 17–19, V (5) 6 (7), and for the other, first definitely established by Lütken and Collett II D 62–64, A 51–54, P (20–21) 22–24, V (7) 8. However, even in this case

* Specimens examined from the Mediterranean Sea, the Black Sea and the Atlantic Ocean have similar numbers of rays. In order to count the rays in the pectoral fin, as in all other fins, the skin covers were removed.

	II D	A	P	V
<i>G. mediterraneus</i>				
According to the author's data	54-58	44-49	17-19	(5) 6
Linne, 1758	54	44	15	2 (?)
Brünnich, 1768	54	45	16	4
Bloch, 1785	56	46	18	6
Canestrini, 1862	52-55	44-47	17	6
Lütken, 1882	55-56	47-49	16	6 (7)
Day, 1884	55-57	48-50	16-18	6-7
Collett, 1892	55-56	47-49	17(16)	6
<i>G. vulagris</i>				
Yarrell, 1836	55	49	20	7
Lütken, 1882	62-64	51-54	21-22	8
Collett, 1892	62-64	51-54	(21-22) 22-24	8

the differences are not too great though a small hiatus exists and, besides, the second species would have to be given a new name because both of the above named authors assign to it the name *Motella vulgaris*. Not having a single specimen of *G. vulgaris* from which to study in greater detail other distinguishing characters, and, more important, to examine its skeleton, we are forced to leave the question of separation of both considered species, as well as all other species of the genus, as found in Collett's (1892) classification. Not without some basis it is possible to presume that the genus *Gaidropsarus* consists perhaps of only one widely distributed species, falling in some parts of its general range into a number of local forms (subspecies, nationes). Actually, not undertaking any distant migrations and generally leading a sedentary mode of life, this species would have had all possibilities for the formation of local forms, like belduga (*Zoarces viviparus* L.). As is known (J. Schmidt, C.-R. Trav. Lab. Carlsberg, XIII, 13, 1917), belduga, in just a portion of its range, breaks up into a number of local forms, and limits of variation in the number of vertebrae are from 101 to 126 (mean values from 110.9 to 118.7); in the spinous portion of the dorsal fin rays number from 0 to 17 (mean values from 4.9 to 11.5) and pectoral rays from 15 to 21 (mean values from 18.3 to 19.4). Among some of these forms there is a hiatus in the enumerated characters; however, not one form appears to be a distinct species. In the most remote places of distribution (along the shores of New Zealand and others) the genus *Gaidropsarus* has perhaps already differentiated into independent species. The other characters by which forms of the genus are differentiated, i.e., head length, diameter of eye and others, vary too much with age and besides, their distinction is not too great. Judging by the width of the inter-orbital space the shape of the skull in all is approximately the same, considerably differing from the skull form in the genus *Enchelyopus* and especially from *Ciliata*. All three genera were separated by some authors into an independent family. The post-larval stage of species of this genus, as in both of the following genera, greatly differs from the adults which gave reason for describing specimens in this stage as distinct genera (*Couchia*, *Ciliata*).

The present state of the study of the genus *Gaidropsarus*, as can be seen from the above discussion calls attention to the necessity of its

monographic revision with a re-examination of all types, which in the present work we had no opportunity to conduct.

Key to the Species

- 1 (24). First dorsal ray short, approximately equal to the horizontal diameter of the eye.
- 2 (5). Pectoral fin with less than 16 rays.
- 3 (4). Pectoral fin with 9 rays. . . 1. *G. megalokynodon* (Kolomb.)
- 4 (3). Pectoral fin with 14 rays. . . 2. *G. pacificus* (Temm. et Schl.)
- 5 (2). Pectoral fin with more than 16 rays.
- 6 (15). Pectoral fin with not more than 19 rays.
- 81 7 (12). Eyes small, equal to or less than the interorbital space*.
- 8 (11). First dorsal ray longer than the filamentous rays.
- 9 (10). V 6. Depth of body approximately 7 times in its length 3. *G. mediterraneus* (Linne)
- 10 (9). V 7. Depth of body approximately 6 times in its length 4. *G. guttatus* (Coll.)
- 11 (8). First dorsal ray equal in length to the filamentous rays. 5. *G. novae-zealandiae* (Hector)
- 12 (7). Eyes large, wider than width of interorbital space.
- 13 (14). V 5. Head large, about $4\frac{1}{2}$ times in body length 6. *G. macrophthalmus* (Gunth.)
- 14 (13). V 6. Head small, about $5\frac{1}{2}$ times in body length 7. *G. biskayensis* (Coll.)
- 15 (6). Pectoral fin with more than 19 rays.
- 16 (19). Pectoral fin with 19 to 20 rays.
- 17 (18). V 6. II D 49, A 43 8. *G. barbatus* (De Buen)
- 18 (17). V 7. II D 68-70, A about 60. 9. *G. capensis* (Caup)
- 19 (16). Pectoral fin with more than 20 rays (usually about 22).
- 20 (23). Eyes not large, equal to or less than the interorbital space.
- 21 (22). First dorsal ray equal to the diameter of the eye. II D 62-64, A 51-54. 10. *G. vulgaris* (Yarr.)
- 22 (21). First dorsal ray greater than eye diameter. II D 54-59, A (43) 45-46 (48) 11. *G. reinhardti* (Coll.)
- 23 (20). Eyes large, greater than the width of the interorbital space. 12. *G. carpenteri* (Gunth.)
- 24 (1). First dorsal ray long, equal to the head length 13. *G. ensis* (Reinh.)

1. *Gaidropsarus megalokynodon* (Kolombatovic)

Motella megalokynodon Kolombatovic, Glasnik Hrv. Naravoslovnoga Društva, XV, 1903 (Adriatic Sea at Spalato).

ID 1, II D 55, A 46, P 9, V 7. Head large, $4\frac{1}{2}$ times in body length. Eyes about 5 times in head length, greater than the length of the snout. Depth of

* Eyelids included, and not only the width of the frontal bones as accepted for other genera.

body less than the length of the head, equal to the postorbital length of the head. Barbels on the end of the snout long, twice the diameter of the eye. Two barbels on the chin, judging from the figure much shorter than the barbels on the snout. Base of first dorsal fin about half the length of the head. One strong tooth on the end of each premaxillary the other teeth less developed. Coloration pinkish-brown. Length is not indicated. (After Kolombatovic).

DISTRIBUTION. Adriatic Sea at Spalato, at depths.

COMPARATIVE NOTES. Most characteristic for this form is the small number of rays in the pectoral fin, if their count is correct. Judging from the picture, there are two barbels on the chin, which are rarely observed for instance in cod, and is nothing else but an anomaly. In the figure the base of the first dorsal is equal to the head length, but in the description it is only half the head length.

2. *Gaidropsarus pacificus* (Temminck et Schlegel)

Motella pacifica Temminck et Schlegel, Fauna Jap., Pisces, 1842:249 (Japan, Nagasaki). — *Onus pacificus* Collett, Christ. Vidensk.-Selsk. Forh., (1891), 1892:6.

- 82 I D 1, II D 45, A 38, P 14, V 5. Head $5\frac{1}{2}$ times in body length, Eyes small, less than length of snout, equal to interorbital space. Mouth opening less than half the length of the head. Body depth contained 8 times in its length. Distance of anal opening from tip of snout $\frac{3}{5}$ of the length of the body. Coloration in alcohol, brown on back, changing to yellowish on the belly. Fins with whitish margin, more pronounced in the posterior portions of the anal and dorsal fins. In the rear of the anal fin at its base is a large oval yellowish colored spot. Length about 30 cm (after Collett).

DISTRIBUTION. At the coasts of southern Japan (Nagasaki).

COMPARATIVE NOTES. Only one specimen known; about 30 cm in length with no indication of the exact locality or detailed measurements. No figure of this species. It is totally incomprehensible why in the 100 years elapsed since Sieboldt travelled, not one specimen has been found of this species. By the number of rays in the fins the species differs greatly from all other species of the genus.

3. *Gaidropsarus mediterraneus* (Linné)—Mediterranean three-barbeled marine nalm, galeya (Tables I, XXII, LXVIII).

Gadus mediterraneus Linné, Syst. nat., ed. X, 1758:255 (Oceano Europeo, II D 54, A 44, P 15). — *Gadus triccirratus* Brunnich, Ichth. Massil., 1768:22 (II D 54, A 45, P 16). — *Gadus mustella*, G. fuscus Risso, Ichth. Nice, 1810:215 (II D 52-54, A 44, P 14-18). — *Gaidropsarus mustellaris* Rafinesque, Ind. ittiol. Sicil., II, 1810:51 — *Gadus jubatus* Pallas, Zoogr. rosso-asiat., III, 1811:202 (Black Sea). — *Gadus argenteolus* Montegu, Mem. Wern. Nat. Hist. Soc., II, 1818:449 (P 16-18, juv). — *Onos mustella*, O. maculata, O. fusca Risso, Hist. nat. Eur. mérid., III, 1826:215, 216 (II D 52-58, A 44-48, P 14-18). — *Motella triccirrata* Nilsson, Prodr. ichth. Scand., 1832:48 (after Bloch, 1795; II D 56, A 46, P 18). — *Motella communis* Canestrini, Arch. Zool., Anat. Fisiol., II, 1862:369 (II D 52-55, A 44-47, P 17, V 6, Mediterranean Sea). — *Motella vulgaris* Steindachner, Sitzungsber. Akad. Wiss. Wien., math.-naturw. Cl., LVII, 1, 1868:710 (ex parte). — *Motella triccirrata*, M. maculata, M. fusca Moreau, Hist. nat. poiss. France, III, 1881:268, 270, 272. — *Motella mediterranea* Lütken, Vidensk. Medd. naturhist. Foren. Kbhvn., (1881), 1882:235 (II D 55-56, A 47-49, P 16, V 6-7). — *Motella triccirrata* Day, Fish. Gr. Brit. Irel., I, 1884:317, pl.

LXXXVIII, f. 1 (II D 55-57, A 48-50, P 16-18, bibliography, distribution). — *Onos mediterraneus* Collett, *Nyt Mag. Naturv.*, XXIX, 1885:93. — *Onus mediterraneus* Collett, *Christ. Vidensk. -Selsk. Forh.*, (1891), 1892:6 (compilation). — *Onos mediterraneus* O. *fuscus* et O. *tricirratus* (ex parte) Smitt, *Scand. fish.*, I, 1893:357, f. 131 (bibliography, measurements). — *Gaidropsarus zernovi* Gratzianov, *Experiments on the observation of fish*, 1907:463 (Black Sea, Bay of Streletzk).

DISTRIBUTION, BIOLOGY. Nordman, *Faune Pontique*, 1840:531, pl. XXVI, f. 1 (Black Sea); Kesler, *Fishes of the Aral-Caspian-Pontian district*, 1877:235 (Black Sea); Pchelina, *Tr. Novoross. Biol. St.*, II, 1, 1936, 33 (larvae); Drenski, *Spis. Bulgarian Akad. Nauk*, XXV, 1923:109 (Black Sea and at the coasts of Bulgaria); Kosyakina, *Tr. Novoross. Biol. St.*, II, 2, 1938:26 (spawning at Novorossiysk); Pchelina, *Tr. Novoross. Biol. St.*, II, 3, 1940:71 (young in the region of Novorossiysk Harbor); Vinogradov, *Tr. Karadagsk. Biol. St.*, 4, 1931:142 (young at Karadag).

ID 1, IID 54-58, A 44-49, P 17-19, V (5) 6*, gillrakers 7-10, pyloric caeca 13-14**, vertebrae 48-49. Gillrakers in the form of tubercles with small spines on top. Swim-bladder present, small and thin-walled† Head not large, 5.0-5.5 times (18.0-19.6%) in body length. Eyes not large, 6.1-7.7 times (13.0-16.4%) in head length, less than the length of the first dorsal fin ray and the length of the snout. In percentage of the body length: 83 anteanal distance 41.4-46.7, antedorsal space 16.8-17.9, pectoral fin length 11.0-13.5, pelvic fin length 9.2-13.5, length of base of first dorsal fin 10.5-12.4, base of second dorsal 55.2-58.0, length of base of anal fin 39.5-43.5, length of first dorsal fin ray 4.1-5.8, depth of caudal peduncle 4.7-5.7, length of caudal peduncle 4.2-5.8. In per cent of head length: length of snout 23.2-26.3, length of upper jaw 41.3-46.0, length of lower jaw 50.7-56.6, interorbital space 9.1-12.8 (only least bony width; width of the least fleshy width 18.5-19.2). Coloration is dependent upon place of habitat and is greatly varied. Back more often brown, more or less dark; sides and belly lighter. Head, entire body and fins with irregularly rounded numerous spots and dots. In the pelagic post-larval stage the back is blue, sides and belly silvery. Length to 50 cm.

DISTRIBUTION. Most common off the coast of Great Britain and Ireland, southwestern coasts of Europe, Mediterranean and Black Seas. Northward along the coasts of Norway to Olesund, eastward to the northern part of the Kattegat. The expedition "Travailleur" and "Talisman" found it at the coasts of Morocco and Sudan.

BIOLOGY. Lives generally at shallow depths near the shores on rocky bottom with aquatic vegetation. More seldom it is found at greater depths and on other grounds. Spawning apparently is extended; in the Black Sea at Novorossiysk it occurs from September to March, a great number of eggs discovered in October, November and December, in 1934 and 1935 also in March; pelagic larvae 40-53 mm in length were caught in May; larvae 2.1 mm in length were caught in November, 1934, just before the entrance to Novorossiysk Harbor larvae 3 mm in length were caught at the end of March, 1938, in the central part of the harbor in the bottom layer. In the vicinity of Novorossiysk the young up to 53 mm in length were caught in the open sea at a depth of 60 meters in June, 1933. In Galatz Harbor young about 40 mm in length were caught in March, 1938, and 2 young 49 mm in length — in May of the same year.

* After Collett (1892), II D 55-56, A 47-49, P 17 (16), V 6. Lütken indicates for V 6 (7).

** According to Day, up to 20.

† Its indicated absence is incorrect.

COMMERCIAL VALUE almost none.

COMPARATIVE NOTES. The description is based on specimens from the Black Sea. Besides, specimens from the Mediterranean Sea and the Atlantic Ocean (Palermo, Nice, Madeira) were also examined. Some of the species indicated in the synonymy were described and based only on difference in coloration. The difference in size of teeth indicated for some species is dependent on age. In regard to the closely related *G. vulgaris* see the comparative notes for the genus. *Motella tricirrata* Nilsson must be considered a synonym of this species and not *G. vulgaris*, as Nilsson identifies it according to Bloch, who gives the radial formula for the fins which brings it closer to *G. mediterraneus*. Here also should be referred *Gadus argenteolus* Montegu (P 16-18, juv). The radial formula for fins in *Onos tricirratus* Smitt [II D (55) 58-60 (64), A (45) 47-49 (54), P 19-21] wholly embraces the range of variation in *G. mediterraneus* and *G. vulgaris*, inasmuch as the ray counts of *M. vulagris* Lütken [= *G. vulgaris* (Yarrell)] and *M. tricirrata* Day [= *G. mediterraneus* (L.)] are included in it. Steindachner united both these species into one.

4. *Gaidropsarus guttatus* (Collett)

Onus guttatus Collett, Bull. Soc. Zool. France, XV, 1890:105 (at the Azores Islands). — *Onos guttatus* Steindachner, Sitzungsber. Akad. Wiss. Wien, math-naturw., Cl., C, 1, 1891:360 (at Canary Islands). — *Onus guttatus* Collett, Christ. Vidensk.-Selsk. Forh., (1891), 1892:7.

84 I D 1, II D 50-54, A 43-46, P 16-17, V 7. Head length $4\frac{3}{4}$ - $5\frac{1}{4}$ times in body length (about 19%). Eyes of medium size, horizontal diameter contained in head length about 6 times, equal to interorbital space and less than the length of the first dorsal ray or the length of the snout. Body deep, depth at the origin of the anal fin contained about $5\frac{2}{3}$ - $6\frac{1}{2}$ times in length. Anal opening located midway between the tip of the snout and the end of the anal fin. Depth of caudal peduncle $3\frac{1}{2}$ times in length of head. Base of first dorsal fin is $1\frac{1}{2}$ times less than the head length. First dorsal ray short. Pectoral fins reaching to the origin of the second dorsal. Body blackish with many well-pronounced spots. Fins and head with similar but less distinct spots. Length to 21.3 cm (after Collett, 1890).

DISTRIBUTION. Atlantic Ocean at the Azores and Canary Islands.

COMPARATIVE NOTES. Form close to if not identical with *G. mediterraneus*.

5. *Gaidropsarus novae-zealandiae* (Hector)

Motella novae-zealandiae Hector, Trans. Proc. New-Zeal. Inst., VI, (1873), 1874:107, pl. XVIII, f. 76b (Cape Campbell).

I D 1, II D 58, A 44, P 17. Head about 6 times in body length. Eyes shorter than snout, contained almost 7 times in head length. Snout equal in length to the width of the interorbital space. First ray of first dorsal,

judging by the description and figure, not longer than the filamentous rays arranged behind it. Coloration in alcohol reddish brown, yellowish beneath. Length 17.8 cm (after Hector).

DISTRIBUTION. New Zealand, Cape Campbell (Hook Strait).

COMPARATIVE NOTES. By the number of rays in its unpaired fins this species definitely differs considerably from the geographically close *G. pacificus* and *G. capensis*.

6. *Gaidropsarus macrophthalmus* (Günther)

Motella macrophthalmus Günther, Ann. Mag. Nat. Hist., (3), XX, 1867:29, t. V, f. B (at Hebrides). — *Onus macrophthalmus* Günther, Chall. Rept., Zoology, XXII, 1887:96. — *Onus macrophthalmus* Collett, Christ. Vidensk.-Selsk. Forh., (1891), 1892:8.

ID 1, IID 55, A 45, P 17, V 5. Head large, $4\frac{1}{3}$ (4.35) times in body length. Eyes large, about 4 times in head length, larger than interorbital space. Body low, about 7 times in its length. Anal opening placed between tip of snout and posterior end of anal fin. Base of first dorsal of medium length, little shorter than the distance from its origin to the eye, contained more than 2 times in head length. First dorsal fin ray short, equal in length to the eye. Coloration uniform, dorsum with irregular narrow transverse bars. Length 7.4 cm. (after Collett, 1892).

DISTRIBUTION. Atlantic Ocean at the Hebrides at depths of 130–150 meters.

COMPARATIVE NOTES. Only one specimen is known, 7.4 cm long. Lütken (Vid. Medd. Nat. Foren. Kjobenh., 1882:244) suggested that this specimen is a young *G. mediterraneus*, which is opposed by Günther (1867), who states he had never seen a specimen of this species with such large eyes. However, Lütken obviously is correct, as such small specimens (46–65 mm) or *G. mediterraneus* from the collections of the Zoological Institute Academy of Sciences have eyes just as large ($4-4\frac{1}{2}$ times in head length and wider than the interorbital space) as *G. macrophthalmus*, but with a head of slightly smaller dimensions.

7. *Gaidropsarus biscayensis* (Collett)

Onus biscayensis Collett, Bull. Soc. Zool. France, XV, 1890:107 (Bay of Biscay); Christ. Vidensk.-Selsk. Forh., (1891), 1892:9.

ID 1, IID 54, A 44, P 17, V 6. Head not large, contained $5\frac{1}{2}$ times (18%) in body length. Eyes large, their horizontal diameter contained about 4 times in head length, exceeding the width of the interorbital space, length of first ray of first dorsal fin and the length of the snout. Body low, its depth contained about $9-9\frac{1}{2}$ times in its length. Anal opening placed slightly closer to the tip of the snout than to the rear of the anal fin. Depth of caudal peduncle contained 4 times in the head length and less than twice in the base of the first dorsal fin. Base of first dorsal fin slightly greater than the distance from its origin to the eye, contained in the head length 2 times. First ray of first dorsal short. Pelvic fins extend somewhat to origin of second dorsal

fin. Pigmentation uniformly brownish, light, second dorsal and caudal with brownish stripes. Length to 13.3 cm (after Collett, 1890).

DISTRIBUTION. Atlantic Ocean along the shores of Europe (Bay of Biscay, at a depth of 155 meters and at Cape Finisterre at a depth of 400 meters).

BIOLOGY unknown.

COMPARATIVE NOTES. Known only from three young specimens (2 to 13.3 cm and 1–7.4 cm in length). Species very close and possibly identical with *G. macrophthalmus* and *G. mediterraneus*. Eyes large, slightly larger than in *G. macrophthalmus*, but head not large, the same as in *G. mediterraneus*. Not being in possession of type specimens of *G. guttatus*, *G. macrophthalmus* and *G. biscayensis*, it is impossible to resolve the question of their identity with *G. mediterraneus* or of their existence as independent species.

8. *Gaidropsarus barbatus* De Buen

Gaidropsarus barbatus De Buen, Bol. Soc. Espan. Hist. Nat., 34, 1934:502, f. 1 (Mediterranean Sea in the vicinity of Malaga).

ID 1, IID 49, A 43, P 19, V 6. Head not large, about 21% of body length. Eye 5 times in head length, smaller than interorbital space, 83% of its width. Snout length 26% of the head length. Body depth about 15% of its length. Anal opening approximately midway between tip of snout and rear end of anal fin, anteanal distance about 40% of body length. Base of first dorsal fin smaller than the distance from its origin to the eye, and contained about 2 times in head length. First dorsal fin ray short, but greater than the diameter of the eye. Length 11.9 cm (after De Buen).

DISTRIBUTION. Mediterranean Sea in the vicinity of Malaga, 3 miles from shore at a depth of 140 meters.

COMPARATIVE NOTES. Single known specimen, described by De Buen as a distinct species; very close by its numbers of unpaired fin rays to *G. carpenteri* and *G. capensis* from the coasts of South Africa. The 86 main distinguishing characters: number of pectoral fin rays (23 on *G. carpenteri*) and pelvic fin rays [7 (6) in *G. capensis*] and dimensions of the eyes—would hardly serve as specific distinction.

9. *Gaidropsarus capensis* (Kaup)

Motella capensis Kaup, Wiegman. Arch. Naturg., 1858:90 (Cape of Good Hope); Kner, Reise Novara, Fische, 1868:279, pl. XIII, f. 3 (Indian Ocean at St. Paul Island); Sauvage, Arch. Zool. Exper. Gener., VIII, 1870:42 (at St. Paul Island). — *Gaidropsarus capensis* Barnard, Ann. S. Afr. Mus., XXI, 1925:323 (Kalk Bay, Algoa Bay).

ID 1, IID 68–70, A about 60*, P 19–20**, V 7 (6). Head contained 4.8–5.1 times (19.4–20.6%) in body length. Eyes not large, contained 6 to 7 times in head length (14.5–18.0%) shorter than the first dorsal ray, snout and interorbital space. Body depth about 6.5 times in length. Anal opening lies nearer the tip of the snout than to the rear of the anal fin. Base of first

* After Barnard, IID 45, A 40; after Sauvage, A 48.

** Kner indicates 16 to 17 rays for P, Collett 19–20 for the same specimens.

dorsal fin less than the distance from its origin to the eye. Coloration light brown without dark or light spots, second dorsal and anal fins with a narrow whitish border. Length to 16 cm (after Kner, Collett).

DISTRIBUTION. The Atlantic Ocean at the southern tip of Africa; the Indian Ocean at St. Paul Island.

BIOLOGY is apparently identical to that of related species of the northern hemisphere. Keeps close to shore down to depths of 45 meters.

COMMERCIAL VALUE none.

COMPARATIVE NOTES. By the number of rays in the second dorsal and anal fins the specimens from the coasts of the southern tip of Africa and from St. Paul Island differ greatly. For the first, are indicated II D 45, A 40, for the latter II D 68-70, A about 60 (48). If there is no mistake in fin ray counts in South African specimens they are two distinct forms. The South African specimens by the number of rays in the second dorsal and anal fins are closest to *G. pacificus*. Specimens from St. Paul Island have the highest number of rays in comparison with all known species belonging to this genus.

10. *Gaidropsarus vulgaris* (Yarrell)

Motella vulgaris Yarrell, Brit. fish., ed. I, II, 1836:186 (II D 55, A 49, P 20, V 7); Lütken, Vidensk. Medd. naturhist. Foren. Kbhvn., (1881), 1882:235 (Faroe Islands). — *Onos vulgaris* Collett, Nyt Mag. Naturv., XXIX, 1885:93. — *Gaidropsarus argenteolus*, Collett, Christ. Vidensk.-Selsk. Forh., (1902), 1903:65.

I D 1, II D 62-64, A 51-54, P (20-21) 22-24, V 8. Head of considerable size, contained 4.5-4.8 times in body length (20.8-22.5%). Eyes not large, contained 7-8 times in head length, equal to first dorsal fin ray and snout, smaller than width of interorbital space. The greatest depth of the body is contained $6\frac{2}{3}$ times in its length. The anal opening lies nearer the rear end of the anal fin than to the tip of the snout. The caudal peduncle is deep, contained about 3 times in the head length, or about $1\frac{1}{2}$ times in the base of the first dorsal fin. The base of the dorsal fin is shorter than the distance from its base to the eye, and is contained more than 2 times in the head length. Pectoral fins reach beyond the second dorsal fin. Coloration reddish-brown. Length to 51.8 cm (after Collett).

87 DISTRIBUTION. Not known exactly. Lütken, who first directed attention to this species, had about 15 specimens from the Faroes. At the coasts of Norway and northward, he indicates it from Olesund, east to Flekke-Fjord (at the entrance to Skagerrak). According to Yarrell, it occurs at the coasts of Great Britain. Collett (1885) had specimens with 21 pectoral fin rays from the Mediterranean Sea.

11. *Gaidropsarus reinhardti* (Collett)

Motella argentata Reinhardt, Kngl. Danske Vidensk. Selsk., Nat. Afh., VI, 1837:110 (Greenland). — *Motella reinhardti* Collett, Christ. Vidensk.-Selsk. Forh., 1878:83 (to the west of Bear Island). — *Onos reinhardti* Collett, Norske Nordh. Exp. 1876-78, Fiske, 1880:131 (bibliography, biology). — *Onos reinhardti* Günther, Chall. Rept. Zoology, XXII, 1887:97, t. XIX, f. B (Faroe Channel); Collett, Christ. Vidensk.-Selsk.

Forh., (1891), 1892:13 (bibliography); Saemundsson, Synops. fish. Iceland, 1927:30 (at the northern shores of Iceland); Koefoed, Rept. Sci. Res. "Michael Sars" North Atl. Exp. 1910, IV, 1, 1932:118 (northward from Great Britain).

I D 1, II D 54-59, A (43) 45-46 (48), P 22-24, V 8. Head length contained 4.5-5.1 times in body length (19.3-20.1%). Eye contained 4.7-5.5 times in head length (18.4-18.7%), shorter than first ray of first dorsal fin, equal to or less than the width of the interorbital space. The body depth about $5\frac{3}{4}$ times in its length. Anal opening lies closer to the rear end of the anal fin than to the tip of the snout. The caudal peduncle depth is contained about $3\frac{1}{2}$ times in head length (5.5-5.8% of the body length) and not fully 2 times in the base of the first dorsal fin. The base of the first dorsal fin is greater than the distance from its origin to the eye, and is contained two times in head length. The first ray of the first dorsal fin is slightly elongated, slightly longer than the eye. Coloration uniform, reddish-brown. Length to 31.8 cm (after Collett).

DISTRIBUTION. In the most northern part of the Atlantic Ocean; in the Faroe Channel and at the southern coasts of Greenland, at the northern coasts of Iceland and to the west of Bear Island.

BIOLOGY has been studied very little. It is found at low and even negative temperatures at depths of 14 to 1,400 meters. It apparently feeds on small fishes, crustaceans (Decapoda-Hippolyte).

COMPARATIVE NOTES. Very close to *G. mediterraneus* and *G. vulgaris*, distinguished from the first by rather greater number of rays in the pectoral fins, from the second by lesser number of rays in II D and A, as can be seen from the following table:

	II D	A	P	V
<i>G. mediterraneus</i>	54-58	44-49	17-19	(5) 6 (7)
<i>G. reinhardtii</i>	54-59	(43) 45-46 (48)	22-24	8
<i>G. vulgaris</i>	62-64	51-54	(20) 22-24	8

Known from a small number of specimens. The small Reinhardt specimen of *Motella argentata* Reinhardt had in its second dorsal no less than 53, and in the anal no less than 43 rays; pectoral fins are in a poor state of preservation, thus it is impossible to establish its identity with *G. reinhardtii* from this specimen.

88 12. *Gaidropsarus carpenteri* (Günther)

Motella macrophthalmus Günther (nec Günther 1867), Ann. Mag. Nat. Hist., (4), XIII, 1874:139 (between Shetland and Faroe Islands). - *Onos carpenteri* Günther, Chall. Rept. Zoology, XXII, 1887:97, t. XLII, f. D (between Shetland and Faroe Islands). - *Onos carpenteri* Collett, Christ. Vidensk.-Selsk. Forh., (1891), 1892:15.

I D 1, II D 49, A 45, P 23, V 6. Head 4 times in body length. Eyes large, less than 4 times in head length, equal to the length of the snout, greater than the width of the interorbital space. The depth of the body 8 times in body length. The anal opening nearer to tip of the snout than to the rear end of the anal fin. The base of the first dorsal fin is a little more than half the head length, almost equal to the distance from its origin to the eye. The first dorsal fin ray is almost equal in length to the diameter of the eye. Pigmentation uniform. The length about 11.6 cm ($4\frac{1}{2}$ inches). (After Collett).

DISTRIBUTION. Atlantic Ocean between the Shetland and Faroe Islands at a depth of 340 meters.

COMPARATIVE NOTES. Only a small specimen is known. By the number of rays in the second dorsal and in the anal its closest relative is *G. capensis*, and by the number of pectoral rays—*G. vulgaris*. The species is extremely doubtful.

13. *Gaidropsarus ensis* (Reinhardt)

Motella ensis Reinhardt, Kngl. Danske Vidensk. -Selsk., Nat. Afn., VI, 1837:110 (Greenland); *ibid.*, VII, 1838:116, 128. — *Onos ensis* Gill, Proc. Acad. Nat. Sci. Phila., 1863:241. — *Motella ensis* Lütken, Vidensk. Medd. naturhist. Foren. Kbnhvn., (1881), 1882:236 (full description). — *Onos rufus* Gill, Proc. U. S. Nat. Mus., VI, 1883:259. — *Onos ensis* Collett, Christ. Vidensk. -Selsk. Forh., (1891), 1892:16 (bibliography); Goode & Bean, Oceanic ichth., 1896:381, f. 327 (distribution along the shores of North America). — *Gaidropsarus ensis* Jordan & Evermann, Fish. N. a. M. America, 1898:255b (bibliography). — *Onogadus ensis* De Buen, Bol. Soc. Esp. Hist. Nat., XXXIV, 1934:501.

I D 1, II D 59, A 44–46, P 22.24 (27), V 8. Head not large, contained $5\frac{3}{4}$ times in body length (16.8%). Eyes not large (in adults), 2 times in length of snout and in width of interorbital space*. Anal opening midway between tip of snout and hind end of anal fin. First ray of first dorsal fin long, almost equal to head length (14.5% of body length).

Coloration uniform brick red. Length to 39.2 cm (after Collett).

DISTRIBUTION. Atlantic Ocean along the shores of North America from Greenland to Cape Hatteras.

BIOLOGY. Keeps at depths, in the Gulf Stream at a depth of over 1,900 meters.

COMPARATIVE NOTES. Known only from a small number of specimens. Very close and perhaps identical with *G. reinhardti*, distinguished from it by the elongate ray of the first dorsal fin. There are no bases whatsoever to segregate it into a special genus.

3. Genus **CILIATA** Couch

Ciliata Couch, Laud, Mag. Nat. Hist., V, 1822:15 (Type: *C. glauca* Couch=larval *C. mustela*). — *Couchia* Thompson, Nat. Hist. Irel., IV, 1856:188 (Type: *C. minor* Thompson=larval *C. mustela*). — *Molvella* Kaup, Wiegmann Arch. Naturg., XXIV, 1, 1858:90 (Type: *M. borealis* Kaup=*C. mustela*).

* According to Jordan and Evermann, large, almost equal to snout length and to interorbital space.

89 Similar to *Gaidropsarus*, but has five barbels: one on the chin and one at each of the anterior and posterior nostrils. The head of vomer is small, its anterior edge in a form of a semicircle. The skull is broad, its greatest width is contained in the length of its base not more than $1\frac{1}{2}$ times. Two pores in the supratemporal portion of the lateral line. No unpaired pores.

FIGURE 13. Distribution of the genus *Ciliata*
1-*C. mustela*; 2-*C. septentrionalis*.

SKELETON. The skull is not high (A), a little lower in its anterior portion than in the posterior, its greatest height is contained about 3 times in the length of its base. The lower edge of the bones of the base of the skull is almost straight, but the vomer and basioccipital are placed on a slight incline, due to which the base of the skull at its ends is somewhat curved. The upper profile of the skull represents a slightly curved line. The supraoccipital crest has a considerable sized backward-directed process on top, the posterior end of which lies somewhat behind the rear end of the basioccipital crest developed in the posterior part, only over the lateral occipitals, no crest on the forward portion of the supraoccipital posteriorly and on the frontals. The anterior edge of the mesethmoid is somewhat concave, placed vertically, almost a right angle with its upper edge. The orbital space is small, shortened, its depth approximately equal to its base. The notch in the facial nerve penetrates deeply into the front part of the prootic, the lower edge rounded, the upper edge at an angle with a small process on the lower edge of the frontals. The foramen of the glossopharyngeal nerve on the opisthotic is small, hardly noticeable. The skull from above (B) is quite broad, its greatest width contained somewhat less than $1\frac{1}{2}$ times in its length,

gradually and slightly narrowing anteriorly. The lateral walls of the skull are limited by almost straight lines with quite deep notches in the anterior part of the pterotics and with a small protuberance at the anterior end of the sphenotic. Edges of frontals without notches in the interorbital space. The lateral ethmoids are expanded laterally, hardly protruding forward under the frontals. The anterior end of the mesethmoid is above the anterior end of the vomer. The edges of the crests of the sensory canals on the pterotics are firmly adjoined to these bones, almost closing the canals from the sides. The mucous cavity is closed from above by the expanded edges of the lateral and median crests of the frontals. There are small triangular crest-like processes on the parietals over the opening of the recurrent dorsal branch of the facial nerve. Three irregular rows of teeth along the anterior edge of the head of the vomer on a broad horseshoe-shaped elevation beneath the skull (C). The lower edge of the parasphenoid is flat, with winglike expansions above the thickened lower portion. Sphenotic wide and greatly elongated. The skull from behind (D) with a small upward-projecting supraoccipital crest. The lateral walls of the skull are limited in straight lines, the skull in the auditory region is not convex. The opercular process of the hyomandibular is somewhat longer than the lower process, narrow at its base and slightly broadened at its tip; the preopercular process has the form of a small outgrowth on the rear edge of the lower process; the articular process projects forward considerably. The posttemporal is small, the lower branch very short, more than twice as short as the upper. The postcleithrum is thin, curved, not broadened at its upper end. The pelvic bone is of considerable size, larger than in the majority of the gadoids. The operculum has a deep notch in its lower edge, the posterior end of which is pointed, and the forward edge is rounded. Parapophyses short, not very wide.

The description is given from one skeleton of *G. mustela*.

DISTRIBUTION. Two species in the northern parts of the Atlantic Ocean along the coasts of Europe (Figure 13).

COMPARATIVE NOTES. This genus most essentially differs from the closely related *Gaidropsarus* and *Enchelyopus* in the form of its skull and in the number of barbels.

Key to the Species

- 1 (2). No rudimentary barbels on the preorbital skinfold. The head small, about 17% of body length 1. *C. mustela* (L.)
- 2 (1). Three barbels on each side on the preorbital skinfold. Head large, about 25% of body length 2. *C. septentrionalis* (Collett)
1. *Ciliata mustela* (Linné)—The five-barbeled marine nalmim (Tables II, XXIII, LXVIII).

Gadus mustela Linné, Syst. nat., ed. X, 1758:255 (Oceano Europeo).—*Gadus quinquecirratus* Cuvier, Règne animal, ed. I, II, 1817:216 (ex Pennant).—*Gadus mustela* Fleming, Hist. brit. animals, 1828:193 (length to 45 cm); Faber, Naturgesch. fish. Isl., 1829:81 (Iceland).—*Ciliata glauca* Couch, Loud. Mag. Nat. Hist., V, 1832:15, 741 (juv.).—*Motella glauca* Jenins, Man. brit. vert. anim., 1836:451 (juv.).—*Motella argenteola* Duben et Koren, Vet. Akad. Handl., (1844), 1846:92.—*Enchelyopus mustela* Gronovius ed. Gray, Cat. fish., 1854:101.—*Couchia glauca* et *C. minor* Thompson, Nat. hist. Irel., IV, 1856:188.—*Motella borealis* Kaup, Wiegmann, Arch. Naturg., 1858:90 (North Cape).—*Motella mustella* Day, Fish. Gr. Brit. Irel., I, 1884:314, pl. LXXXVIII, f. 2 (variation in the structure of barbels).—*Onos mustela* Smitt, Scand. fish., I, 1893:554, f. 132, t. XXVII, f. 2, 3 (bibliography).

91 DISTRIBUTION, BIOLOGY. Schagerström, *Physiogr. Sölsk. Tidskr.*, I, 1838:305 ("Öre Sund Strait"); Kroyer, *Damm. Fiske*, II, 1843-1845:185, fig. (northern part of Kattegat); Steindachner, *Sitzungsber. Akad. Wiss. Wien, math-naturw. Cl.*, LVII, 1, 1868:710 (Korunya, Lisbon); Malm, *Göteb. Bohusl. Fauna*, 1877:495 (near the coasts of Bohuslan Province); Moreau, *Hist. nat. poiss. France*, III, 1881:273 (English Channel, Arcashon and Biarritz in Bay of Biscay); Saemundsson, *Synops. fish. Iceland*, 1927:31 (Iceland); Ussing, *Flora og Fauna, Kbhvn.*, 43, 1, 1937:27 (in Danish fjords).

I D 1, II D 50-55, A 40-41, P 17, V 7, gill-rakers 9, Pyloric caeca 12*, vertebrae 47. The gill-rakers are shaped as tubercles with small bristle-like spines on top. The lateral line has about 27 pores and a sharp curve beneath the beginning of the second dorsal fin. The body shortened, the head comparatively small, 17.3-19.7% of body length. Interorbital space broad, 21.7-22.4% of head length. Snout blunt. A single pair of long barbels before the nostrils, a single pair of shorter ones at the tip of the snout, one barbel on the chin, no rudimentary barbels along the upper jaw. The upper jaw projects forward, scarcely extending beyond the vertical of the posterior edge of the eye. Eyes small, their longitudinal diameter 11.8-14.5% of head length, slightly exceeding half of the width of the interorbital space; eyes directed somewhat upward. Antedorsal distance 15.7-17.8%, anteanal distance 39.3-43.6% of body length. First dorsal ray 20.3-33.7% of head length, 4.0-5.8% of body length. Coloration reddish-brown or olive green. The dorsum light gray; the venter white, yellowish or reddish, without spots or stripes. Length generally 28, as indicated by Fleming (1. c.) to 45 cm (2 specimens).

DISTRIBUTION. Atlantic Ocean, along the shores of Europe, northward to Finmark (Eks-fjord), at the southern coasts of Iceland, southward to the Bay of Biscay and the western coasts of the Pyrennees, eastward to Sund; most common along the coasts of Great Britain and Ireland. In connection with the distribution along the coasts of Iceland it is interesting to note that during the winter of 1820-21 during a heavy storm hundreds of individuals of this species were thrown on the southern shore (Faber, 1. c.). At present it is extremely seldom found and only in the western part of the southern coast (Saemundsson). It is found in areas which are very close to our sea; there is reason to presume that in connection with the general warming during recent years we may expect to find this species in our waters also.

BIOLOGY is little known. Generally keeps close to shores, not descending to great depths beyond the limits of the distribution of green algae, preferring rocky bottom but also seen on sandy bottom. Spawning takes place winter and spring. The eggs as in all gadoids are pelagic. There are indications, apparently based upon mixing of the eggs with some other fish, that the eggs develop in nests. Feeds on small fish, mollusks, and crustaceans.

COMMERCIAL VALUE none.

COMPARATIVE NOTES. The development and even the number of barbels are variable: Day (1. c.) described 2 specimens (7.6 and 10.2 cm in length) which have short barbels along the edge of the snout; in a specimen 13.2 cm in length the barbels on the end of the snout were not developed. Sometimes the barbels on one side are connected with membrane to the

* According to Smitt, 8-10.

barbels on the other side and in one case both barbels of one side were fused into one, the other side (of the head) being of normal structure.

2. *Ciliata septentrionalis* (Collett)—Northern marine nalm

Motella septentrionalis Collett, Ann. Mag. Nat. Hist., (4), XV, 1875:82 (Flöro, north of Bergen; Bödd north of the Arctic Circle).—*Onos septentrionalis* Collett, Norske Nordh. Exp. 1876–1878, Fiske, 1880:138, t. IV, f. 35, f. 36.—*Motella septentrionalis* Lütken, Vidensk. Medd. naturhist. Foren. 92 Kbnhvn, (1881), 1882:234.—*Onos septentrionalis* Smitt, Scand. fish., I, 1893:548, f. 130 (bibliography, description).—*Gaidropsarus septentrionalis* Jordan a, Evermann, Fish. N.a.M. America, III, 1898:2559; Collett, Christ. Vidensk.-Selsk. Forh., (1902), 1903:63.

ID 1, IID 45–53, A 41–43, P 15–16, V 7. Lateral line with about 20 large pores (about 18 in the type specimen), and a sharp curve beneath the origin of the second dorsal fin. Body short. Head large, about 25% (4 times) in body length, dorso-ventrally depressed. Interorbital space wide, about 20% of head length. Snout blunt. A single pair of long barbels before the nostrils and a pair of shorter barbels at the tip of the snout, a single row of three or more shorter or rudimentary barbels behind these along the preorbital skinfold on the upper jaw. Upper jaw longer than lower jaw, extending far back of the vertical of the posterior edge of the eye. Eye not large, horizontal diameter about 11.5% of head length and only slightly more than the width of the interorbital space, directed somewhat upward. Antedorsal distance about 23%, anteanal distance about 46% of body length. First dorsal fin ray 19.3% of head length. Coloration brown without traces of spots, paler on the sides. The largest specimen, 17.2 cm (after Collett and Smitt). About 15 specimens from the coasts of Norway and one specimen from the coasts of Greenland are known (Collett).

DISTRIBUTION. The Atlantic Ocean along the northwest coast of Norway from Flöro (north of Bergen) to Finmark (Eks-Fjord) and at the coasts of Greenland (1 specimen, exact locality not indicated, Collett, 1880). The range of this little known species comes closer to our waters and we have basis to expect to find it along the Coast of Murman.

BIOLOGY unknown, maintains itself at great depths probably over 100 meters.

COMMERCIAL VALUE none.

COMPARATIVE NOTES. Very close to the preceding species, not always differing from it, as was indicated above even in the number of barbels. However, the comparatively larger head, antedorsal distance and other characters do not permit us to doubt the individuality of this species. Judging from the broad interorbital space the skull is just as wide as *C. mustela*.

4. Genus **ENCHELYOPUS** Bloch et Schneider

Enchelyopus Bloch et Schneider, Syst. ichth., 1801:950 (Type: *Gadus cimbrius* L. = *E. cimbrius*).—*Rhinonemus* Gill, Proc. Acad. Nat. Sci. Phila., 1863:241 (Type: *R. caudacuta* Gill = *E. cimbrius*).

Similar to *Gaidropsarus* and *Ciliata*, but has 4 barbels, one on the chin, one at the tip of the snout, and one at each nostril; the head of the vomer is small, the skull is narrow, its width contained about 2 times in the length of its base. One pore in the supratemporal portion of the lateral line on each side and one unpaired pore at back of the head between them.

- SKELETON. The skull is not high (A), the height contained about 4 times in the length of its base. The lower edge of the bones at the base of the skull is straight, only the ends of the basioccipital and vomer slightly curved downward. The upper profile of the skull in the anterior third slightly descending anteriorly, straight, farther back it is slightly curved and almost parallel with the base. The supraoccipital crest is developed only in the posterior portion above the lateral occipitals, extending posteriorly somewhat beyond the hind edge of the basioccipital, without the process on top*.
- 93 The anterior edge of the mesethmoid is concave, placed vertically, its upper edge straight. The orbital space is large, high, its height contained about $2\frac{1}{2}$ times in the length of the base. The notch of the facial nerve is deep, its upper and lower edges with slight extensions. The foramen of the glossopharyngeal nerve on the opisthotic is small. The skull from above (B) is narrow, especially in the interorbital region, its greatest width contained a little less than 2 times in the length of the base. The lateral edges of the frontals are arranged at an angle to the longitudinal axis of the skull with rather deep notches at the anterior end. The lateral edges of the frontals are straight anteriorly and behind the narrow interorbital region. Lateral ethmoids greatly projecting on the sides, but hardly projecting anterior to the forward edges of the frontals. The anterior end of the vomer lies beneath the forward end of the mesethmoid. The edges of the crests above the sensory canals on the frontals close these canals from the sides for their entire stretch. The mucous cavity is closed above by the expanded edges of the middle and lateral crests of the frontals. The scarcely developed parietal crests slightly close the foramen of the dorsal recurrent branch of the facial nerve from above. Along the anterior edge of the vomer underneath the skull (C) is a small horseshoe-shaped growth with small teeth. Lower edge of parasphenoid slightly rounded anteriorly, flattened and broadened posteriorly. Sphenotic beneath the frontals quite short, not laterally expanded. Supraoccipital crest in the rear of the skull (D) scarcely extending over the supraoccipital and epiotics. Prootics somewhat convex, auditory region slightly inflated on the sides. Opercular process of the hyomandibular thin, elongate, equal in length to the lower process, the preopercular process, scarcely developed, the articular extending upward considerably.
- 94 The posttemporals of small size, the lower branch is half the length of the upper. The pelvic bone is of considerable size. The operculum has a deep notch on its lower edge, the front and especially the posterior ends are very sharp. The preoperculum is broad, with a large, sharp process anteriorly. Parapophyses short, narrow.

This description is based on one skeleton.

DISTRIBUTION. One species in the northern part of the Atlantic Ocean along the coasts of Europe and North America (Figure 14).

* This process may have been broken off perhaps on the skull examined.

FIGURE 14. Distribution of *Enchelyopus cimbrius*

*1. *Enchelyopus cimbrius* (Linné)—Four barbeled marine nalim
(Tables II, XXIV, LVIII)

Gadus cimbrius Linné, Syst. nat. ed. XII, 1766:440 (Oceano Atlantico, scanico). — *Gadus mustela* (non L.) et *G. cimbrius* Strussenfelt, Vet. Akad. Handl., 1773:24, t. 2, f. A, B. — *Enchelyopus cimbrius* Bloch ed. Schneider, Syst. ichth., 1801:50, pl. IX (Atlantic Ocean and Baltic Sea). — *Motella cimbriica* Nilsson, Prodr. ichth. Scand., 1832:48. — *Motella caudacuta* Storer, Proc. Boston Soc. Nat. Hist., III, 1848:5 (along the shores of North America). — *Rhinonemus caudacuta* Gill, Proc. Acad. Nat. Sci. Phila., 1863:241. — *Couchia edwardii* Couch, Journ. Linn. Soc. London, Zool., IX, 1866:38 (larvae). — *Onos* (*Rhinonemus*) *cimbrius* Goode a. Bean, Proc. U. S. Nat. Mus., I, (1878), 1879:348 (synonymy of species, identical with *M. caudacuta* Storer). — *Rhinonemus cimbrius* Jordan, Cat. fish. N. America, 1885:128. — *Onos cimbrius* Smitt, Scand. fish., I, 1893:544, t. XXVII, f. 1 (bibliography, distribution, ecology). — *Gaidropsarus cimbrius* Collett, Christ. Vidensk.-Selsk. Forh., (1902), 1903:59.

DISTRIBUTION, BIOLOGY. Holt, Journ. Mar. Biol. Assoc., (n. s.), V, 3, 1898:343 (Bristol Bay); Möbius u. Heincke, Fische Ostsee, 1882:238 (Baltic Sea); Le Danois, Bull. Soc. Zool. Paris, XXXVIII, 1913:228 (in the area of Cape Penmark, bibliography); Bigelow a. Welsh, Fish. gulf Maine, 1925:458 (distribution, biology); Knipovitch, Tr. Inst. Izuch. Severa, 27, 1926:162 (70°55' north latitude, 33°30' east longitude); Saemundson, Synops. fish. Iceland, 1927:31 (Iceland); Chaîne et Duvergier, Act. Soc. Linn. Bordeaux, LXXX, 1928:48 (Borde); Bate, Contrib. Canad. biol. fisher., (n. s.), V, 6, 1929:109 (shores of Canada, development); Jeffers, Contrib. Canad. biol. fisher., (n. s.), VII, 15–23, 1923:8 (Belle-Isle Strait).

I D 1, II D 45–50, A 37–41, P 15–16, V 5, gill-rakers 9–10, vertebrae 54. Gill-rakers of normal structure. About 29 pores* in the lateral line, spaced more widely in the posterior portion of the body, the lateral line with a slight curve beneath the posterior end of the pectoral fin. Head not large, 16.0–17.2% of body length. Interorbital space very narrow, 7.9–8.9% of body length. One pair of long barbels at the anterior nostrils, one shorter

* To be exact, pairs of pores.

barbel on the chin and one small barbel at the tip of the snout. The upper jaw extends slightly beyond the vertical of the rear edge of the eye. The eyes are large, their lateral diameter 22.2–24.4% of the head length, 2 1/2 to 3 times as great as the interorbital space. In per cent of body length: anteanal distance 37.4–43.0, antedorsal 14.4–15.1, length of pectoral fin 13.1–14.9, length of pelvic fin 7.4–8.9, base of first dorsal fin 10.5–11.8, base of second dorsal fin 58.3–59.2, base of anal fin 41.7–45.3, length of first dorsal fin ray 13.2–14.2, the depth of caudal peduncle 3.3–3.7, the length of the caudal peduncle 16.0–17.2. In per cent of head length: the length of the snout 24.4–27.1, the length of the upper jaw 43.9–48.0, the length of the lower jaw 48.7–55.8. The coloration of the dorsum reddish-brown, paler on the sides, with irregular brown spots in the rear of the body; belly with brownish dots. First dorsal fin ray blackish-sky-blue, the other unpaired fins grayish-blue or ashen gray with dark spots at the posterior end of the second dorsal and anal fins and above and below the caudal fin, a few spots of slightly smaller dimensions on the entire extend of the second dorsal. Pectoral fins sky-blue-black, belly grayish-sky-blue. Reaches 41 cm in length, usually 20–35 cm (6 specimens).

DISTRIBUTION. Northern part of the Atlantic Ocean at the coasts of Europe northward to the western part of the Barents Sea (to 70° 55' north latitude, 33° 30' east longitude), all around Iceland, along the coasts of Norway, Faroe Islands, southward to the southern end of Great Britain and the Bay of Biscay (to Bordeaux), in western part of Baltic Sea and occasional specimens to the Bay of Finland*. Very common along the coasts of Norway. Common along the coasts of North America from Gulf of St. Lawrence (and perhaps even farther) to Narragansett Bay, at depths to Cape Fear.

BIOLOGY is very little known. Keeps to the bottom usually at moderate depths, but quite often is found near the shores at very shallow depths; it was, however, found on the slopes of the continental shelf at a depth of 550 meters and even 1,300 meters. In the southern parts of its range along the coasts of North America it is generally found at greater depths. Prefers soft muddy bottom; apparently does not undertake large migrations, with the exception of small seasonal movements in the fall to the shores to lesser depths, and in the spring from the shores to greater depths. Time of spawning not definitely known but apparently is very prolonged; from January to August and even later, to September–October, at the coasts of Canada from June to September inclusive; development of eggs takes place here at 13–19° C. Feeds on crustaceans, worms and mollusks.

COMPARATIVE NOTES. *Motella caudacuta* Storer (= *Rhinone-mus caudacuta*) undoubtedly is a form identical with *E. cimbrius*. Specimen examined by Storer had a somewhat larger number of rays in second dorsal fin (53) and in anal fin (48). Such a number of rays in these fins in *E. cimbrius* has been found by no one else on specimens from European shores or North American shores. In our specimens from the coasts of North America (39° 55' north latitude, 71° 41' east longitude) [editor's note—should be west longitude] II D 49, A 41. Goode and Bean (l. c.), who established the identity of this species considered that Storer had committed an error in his count of fin rays.

* Number 26353 of the collection of the Zoological Institute. Delivered by V. S. Mikhin.

5. Genus **RANICEPS** (CUVIER) OKEN

"Les *Raniceps*" Cuvier, *Regne animal*, ed. I, II, 1817:217 (Type: *Blennius raninus* L. = *R. raninus*). — *Raniceps* Oken, "Isis," 1817:1182 (Type: *B. raninus* L. = *R. raninus*, secundum Cuvier).

Olfactory lobes placed between the nasal capsules and the forebrain. The upper broader portion of the postcleithrum separated into a distinct bone. Body greatly depressed anteriorly. Two dorsal fins and one anal fin, first dorsal fin small, consisting of only 3 rays, the second of more than 60 rays. Second dorsal and anal slightly joined with the caudal. Lower jaw shorter than upper. A barbel below the chin. Teeth on head of vomer, premaxillary and dentary small, hooklike, bent, in several rows, larger in the outer row. Head of vomer moderately developed. Lateral line undeveloped (see page 101). Pit organs on the head. Mucous cavity of considerable size, not closed anteriorly, middle crests of frontals are developed. Facial nerve emerges through a notch. Skull very broad, its width almost equal to its length. Py-
96 loric caeca two, rudimentary. Swim-bladder normally developed.

FIGURE 15. Distribution of *Raniceps raninus*

SKELETON. Skull high (A), little lower in front than behind, its greatest height contained little more than 3 times in its base. The lower profile of the skull presents a slightly curved line, the parasphenoid with a slight curve under the anterior end of the prootic; the basioccipital is slightly curved downward. The upper profile of the skull is slightly curved. Crest of the supraoccipital with a small indentation at the level of the rear end of the epiotic, developed as well in the posterior part of the supraoccipital above the lateral occipital and also in the forward portion between the parietals; the crest on the frontals is absent. Anterior end of mesethmoid descending rather steeply, straight, with a small convexity in the middle, placed at a right angle to the upper, slightly raised edge. Orbital space elongate, its height contained about 3 times in the length of its base. Notch of the facial nerve deep, its rim with small ridges at the junctions of the forward end of the prootic with the alisphenoid above and with the ascending processes of the parasphenoid below. A small foramen for the glossopharyngeal nerve on the opisthotic. The skull from above (B) is very broad, its greatest width almost equal to the length of its base. The

edges of the skull are limited from the sides with wavy lines, somewhat convergent anteriorly. The lateral edges of the pterotic with projections in the middle and notches in the forward part. The sphenotic is slightly expanded laterally. The lateral edges of the frontals are without noticeable notches in

the interorbital region. The lateral ethmoids are almost equally expanded transversely as well as longitudinally, considerably extending on the sides and forward from beneath the front ends of the frontals. The anterior end of the mesethmoid lies beneath the anterior end of the vomer. The crests above the sensory canals on the pterotic and frontals are broad, lying very close to these bones. Mucous cavity large, shallow, without sharply defined edges, not divided in half by the posterior end of the central crest. The central crests are short, their edges not fused with the edges of the lateral crests and not closing the mucous cavity in front. The foramen of the recurrent dorsal branch of the facial nerve lies in the anterior part of the parietal, not covered from above, small crest-like projections located posterior to them. Vomer broad when viewing the skull from below (C), flat, its head with numerous teeth, arranged in a wide band along its forward edge. Parasphenoid flat, broad, its rear end from below on the same level with greatly developed laterally flared walls of the skull. The skull from back (D) not high and broad, with a few flattened and dorsally broadened supra-

97 occipital crests rising above. Base of the skull broad, lateral sides of the skull limited by curved lines. The articular process of the hyomandibular long and broad, the lower process narrow, as are the opercular and preopercular processes, closely approaching and connected with each other for almost their entire length. Both branches of the posttemporal long, the lower almost half the length of the upper. The postcleithrum sharply curved at the upper end, not widened even above the curve; the upper portion of this bone is greatly broadened and separated as a distinct bone. The pelvic bone processes are long. The operculum is narrow, with a deep notch in its lower edge and pointed at both ends. The urohyale is of small size, narrow with broadened lower edge. Parapophyses elongated, widened at their bases. This description is based on one skeleton.

DISTRIBUTION. One species at the European coasts of the Atlantic Ocean (Figure 15).

COMPARATIVE NOTES. The structure of the suborbitals in *Raniceps*, as indicated by Dietz (1921:440), is of irregular form, and the third has the same appearance as in the *Scleroparei*, without any distinction from the structure of these bones in the other gadoids, for example *Lota*. Connection of the third suborbital with the preoperculum none, it ends well in advance of the preopercle. This genus appears to be the most divergent group from all *Lotinae* (the location of olfactory lobes and the recently discovered peculiarity—a second postcleithrum).

1. *Raniceps raninus* (Linné) (Tables III, XXV, LXVIII)

Blennius raninus Linné, Syst. nat., ed. X, 1758:258 (habitat in Sueciae lacubus). — *Blennius raninus* and *B. fuscus* Müller, Zool. Dan. prodr., 1776:43. — *Gadus raninus* Müller, Zool. Dan., II, 1784:6, pl. XLV. — *Gadus fuliginosus* Walbaum, Schr. Ges. Naturf. Fr. Berlin, V, 1784:107. — *Gadus trifurcus* et *G. minimus* Walbaum in: Artedi, Gen. pisc., 1792:139, 143 (ex Pennant). — *Batrachoides blennoides* Lacepède, Hist. nat. poiss., II, 1800:451, 456. — *Phycis ranina* Bloch ed. Schneider, Syst. ichth., 1801:57. — *Blennius trifurcatus* Shaw, Gener. zool., IV, 1803:174. — *Betrachocephalus blennoides* Hollberg, Göteb. Vettensk. Handl., III, 1819:39, fig. — *Raniceps trifurcatus* et *R. jago* Fleming, Hist. brit. animals, 1828:194. — *Raniceps niger* Nilsson, Prodr. ichth. Scand., 1832:50. — *Raniceps fuscus* Krøyer, Danm. Fiske, II, 1843–1845:231, fig. — *Raniceps raninus* Day, Fish. Gr. Brit. Irel., I, 1884:320, pl. XC, f. 1 (synonymy); Smitt, Scand. fish., I, 1893:558, pl. XXV, f. 3 (synonymy, distribution, biology); Otterström, Danm. Fauna, Fisk., II, 1914:44 (description, distribution).

DISTRIBUTION, BIOLOGY. Möbius u. Heinke, Fische Ostsee, 1883:238 (Kiel and Meklenberg Harbors); Hjort, Rapp. Proces. -Verb., X, 1909:67 (spawning grounds); J. Schmidt, ibid.:109, 147 (spawning conditions); De Buen, Fauna ict., 1935:77 (Atlantic coast of Pyrenee Peninsula).

ID 3, IID 63-64, A 57-60, P 21-22, gill-rakers 11-12, vertebrae 47. Pectoral fins broad, rounded, reaching beyond origin of anal fin. Second pelvic fin ray elongate, much longer than the other rays, almost reaching the origin of the anal fin. In per cent of body length: anteanal distance 43.3-44.5, antedorsal distance 30.7-30.9, length of pectoral fin 15.2-15.3, length of pelvic fin 11.6-12.2, base of first dorsal fin 1.7-2.2, base of second dorsal fin 51.4-53.6, base of anal fin 42.2-44.5, height of first dorsal fin 2.3-2.7, depth of caudal peduncle 3.4-3.7, its length 4.0-4.5; length of head 27.2-27.3. In per cent of head length: length of snout 23.1-27.6, horizontal diameter of eye 15.2-17.5, length of upper jaw 54.9-57.6, length of lower jaw 55.1-57.0, interorbital space 26.2-26.5, length of barbel 6.7-7.4. Coloration uniformly brownish black with a bluish cast, lips whitish, the fins same color as the dorsum; the tips of the pelvic fin rays and narrow stripe along the second dorsal, forward portion of anal and end of caudal are whitish. Length 20-25, ultimately to 30 cm. (3 specimens).

DISTRIBUTION. Rather restricted: European coasts of the Atlantic Ocean from Trondheim Fjord to the Bay of Biscay and the Iberian Peninsula, around Great Britain and Ireland, eastward to Skaggerak, to Kiel and Meklenberg Harbors. Linné erroneously indicated also Swedish lakes.

BIOLOGY. Lives in coastal waters at shallow depths, generally 10 to 20 meters, more seldom found at greater depths — to 75 to 100 meters. Lives as solitary individual, does not undertake extensive migrations, limiting itself apparently to local movements. Spawning takes place during summer and fall at temperatures not lower than 10 to 12°C, at shallow depths (75 and even 50 meters), near shores, apparently throughout the entire range of distribution. At any rate, spawning has been established along the coasts of Great Britain and Ireland, in the North Sea, the English Channel, Skaggerak and even in Sesser Belt. Feeds on crustaceans, mollusks, worms, echinoderms and apparently fish.

COMMERCIAL VALUE none, caught individually and occasionally, practically useless for food.

COMPARATIVE NOTES. Tubercles which occur on the anterior part of the body above the pectoral fins in some specimens are caused by folds of the skin and the loss of scales in those places. It is possible that there are also pit organs present. This characteristic distinguishes *R. trifurcatus* and *R. jago* Fleming. The lateral line in all *Raniceps* specimens examined is absent on the body; however it is indicated and shown on the illustration by Day (1. c.). On the other hand, Otterström (1. c.) indicates that pronounced lateral lines in this species are not found. Dr. Norman, who examined at my request the specimens in the British Museum, informs me that the lateral line is sometimes absent; however, in well preserved specimens it is observable on the forward portion of the body.

6. Genus **PHYCIS** Röse

Phycis (non *Phycis* Fabricius 1798, Insecta Lepidoptera = *Phycita* Fabricius 1798) Röse in: Artedi, *Synonymia*, 1738:111 (Type: *Phycis* of Aristotel = *Phycis tinca* Bloch et Schneider = *Ph. blennoides*)*; Bloch ed. Schneider, *Syst. ichth.*, 1801:56 (Type: *Ph. tinca* Bloch et Schn. = *Ph. blennoides*).

Two dorsals and one anal fin, the first dorsal fin consisting of 8 to 11 rays, the second of more than 50. The second dorsal and anal fins are separated from the caudal fin by a small interspace. The pelvic fins consist of 3 rays: 2 long and one rudimentary. The frontals are fused into one unpaired bone. The lower jaw is shorter than the upper. A barbel below the chin always present. Teeth small, in several rows on the premaxillary, dentary and head of vomer. Head of vomer weakly developed. Lateral line on anterior half of body in the shape of a low arch placed above the midline, and beyond it runs along the middle of the body, straight, continuous almost to the end of the anal fin, and discontinuous beyond. Pores on the head**.

99 The mucous cavity is opened or closed anteriorly; there is a notch on the sides of the skull for the facial nerve. Opisthotic with a large posteriorly directed process for the articulation of the pectoral girdle; posttemporals and supracleithrum normally developed.

SKELETON. Skull not high (A), its greatest height in all species contained about 3 to $3\frac{1}{2}$ times in the length of the base. The bones in the base of the skull are placed along a straight line, only the vomer and the basioccipital are slightly curved downward. The upper profile of the skull presents a more or less curved line, gradually descending anteriorly. The supraoccipital crest is developed only in the rear portion over the exoccipitals; the crest on the front part of the supraoccipital between the parietals and frontals is absent; the rear edge of the crest is placed above the rear edge of the basioccipital or beyond it. The anterior edge of the mesethmoid is slightly inclined forward, with a small notch in the middle or straight, arranged at an obtuse angle to its upper edge. The orbital space is elongate, its base $2\frac{1}{4}$ to 3 times greater than its height. The notch of the facial nerve enters the anterior edge of the prootic rather deeply, widely open in front, its edges with small projections at the junctions of forward end of the prootic with the ascending process of the parasphenoid beneath and with the alisphenoid above. A small but noticeable foramen for the glossopharyngeal nerve on the opisthotic. The skull is broad from above (B); the length of its base exceeds its greatest width by approximately half again, its width gradually diminishes toward the interorbital region. The lateral edges of the pterotic are convex, rounded, with a small notch in front. The frontals gradually narrow toward the interorbital region, broadening somewhat in front. The lateral ethmoids are expanded laterally, almost not covered by the front edge of the frontals. The frontals in the middle or in the posterior part of both sides with a small transverse crest diverging from the lateral crest toward the midline of the skull. The anterior edge of the mesethmoid is located over the anterior end of the vomer or slightly behind it. The crests above the sensory line canals on the frontals and pterotic are very wide, their edges somewhat raised. Mucous cavity rather deep with well limited edges,

* Although the type species of the genus *Phycis* was named non-binomially, since *Phycis* Fabricius 1798 was referred by him to *Phycita* and at present is not being used in entomology, the generic name should be retained.

** The number and location of pores was not studied in all specimens.

slightly divided into two parts at the base by a low longitudinal partition. The edges of the median crest of the frontals almost touch or are connected to the lateral crests, leaving the mucous cavity open anteriorly (in *Ph. phycis*) or closing it (in other species). The foramina of the recurrent dorsal branch of the facial nerve on the parietals are located at the very forward edge of the weakly developed crests, slightly covered or not covered at all by the latter from above. A process of the opisthotic to which is connected the posttemporal extends to the side of the epiotic on each side. From below the skull (C) along the entire anterior edge of the vomer is an elevation with a wide band of very small teeth placed in a few irregular rows. The parasphenoid is broad, especially posteriorly, its lower edge for its entire stretch is flat. The rear ends of the occipitals extend from the sides of the basioccipital or are concealed on each side of the skull in the back. In the opisthotic notch a process of these bones protrudes. The skull from the back (D) with a high rising supraoccipital crest somewhat broadened and flattened at the top. The processes of the opisthotic are placed beneath the epiotic over the foramen of the vagus nerve. The auditory region of the skull is convex from the sides. The skull from beneath is semispheric, even somewhat flattened. The articular process of the hyomandibular is broad for its entire length, extending somewhat forward over the opercular process; the opercular process is shorter than the lower process, which is not too broad; the preopercular process is located along the opercular one, both are fused for their entire stretch and are directed somewhat downward. The posttemporal is not large, the lower limb is almost twice as short as the upper. The postcleithrum is thin, long, slightly arched at its upper end. The pelvic bone is of considerable size, its lower process thin and long. The operculum is almost in the shape of an equilateral triangle, its lower edge with a small notch and both ends pointed. The preopercle in front has a wide downward directed process. The urohyale is rather wide. The parapophyses are long, thin, slightly broadened at their bases.

This description is based on one skeleton of *Ph. phycis*, one *Ph. blennoides*, and one *Ph. chesteri*.

DISTRIBUTION. Northern section of northern part of Atlantic Ocean, one species at the coasts of North America, two species along the coasts of Europe and in the Mediterranean Sea (Figure 16). In a fossil state *Phycis* (or *Urophycis*) are known from the Lower Pliocene.

COMPARATIVE NOTES. *Phycis* and *Urophycis*, like some other genera, form a group within the subfamily *Lotinae*, very distinctly differing from the other genera by a whole complex of characters (frontals fused into an unpaired plate, structure of pelvic fins).

Hypsiptera argentea Günther (Cat. Fish., II, 1860:386), as indicated by Lütken [Ann. Mag. Nat. Hist., (5), VII, 1881:123; Vidensk. Medd. Naturhist. Foren. Kbhvn., (1881), 1882:252], appears to be a pelagic form of *Phycis*; in the opinion of Emery (Mith. Zool. Stat. Neapel, VI, 1886: 159), it is *Ph. phycis*. In regard to *Ph. macronemus* of Rafinesque, described very incompletely, it is very difficult to say anything.

FIGURE 16. Distribution of the genus *Phycis*
 1-*Ph. phycis*; 2-*Ph. blennoides*; 3-*Ph. chesteri*.

Key to the Species

- 101 1 (2). About 130 transverse rows of scales, about 11-12 scales between first dorsal fin and lateral line. First dorsal fin without any elongate rays, pelvic fins reaching origin of anal fin. Mucous cavity not closed in front of skull 1. *Ph. phycis* (L.)
- 2 (1). Fewer than 120 transverse rows of scales, 5-6 scales between first dorsal fin and lateral line. Third ray of first dorsal fin greatly elongate, pelvic fins reaching far beyond anal fin origin. The mucous cavity on the skull closed in front.
- 3 (4). About 100 transverse rows of scales, gill-rakers about 13. 2. *Ph. blennoides* (Brunn.)
- 4 (3). About 90 transverse rows of scales, gill-rakers about 21. 3. *Ph. chesteri* (Goode et Bean)

1. *Phycis phycis* (Linné) (Tables XXVI, LXVIII)

Gadus phycis Linné, Syst. nat., ed. XII., 766:442 (Mediterranean Sea). — *Phycis mediterraneus* DeLaroche, Ann. Mus. Paris, XIII, 1809:332. — *Phycis furcatus* Bowdich, Excurs. Madeira, 1825:125 f. 128 (Madeira). — *Phycis limbatus* Valenciennes in: Webb et Bertelot, Hist. nat. iles Canaries, II, 2, 1825:78, pl. XIV, f. 2 (Canary Islands). — *Urophycis mediterraneus* Jordan a. Gunn, Proc. Acad. Nat. Sci. Phila., 1898:347. — *Phycis phycis* Fowler, Marine fish. W. Africa, I, 1936:474.

DISTRIBUTION, BIOLOGY. Bibron, Exp. sci. Morée, III, 1, 1833:80 (coasts of Greece); Guichenot, Explor. sci. Algérie, Zool., V, 1850:103 (Algeria); Steindachner, Sitzungsber. Akad. Wiss. Wien, math.-naturw. Cl., LVII, 1, 1868:701 (Lisbon, Cadiz, Straits of Gibraltar, Malaga, Barcelona, Teneriffe Island); Kolombatovič, Fische Spalato, 1882:40 (Adriatic Sea; rare); Rocherbrune, Faune Senegamb., Poiss., 1883:114 (south to Cape Verde); Vaillant, Exp. sci. "Travailleur" et "Talisman", Poiss., 1888:289 (Bay of Biscay); D'Ancona, Fauna flora golfi Napoli, 38, 1933:239 (reproduction).

ID 10-11, II D 60-63, A 58-64, P 17-18, gill rakers 12-13, scales 120-140, 11-12 scales between first dorsal fin and lateral line, vertebrae 47, mucous cavity open in front, foramina of the recurrent dorsal branch of the facial on the palatine are not covered by crests, skull broad in the inter-orbital area, about 25% of its length. Interorbital space broad, 17.0-19.7% of the head length. Eyes not large, 18.3-22.4% of head length. Jaws short, upper jaw 45.0-47.2, lower 51.0-52.3% of head length. Caudal peduncle short and high, its length 4.1-4.6%, its depth 4.8-5.2% of body length. Pelvic fins usually reach only the beginning of the anal fin, constituting 22.3-22.8% of the body length. First dorsal fin has no elongated rays, its height scarcely exceeding the height of the second dorsal, constituting only 8.0-9.3% of body length. Posterior ends of second dorsal and anal fins appear slightly rounded at the height of the angles. In per cent of body length: anteanal distance 40.6-45.2, antedorsal distance 26.1-28.2, length of pectoral fin 14.6-15.7, base of first dorsal fin 6.4-8.0, of the second dorsal fin 49.2-52.7, base of anal fin 46.8-48.5, length of head 21.8-22.7. Percentages of head length: snout length 26.6-28.7, length of barbel 25.4-27.0. Coloration brown blackish or reddish, darker on back, lighter on sides and belly. Length to 60 cm and more, most often 15-25 cm. (5 specimens).

DISTRIBUTION. Eastern coasts of the Atlantic Ocean, along the shores of Europe north to the Bay of Biscay, south along the coasts of Africa to Cape Verde. In the Mediterranean Sea along the shores of the Iberian and Appenine Peninsulas, Sicily and Algeria, rare in the Adriatic Sea.

BIOLOGY. Lives at moderate depths but is found at depths of 600 meters or more. Rather rare but in some places is found more often than *Ph. blennoides*. Breeds apparently throughout its entire range; larvae and post-larval stages were found in the Mediterranean as well as in the Atlantic (Bay of Biscay). Spawning time January to May.

2. *Phycis blennoides* (Brünnich) (Tables III, XXVII, XVIII)

Gadus blennoides Brünnich, Ichth. Massil, 1768:241 (Mediterranean Sea at Marseilles). — *Gadus albidus* Linne ed. Gmelin, Syst. ichth., I, 1788:1171. — *Gadus bifurcus* Walbaum in: Artedi, Gen. pisc., 1792:137. — *Blennius gaboides* Lacépède, Hist. nat. poiss., II, 1800:484. — *Phycis blennoides* et *Ph. tinca* Bloch ed Schneider, Syst. ichth., 1801:56, Pl. XI. — *Batrachoides gmelini* Risso, Ichth. Nice, 1810:143, pl. VI, f. 6 (Villafranche). — *Phycis furcatus* Fleming, Hist. brit. animals, 1828:193. — *Phycis blennoides* Day, Fish. Gr. Brit. Irel., I, 1880-84:303, pl. LXXXV, f. 2 (bibliography, distribution). — *Phycis albidus* Vaillant, Exp. sci. "Travailleur" et "Talisman", Poiss., 1888:288, pl. XXVI, f. 4, 4a. — *Phycis blennoides* Smitt., Scand. Fish., I, 1893:540, Pl. XXI, f. 2 (bibliography, distribution).

DISTRIBUTION, BIOLOGY. Guichenot, Exp. sci. Algérie, Zool., V, 1850:103 (coasts of Algeria); Collett, Christ. Vidensk.-Selsk. Forh., (1902), 1903:51 (northward to 69° north latitude); Saemundsson, Synops. fish. Iceland, 1927:30 (Iceland); D'Ancona, Fauna flora golfo Napoli, 38, 1933:233 (reproduction); Cipria. Mem. talassogr. ital., 1936:237, 1, fig. (development); Lönnberg, Fauna och Flora, Uppsala, 1937:153 (Kattegat).

I D 8-9, II D 60-64, A 50-55, P 16-18, gill rakers 12-13, scales about 100, 5-6 scales between the first dorsal fin and lateral line, vertebrae 49. Mucous cavity on the skull is closed in front, the foramen of the recurrent dorsal branch of the facial nerve on the palatine is slightly covered by small crests; the skull is narrowed in the interorbital region, nearly 15% of its length. The interorbital space is narrow, 11.7-13.8% of head length. The eyes are large, 25.0-29.0% of head length. Jaws long, the upper 48.2-50.7%, lower 53.1-55.1% of head length. Caudal peduncle long and low, its length 3.2-5.9%, depth 2.9-3.8% of body length. Pelvic fins long, extending to the middle and even beyond the anal fin, constituting 35.7-43.9% of body length. First dorsal fin higher than the second, its third ray slightly longer, constituting 12.2-17.2% of body length. The rear ends of the second dorsal and anal fins are rounded. In per cent of body length: anteanal distance 41.8-44.8, antedorsal distance 22.8-26.2, length of pectoral fin 13.8-15.5, base of first dorsal fin 6.5-7.5, of second 52.5-53.0, the base of the anal 42.0-44.1, the head length 19.3-22.5. In percent of head length: snout length 26.2-26.3, barbel 18.4-21.0. Coloration brown or grayish-pink, belly whitish or silvery. Length to 75 cm., generally 15-30 cm. (5 specimens).

DISTRIBUTION. Eastern coasts of the Atlantic, north along the coasts of Europe occasionally to the Vestarol Islands (68.5° north latitude), eastward at Skaggerak and Kattegat, at the western part of the southern coasts of Iceland, around Britain and Ireland, Iberian Peninsula and Madeira, along the coast of Morocco in Africa. Western part of the Mediterranean along the European coast and Algeria, in the Adriatic. It is found in places very near to our waters; in connection with the general warming up in recent years it is possible that this species enters our waters.

BIOLOGY. Prefers sandy and muddy bottoms. Feeds on crustaceans and fish. Spawns in the spring extending into summer inclusive of August.

103 **Spawning grounds:** Mediterranean, Atlantic along the shores of Great Britain. In the Mediterranean reproduction takes place in January-May.

COMMERCIAL IMPORTANCE very small, used as food but seldom caught.

COMPARATIVE NOTES. The species is well distinguished from the preceding one in external characters, differs considerably from the preceding also osteologically by its narrower skull in the interorbital space, the closed mucous cavity and in other characters. The foramina of the recurrent dorsal branch of the facial nerve on the parietals are placed beneath small crests and not in front of them as in the preceding species. *Batrachoides gmelini* Risso, judging from the description and figure, is apparently identical to this species and not to the preceding.

3. *Phycis chesteri* Goode et Bean (Tables XXVIII, LXVIII)

Phycis furcatus (non Fleming) Storer, Boston Journ. Nat. Hist., I, 1837 (coast of the state of Massachusetts). — *Phycis chesteri* Goode a. Bean, Proc. U. S. Nat. Mus., 1878:256 (Cape Ann, Atlantic); Goode a. Bean, Oceanic ichth., 1895:360, f. 313 (measurements, distribution). — *Urophycis chesteri* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2556; Bigelow and Welsh, Fish. gulf Maine, 1925:456, f. 227 (biology).

I D 10, II D 54, A 47, P 16*, gill-rakers 21, scales 90, 5-6 between the first dorsal fin and the lateral line, vertebrae 49. Mucous cavity on skull locked in front, recurrent dorsal branch of the facial nerve foramen on the palatine is hardly covered by small crests, the skull is narrow in the inter-orbital region, about 15% of its length. The interorbital space is narrow, about 13.4% of the head. The eyes are large, 31.7% of the head length. The jaws are long, the upper 48.6, lower 58.9% of the head. Caudal peduncle long and not deep, its length 5.2, depth 2.4% of body length. The pelvic fins are long, extending beyond the middle of the anal fin, and constituting 49.7% of body length. The third ray of the first dorsal fin is greatly elongated and extends to the center of the second dorsal fin, constituting 33.7% of body length. The pectoral fin is also slightly longer than in the preceding species, and constitutes 18.7% of body length. Posterior ends of the second dorsal and anal fins rounded. In per cent of body length: anteanal distance 39.4, antedorsal distance 22.6, base of first dorsal 5.9, second 51.1, base of anal fin 42.6, length of head 19.0%. In per cent of head length: snout length 28.0, barbel length 12.9. Coloration in alcohol red or reddish brown on the back, muddy or reddish-white below, dorsal fins of the same color as the dorsum, with dark edges. Length to 28 cm. (1 specimen).

DISTRIBUTION. Atlantic Ocean off the coast of North America from Newfoundland (Laurentian Channel) to Cape Lookout.

BIOLOGY. Very little studied. Keeps at the bottom at great depths 200-900 meters and somewhat greater (1,000 meters), known on occasion in lesser but still somewhat considerable depths (60 meters). Judging from the catch of adult fish with mature sexual products and pelagic young spawning apparently occurs in summer and fall.

104 COMPARATIVE NOTES. By the structure of its skull and other osteological characters this species is close to *Ph. blennoides*, and bears a resemblance in a number of other characters (the lower and longer caudal peduncle, narrower interorbital space, elongated jaws, large eyes, elongated fins). They differ from each other by the fact that *Ph. chesteri* has much longer pectoral and pelvic fins, particularly the third ray of the first dorsal, and the somewhat lesser length of the barbel. Measurements of three specimens of *Ph. chesteri* given by Goode and Bean (l. c.) are close to the measurements of our specimen. Craniologically the species differs by the fact that *Ph. chesteri* has the upper profile of its skull less curved, has no notch in the front edge of the mesethmoid, the supraoccipital crest scarcely extends past the basioccipital, part of the skull behind the forward angle of the sphenotic is somewhat shorter than in *Ph. blennoides*, and this angle is rounded. Investigation of a greater number of fish and skulls of both of these forms will perhaps prove them to be subspecies. *Ph. furcatus* Storer should be considered identical to this species inasmuch as Storer defined it as *Ph. furcatus* = *Ph. blennoides*, a species much closer to *Ph. chesteri*.

* According to Goode and Bean, I D 9-10, II D 55-57, A 56, P 17-18, V 3.

7. Genus **UROPHYCIS** Gill

Urophycis Gill, Proc. Acad. Nat. Sci. Phila., (1863), 1864:240 (Type: *Blennius regius* Walbaum = *U. regius*). — *Emphycis* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2552 (Type: *Gadus tenuis* Mitchill = *U. tenuis*).

Similar to *Phycis*, but the opisthotic process is almost undeveloped, the posttemporal and supracleithrum are rudimentary.

SKELETON. Skull in lateral aspect (A) not high, its base exceeds the greatest height by $3\frac{1}{4}$ to 4 times. The lower edge of the bones of the base of the skull in a straight line, curved only at the ends. The upper profile of the skull is slightly curved at the anterior end of the supraoccipital or in the interorbital region, for the rest of the length it is rather straight, slightly descending forward. The frontal and supraoccipital crest anteriorly between the parietals is absent, developed only in the posterior part of the supraoccipital above the exoccipitals, extending back beyond the posterior end of the basioccipital. The front edge of the mesethmoid is almost vertical, slightly rounded or with a slight notch placed almost at right angles to the upper surface. The greatest height of the elongate orbital space is contained $2\frac{1}{2}$ to 3 times in its base. The notch of the facial nerve is rather deep, the anterior and ventral edges slightly rounded. Foramen of the glossopharyngeal nerve on the opisthotic is not large but noticeable. The skull from above (B) is broad posteriorly, somewhat narrowing anteriorly, its greatest width contained $1\frac{1}{2}$ to 2 times in its length. The lateral edges of the pterotic are rounded, with a slight notch in front, almost parallel to each other; beyond them are located the upper edges of the opisthotic. The edges of the sphenotic are somewhat convergent in front. The frontals are short and rather broad, gradually narrowing in the middle and somewhat broadening anteriorly. The lateral ethmoids are expanded laterally and almost entirely extend anteriorly from beneath the frontals. Small transverse crests extend from the lateral crests in the middle of the frontals toward the midline of the skull in some (*U. regius*, *U. tenuis*). The anterior edge of the vomer protrudes slightly from beneath the anterior edge of the mesethmoid or is located beneath it. The crests over the sensory canals on the pterotics and frontals are not extremely broad, their edges are slightly elevated. The mucous cavity is quite deep, its edges are distinctly limited, at its base it is divided by a longitudinal partition open in front (*U. regius*, *U. chuss*, *U. floridanus*) or closed (*U. tenuis*, *U. brasiliensis*) by the fused edges of the lateral and median crests of the frontals, forming in such case
105 canals which are closed above. The crests on the parietals are scarcely developed, the foramina of the recurrent dorsal branch of the facial nerve are located at their very forward edge, scarcely covered by them. Along the anterior edge of the head of the vomer on the skull below (C) from either side of its apex there is a slight elevation with from 1 to 3 very irregular rows of small teeth. The teeth at the apex of the head of the vomer are smaller and placed in narrower rows. The parasphenoid is broad, its lower surface for its entire length flat. The lateral occipitals do not extend from the sides of the basioccipital. The opisthotic processes to which the pectoral girdle is attached are absent or rudimentary. The skull from beneath (D) is hemispherical or flattened at the base. The supraoccipital crest extends slightly above the skull, its upper edge somewhat broadened, flat. The articular

process of the hyomandibular extends more or less above the opercular process; the lower process is rather narrow at its base, slightly broadened toward the tip; the opercular process is broad at the base and narrows toward the tip. The preopercular process is absent. The posttemporals and supracleithrum are scarcely distinguishable, of very small size. The postcleithrum is thin, long, somewhat curved at its upper end. The pelvic bone has a thin and long lower process. The operculum is rather narrow and blunt at its upper end with a deep notch along its lower edge, and both lower ends pointed. The preopercle in front with a sharp or rounded upward directed process. The urohyale broad, somewhat pointed or rounded posteriorly. The parapophyses are rather long, thin, broadened at the base.

Description given from one skeleton of *U. regius*, one *U. chuss*, one *U. floridanus*, two *U. tenuis* and two *U. brasiliensis*.

DISTRIBUTION. Bipolarly distributed genus: 6 species are known in temperate waters and at depths in subtropical parts of the Atlantic Ocean along the coasts of North America; one species at the coasts of South America (Figure 17). From the 6 species of the northern hemisphere only 3 appear to be widely distributed and well known, the others have narrow distributions and are little known, often only from a few specimens.

COMPARATIVE NOTES. From the general structure of the skull as well as from external characters, the genera *Phycis* and *Urophycis* and the genera *Eleginus* and *Microgadus* cannot be separated into two independent genera. However, the structure of the upper part of the pectoral girdle (posttemporals, supracleithrum) and the portion of the skull (opisthotic) to which the pectoral girdle is connected have considerable distinctions indicated in the diagnoses of these genera. By these peculiarities the genera *Phycis* and *Urophycis*, externally resembling each other as much as do *Eleginus* and *Microgadus*, most naturally fall into two genera, one of which like *Eleginus*, is found along the coasts of Europe, and the other like *Microgadus* at the coasts of North America. The difference consists only in that *Phycis* and *Urophycis* are not found in the Pacific Ocean and range farther southward. By basic osteological characters which are placed at the base of the classification of the family species of the genera *Phycis* and *Urophycis*, like *Eleginus* and *Microgadus*, are almost identical and form two parallel series. It must be pointed out that the changes in numbers of scales in osteologically studied species of the genera *Phycis* and *Urophycis* parallel the changes in basic characters which are placed at the base of the classification of the family, with the only difference being that in the series of species of *Phycis* the number of scales diminishes while in the series of species of *Urophycis* it increases. Because of the fact that the osteology of some of the rare forms has not been studied, regardless of the presence of good osteological distinctions in those forms which have been examined in this respect, the diagnostic keys to the species have been compiled only from external characters, mainly from the numbers of transverse rows of scales difficult to count. It is possible that after studying the osteology of all species of *Urophycis* they will place themselves in the same series as in the key to the species. Species of the genus *Urophycis*, not studied osteologically, however, are not included in the classification of the family but are placed at the end after the species which have been studied osteologically. Until the osteology of these three little-studied species is investigated it is difficult to say

positively to which of the two genera *Urophycis* or *Phycis* they should be referred, but yet they are very isolated and very remote from the species of the genus *Phycis* and their distribution speaks for their belonging rather to the genus *Urophycis*.

- 107 *Ph. borealis* Saemundsson (Vidensk. Medd. naturhist. Foren. Kbnhvn. 65, 1913:65; *ibid.*, 74, 1922:185), described from five specimens from the southwestern coasts of Iceland (see also his Synops. fish. Iceland, 1927:31), is the closest and perhaps identical to *U. tenuis* (I D 10, II D 55-58, A 49-51, P 16, scales 160, dorsal fin with short thread-like ray, pelvic fin does not reach origin of anal fin, on the drawing 21% of body length). By the number of transverse rows of scales these specimens cannot be referred to *Ph. phycis*, nor to *Ph. blennoides* or *Ph. chesteri*; besides, from the first they differ by the elongated ray of the first dorsal fin, from both the latter by the shorter pelvic fins, not reaching the origin of the anal fin and the not so greatly elongated rays of the first dorsal fin. *Ph. borealis* differs from *U. regius*, *U. cirratus*, *U. floridanus* and *U. earllei* by the elongated first dorsal ray, from *U. chuss* by much shorter pelvic fins and not so greatly elongated ray in the first dorsal fin. Not knowing the structure of the skull we cannot say to which genus these specimens should be referred. If the opisthotic has no process, characteristic of *Phycis*, then *Ph. borealis* would be nearer to or perhaps identical with *U. tenuis*, but if the process is present, then it should be a distinct species of the genus *Phycis*, which is scarcely possible, because it is difficult to admit that this species possessed quite a small range and was so little known in spite of not living at very great depths (40-120 meters). The penetration to the coasts of Iceland of an American species is most likely*.

Key to the Species

- 1 (4). Not more than 100 transverse rows of scales.
- 2 (3). I D 9, II D 47, A 45 1. *U. regius* (Walb.)
- 3 (2). I D 10, II D 66, A 57 6. *U. cirratus* Goode et Bean
- 4 (1). More than 100 transverse rows of scales.
- 5 (8). Not more than 140 transverse rows of scales.
- 6 (7). About 110 transverse rows of scales, third ray of first dorsal fin elongate and threadlike 2. *U. chuss* (Walb.)
- 7 (6). About 120 transverse rows of scales, third ray of first dorsal fin not elongate. 3. *U. floridanus* (Bean et Dresel)
- 8 (5). One hundred forty transverse rows of scales or more.
- 9 (12). About 140 transverse rows of scales, third dorsal ray elongate.
- 10 (11). Pelvic fins hardly reaching origin of anal fin 4. *U. tenuis* (Mitch.)
- 11 (10). Pelvic fins long, reaching far beyond the origin of anal fin. 5. *U. brasiliensis* (Kaup)

* A specimen of *Ph. borealis* 24 cm long was studied (Svetovidov, Trudy Zool. Inst. Akad. Nauk USSR, vol. XVIII, 1955:346-348). The opisthotic processes were absent, the posttemporal and supracleithrum rudimentary. In other characters it is identical with *U. tenuis*.

- 12 (9). About 155 transverse rows of scales, third dorsal fin ray not elongate 7. *U. earlii* (Bean)

FIGURE 17. Distribution of the genus *Urophycis*
 1-*U. regius*; 2-*U. chuss* and *U. tenuis*; 3-*U. cirratus*;
 4-*U. earlii*; 5-*U. floridanus*; 6-*U. brasiliensis*.

1. *Urophycis regius* (Walbaum)* (Tables XXIX, LXIX)

Blennius regius Walbaum in: Artedi, Gen. pisc., 1792:186 (secundum Schöpfung). — *Enchelyopus regalis* Bloch ed. Schneider, Syst. ichth., 1801:53 (secundum Schöpfung). — *Gadus punctatus* Mitchill, Trans. Lit. Philos. Soc. N. Y., 1, 1815:372 (New York). — *Phycis punctatus* DeKay, New York fauna, 1842:292, t. XLVI, f. 149. — *Phycis regalis* Günther, Cat. fish., IV, 1862:355 (coast of North America).—

* At the coasts of North America, spotted-hake.

Urophycis regius Gill, Proc. Acad. Nat. Sci. Phila., (1863), 1864:240. — *Urophycis regius* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2553, f. 898 (bibliography); Bigelow a. Welsh, Fish. gulf Maine, 1925:455, f. 226 (distribution, biology); Hildebrandt a. Cable, Bull. Bureau Fisher., XLVIII, 1938:612 figs. 132, 136, 140 (from Nova Scotia to South Carolina, eggs*, larvae).

I D 9, II D 47, A 45, P 16 gill-rakers 17, scales about 85** vertebrae 46. Mucous cavity not closed in front. Forward edge of the frontals extends slightly anterior to the lateral ethmoids; part of the skull back of the anterior end of the sphenotic is larger than the part placed in front of it, the hind ends of the opisthotic reach the posterior end of the basioccipital. Interorbital space broad, 19.3% of head length. Eyes comparatively not large, 23.8% of head length. The jaws are elongate, upper jaw 49.1, lower 54.6% of head length. Caudal peduncle deep and shortened, its depth 4.6, length 5.0% of body length. Pelvic fins extend only to the origin of the anal fin and constitute 23.1% of body length. Pectoral fins reach the origin of the anal fin, 17.0% of body length. First dorsal fin with no elongated rays, considerably exceeding the height of the second dorsal, its height constituting only 8.2% of body length. The posterior ends of the second dorsal and anal fins are in the shape of angles slightly rounded at the top. In per cent of body length: anteanal distance 35.6, antedorsal distance 22.8, base of first dorsal 7.4, second 55.7, base of anal fin 49.2, head length 21.2. In per cent of head length: length of snout 25.2, length of barbel 4.6. Coloration brown, darker above, the unpaired fins of the same color as the dorsum, first dorsal fin black above with a white margin; lateral line darker than body, with a row of pale spots along it; the pores of the mucous canals on the sides of the head are dark. The greatest length to 40 cm. (1 specimen).

DISTRIBUTION. Atlantic Ocean at the coasts of North America from Cape Fear to Cape Cod, more seldom to Halifax (Nova Scotia).

BIOLOGY. Not studied. Keeps at the bottom at considerable depths, not found along the shores at shallow depths. Spawns, judging from the occurrence of the females with ripened eggs, in August—young 8.35 mm in length, mostly during summer.

COMMERCIAL IMPORTANCE none.

COMPARATIVE NOTES. By the form of the skull and especially by the size and outline of the lateral edges of the forward end of the sphenotic to the posterior end of the wing-like process of the opisthotic when the skull is viewed from above, this species considerably differs from the other two species of its genus, which were studied osteologically. Skull of specimen 10.3 cm long is absolutely identical to that of a larger fish (length of skeleton 21.4 cm) figured in Table XXIX. Besides, there are several external differentiating characters (dark lateral line, absence of elongated rays from the first dorsal fin, number of transverse rows of scales and some others) by which this species is very difficult to confuse with any other species of the genus.

* For the first time all doubts are removed as to the presence of an oil droplet in the egg.

** According to Hildebrandt and Cable, I D 8–9, II D 46–51, A 43–49, scales 89–97.

2. *Urophycis chuss* (Walbaum)* (Tables XXX, LXIX)

Blennius chuss Walbaum in: Artedi, Gen. pisc., 1792:186 (secundum Schöpfung). — *Enchelyopus americanus* Bloch ed. Schneider, Syst. icht., 1801:53 (secundum Schöpfung). — *Gadus longipes* Mitchill, Trans. Lit. Philos. Soc. N. Y., I, 1815:372, t. I, f. 4 (New York). — *Phycis marginatus* Rafinesque, Amer. Month. Mag., 1818, Jan.:205 (along the shores of North America). — *Phycis filamentosus* Storer, Mem. Amer. Acad. Art. a. Sci. (n. s.), VI, II, 1858:367, t. XXIX, f. 4. — *Phycis tinca* Kaup, Wiegmann Arch. Naturg., 1858:89 (North America). — *Phycis chuss* Gill, Proc. Acad. Nat. Sci. Phila., (1863), 1864:237 (bibliography). — *Urophycis chuss* Jordan a. Evermann, Fish. N. a. M. America, II, 1898:2555, f. 902 (bibliography); Bigelow a. Welsh, Fish. gulf Maine, 1925:447, f. 220 (biology, distribution); Fraser a. Brunner, Proc. R. Irish Acad., XLII B, 1925:319 (coast of Ireland); Hildebrandt a. Cable, Bull. Bureau Fisher., XLVIII, 1938:612, fig. 123–127, 129, 131, 133–135 (southward to North Carolina, description of eggs, larvae).

ID 10, II D 56–59, A 51–56, P 16, gill-rakers 16–18, scales 105–115**, vertebrae 48. Mucous cavity not closed in front, anterior end of the frontals covers from above more than half the lateral ethmoids, the part of the skull behind the anterior end of the sphenotic is shorter than the part of the skull in front of the anterior end of the sphenotic, the hind ends of the opisthotic not reaching the posterior end of the basioccipital. The interorbital space is broad, 16.7–17.1% of head length. Eyes of considerable size, 24.9–28.4% of head length. Jaws short, upper jaw 43.9–45.6%, lower 51.8–52.4% of head length. Caudal peduncle deep and shortened, its depth 3.6–4.5%, length 3.9–5.1% of body length. Pelvic fins elongate, generally reaching past the origin of the anal fin, but sometimes terminating before it, constituting 23.4–30.4% of body length. First dorsal fin higher than the second, its third elongated ray constituting 15.4–17.3% of body length. Anterior ends of second dorsal and anal fins are in the form of angles slightly rounded at the top. In per cent of body length: anteanal distance 34.4–37.3, antedorsal distance 23.1–24.4, pectoral fin 13.3–14.8, base of first dorsal fin 7.5–8.0, base of second dorsal fin 55.5–57.2, base of anal fin 45.5–48.9, length of head 19.6–20.9, length of snout 29.0–30.6, length of barbel 7.0–9.5. The back and sides of body are reddish or olive-brownish, the back sometimes almost black, the lateral line is pale and without white spots, belly and lower part of head white; grayish or yellowish unpaired fins are the same color as back; pelvic fins pale, pinkish or yellowish. Reaches 75 cm and above 1 meter, but generally smaller (4 specimens).

DISTRIBUTION. The Atlantic Ocean along the coasts of North America from Newfoundland Bank to Chesapeake Bay, occasionally to North Carolina (Kitty Hawk). Indicated west of Ireland.

BIOLOGY. Keeps together with *U. tenuis*, however not everywhere, as in some places one species predominates in the catch while in other places the other species predominates. It is normally found in places with soft muddy bottoms, more seldom on sandy or shell bottoms, but never on rocky bottoms. The immature fishes live along the coasts at comparatively shallow depths (4–6 meters); the adults depart for deeper waters, not less than 35 meters, generally 110–130 meters. Cases are known when they were found at depths of over 550 meters. Apparently does not undertake distant migrations, except seasonal movements in the fall to lesser depths

* At the coasts of North America, squirrel-hake.

** According to Hildebrandt and Cable, ID 9–11, II D 56–61, A 52–56, scales 104–112.

toward the coasts, in summer from the coasts to greater depths. It does not enter the mouths of rivers and greatly freshened water. Feeds mainly on small crustaceans (amphipods, shrimps, etc.), fish (herring, flatfish, mackerel and others). Distinguished by very rapid growth which can be seen from the following figures:

	Males	Females
First Year	17,5 cm	18,5 cm
Second Year	33,0 cm	36,0 cm
Third Year	38,5 cm	44,5 cm

- 110 Spawning generally takes place at the beginning of summer, commencing in spring and continuing into the fall. Apparently, like many other gadoids, this species comes for spawning to shallower depths than those which it generally inhabits. Spawning conditions not studied. As in other species of the subfamily eggs have an oil globule. Immediately after it is shed the egg has a few small colorless oil globules which coalesce into one soon after fertilization.

COMMERCIAL IMPORTANCE quite considerable; annual catch, together with *U. tenuis*, varies from 90 to 160 thousand metric centners.

COMPARATIVE NOTES. This species, besides the number of external characters, differs more distinctly from the preceding species by the structure of its skull, as may be seen from the figures in Tables XXIX and XXX. *Ph. filamentosus* Storer, to judge by the description, is none other than *U. chuss*, which was very correctly pointed out by Gill (1. c.). As to *Ph. aldrichii* Bourne [Journ. Mar. Biol. Assoc., (n. s.), I, 1889-1890:310], which Bourne described as a new species only because it was difficult for him to definitely identify it, pointing out at the same time its nearness to *Ph. americanus*=*U. chuss*, it is difficult to state anything definite. The only difference between it and *U. chuss* appears to be the absence of an elongate ray in the first dorsal, which could have been torn, because the two specimens from which this species was described were very greatly damaged. If this supposition is correct, appearance of individual specimens of *U. chuss* at the shores of Ireland is of great interest.

3. *Urophycis floridanus* (Bean et Dresel) (Table XXXI)

Phycis floridanus Bean a. Dresel, Proc. Biol. Soc. Wash., 1884:100 (Gulf of Mexico). — *Urophycis floridanus* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2554; Hildebrandt a. Cable, Bull. Bureau Fisheries, XLVIII, 1938:612, figs. 128, 130, 137, 141 (from North Carolina to Pensacola, description of eggs and larvae).

I D 12-13, II D 59, A 49-52, scales about 110*, vertebrae 50. In structure the skull is similar to the preceding species. The interorbital space is broad, 17.8-20.4% of head length. Eyes comparatively small, 20.0-22.6% of head length. Jaws elongate, upper jaw 47.6-49.4, lower 51.8-52.4% of

* According to Hildebrandt and Cable, I D 12-13, II D 54-59, A 40-49, scales 110-120.

head length. Caudal peduncle deep and shortened, depth about 4.1–4.3, length 4.9–5.3% of body length. Pelvic fins in young specimens reach the origin of the anal fin, in adults they are shorter, constituting 27.4–29.5% of body length. First dorsal fin has no elongate rays, its height 9.4–11.8% of body length. The posterior ends of the second dorsal and anal fins are slightly rounded at the tips. In per cent of body length: anteanal distance 39.6–42.4, antedorsal distance 22.9–24.0, length of pectoral fin 14.3–15.1, base of first dorsal fin 7.4–8.5, base of second dorsal fin 49.9–52.2, base of anal fin 42.9–44.6, head length 21.7–22.3. In per cent of head length: length of snout 25.2–25.7, length of barbel 16.0–17.4. Back brown or bluish, belly silvery, lateral line dark with a row of pale spots. Vertical fins pale brown, often with a darker border; first dorsal fin partially black without white edge. Length to 40 mm (2 specimens). [Corrected by author to 144 mm. Author also adds—After Jordan and Evermann length to 19 cm.]

DISTRIBUTION. From the Gulf of Mexico, where in the cold time of year it approaches the coasts of Florida at Pensacola, to North Carolina (Beaufort).

111 4. *Urophycis tenuis* (Mitchill)* (Tables XXXII, LXIX)

Gadus tenuis Mitchill, Trans. Lit. Philos. Soc., N. Y. 1815:372 (New York). — *Phycis americanus* (non Bloch et Schneider) Storer, Mem. Amer. Acad. Art. a. Sci., (n.s.), VI, II, 1858:365, t. XXXIX, f. 3. — *Phycis dekeyi* Kaup, Wieg. Arch. Naturg., 1858:89 (North America). — ?*Phycis rostratus* Günther, Cat. fish., IV, 1862:353 (without indicating locality, scales about 150). — *Phycis tenuis* Gill, Proc. Acad. Nat. Sci. Phila., (1863), 1864:238 (critical remarks on synonymy). — *Urophycis* (*Emphycis*) *tenuis* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2555, f. 901 (bibliography); Bigelow a. Welsh, Fisch. gulf Maine, 1925:446 (distribution, biology).

I D 10, II D 55–59, A 47–49, P 16, gill-rakers 15–16, scales 130–140, vertebrae 50. Mucous cavity locked in front, of considerable size, anterior edge of frontals covers more than half of the lateral ethmoid from above; part of the lateral edge of the skull behind the forward edge of the sphenotic to the end of the opisthotic is smaller than the part located anterior to it; posterior end of the opisthotic reaches the basioccipital. Interorbital space broad, 18.3–18.6% of head length. Eyes not large, 19.0–24.1% of head length. Jaws short, upper jaw 46.3–47.6, lower 50.4–52.8% of head length. Caudal peduncle deep and elongate, its depth 4.5–5.0%, length 5.5–6.6% of body length. Pelvic fins generally short, scarcely reaching the origin of the anal fin, constituting 22.2–23.1% of body length. First dorsal fin higher than the second, its third ray elongate, constituting 11.9–12.5% of body length. Posterior ends of second dorsal and anal fins slightly rounded at their tips. Percentages of body length: anteanal distance 41.1–42.6, antedorsal distance 24.6–25.5, length of pectoral fin 14.3–15.4, base of first dorsal fin 7.4–7.5, of second dorsal fin 50.3–52.7, base of anal fin 41.1–41.3, length of head 22.2–22.5. In per cent of head length: length of snout 24.5–28.6, length of barbel 5.0–6.9. Coloration greatly variable, dirty- or reddish-brown from above, the sides sometimes bronze, lateral line

* Along the shores of North America, squirrel-hake.

pale, belly dirty- or yellowish-white with small black dots. Dorsal fins of the same coloration as back, anal—as belly, all with black edges; pelvic fins pale with yellowish tint. Reaches a great size, over 1 meter; however, the usual measurements do not exceed 70 cm (3 specimens).

DISTRIBUTION. Very closely coincides with the distribution of *U. chuss*, extending, however, from North Carolina somewhat farther to the south.

BIOLOGY. With the exception of spawning, very similar to the biology of *U. chuss* and almost all said of that species could be referred to this, with the only difference that the ties are even closer with the muddy bottom. We know very little of propagation; it takes place, however, apparently at the end of winter and during early spring (to April). Conditions for spawning, as well as for eggs and larvae, have not been studied.

COMPARATIVE NOTES. This species differs from the preceding in external characters by a greater anteanal distance, slightly smaller size of eyes, shorter snout, greater number of transverse rows of scales; the latter characteristic seems to be the best of the external morphological. The pelvic fin of this species generally does not reach the origin of the anal. However, Bigelow and Welsh (l. c.) point out that in *U. chuss*, in which the pelvic fins generally extend farther back than the origin of the anal fin, there are specimens with pelvic fins not reaching the origin of the anal.

- 112 Generally speaking, externally, *U. tenuis* and *U. chuss* are almost indistinguishable and, as is pointed out by Bigelow and Welsh (l. c. 447), are not distinguishable by fishermen. Craniologically—the form of the skull with the mucous cavity closed in front—both species, however, differ very sharply; while we have no basis to presume that the fact of the locked mucous cavity is connected with the greater size this species sometimes attains because the mucous cavity is locked by a broad bridge in an examined specimen 12.9 cm in length. Besides, in *Ph. phycis*, which has closely adjoining lateral and median crests of the frontals, even the largest specimens (42.5 cm in length) do not have a closed mucous cavity in front. *Ph. americanus* Storer, and *Ph. dekayi* Kaup have a somewhat longer snout than *Ph. tinca* Kaup. Therefore it is very possible that *Ph. dekayi* is identical to this species, and *Ph. tinca*—with the preceding one.

5. *Urophycis brasiliensis* (Kaup) (Tables XXXIII, LXIX)

Phycis brasiliensis Kaup, Wiegem. Arch. Naturg., 1858:88 (Montevideo). — *Urophycis brasiliensis* Pozzi y Bordale, An. Soc. Cient. Argentina, CXX, 1, 1935:158 (from the coasts of Argentina).

I D 9, II D 53–56, A 48–58, P 17–18, gill-rakers 15, scales 135, vertebrae 47. Mucous cavity on the skull is closed in front, but of lesser size than in *U. tenuis*, anterior edge of lateral ethmoids extend somewhat forward from beneath the frontals, part of the lateral edge of the skull behind the anterior edge of the sphenotic to the end of the opisthotic is greater than the part located forward of it, posterior end of the opisthotic extends back to the posterior end of the basioccipital. Interorbital space broad, 17.1–17.4% of head length. Eyes not large, 15.9–16.5% of head length. Jaws short, upper jaw 45.2–47.5, lower jaw 53.1–53.3% of head

length. Caudal peduncle deep and shortened, its depth 4.3–4.4, length 4.5–4.6% of body length. Pelvic fins long, extending back to middle of anal fin, constituting 45.0–46.7% of body length. Third dorsal fin ray greatly elongate, constituting 24.5–26.7% of body length. Barbel long, 13.9–14.5% of head length. Posterior ends of second dorsal and anal fins slightly rounded at the tips. In per cent of body length: anteanal distance 43.5–44.4, antedorsal distance 23.6–25.0, pectoral fin 12.7–13.0, base of first dorsal fin 5.4–5.7, base of second 56.3–57.9, base of anal fin 40.7–44.0, head length 21.4–21.8. In per cent of head length: length of snout 26.4–27.5. Pectoral, pelvic, dorsal and anal fins and lower part of body with brown dots. Length, judging by examined specimens, about 25–30 cm (2 specimens).

DISTRIBUTION. Atlantic Ocean along the coasts of South America between 35° and 40° south latitude.

BIOLOGY. Not studied. Keeps at depths of about 50 meters.

COMPARATIVE NOTES. Craniologically this species is very close to *U. tenuis*, differing, however, by the smaller size of the mucous cavity, and more elongated backward and sharpened wing-like processes of the opisthotic. This differentiates both of the examined skulls of *U. brasiliensis* from two skulls of *U. tenuis*. A number of externomorphological distinctions (longer third ray of first dorsal fin and, in particular, longer pelvic fins, longer barbel, etc.), together with the diagnostic osteological data speak for specific recognition of this geographically very interesting form. Due to the more restricted mucous chamber this species must
113 be placed in the classification after *U. tenuis*.

6. *Urophycis cirratus* (Goode et Bean)

Phycis cirratus Goode a. Bean, Oceanic ichth., 1896:358, f. 310 (Gulf of Mexico). — *Urophycis cirratus* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2553, f. 899.

I D 10, II D 66, A 57, scales 93. First dorsal fin has no elongated rays. Pelvic fins reach beyond the origin of the anal fin, sometimes as far as the middle of it. Only a few specimens are known. Close to *U. regius*, differentiated by a greater number of rays in the second dorsal and anal fins and by longer pelvic fins (after Goode and Bean).

DISTRIBUTION. All known specimens were caught in the northern part of the Gulf of Mexico at great depths, 400 to 600 meters.

7. *Urophycis earlIIi* (Bean)

Phycis earlIIi Bean, Proc. U. S. Nat. Mus., III, 1880:69 (Charleston, South Carolina). — *Urophycis earlIIi* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2554, f. 900; Hildebrandt a. Cable, Bull. Bureau Fisher., XLVIII, 1938:612, f. 139 (along the coasts of North and South Carolina, descriptions of eggs and larvae).

I D 10, II D 60–63, A 53–54, P 15, scales about 155*. First dorsal fin without elongate ray. Pelvic fins almost reach anal opening. Species very

* According to Hildebrandt and Cable, I D 8–9, II D 54–63, A 50–56, scales 153–175. Coloration from dark brown to almost black, sometimes with pale spots, lateral line not dark and without pale spots, vertical fins almost black, first dorsal fin without white edges.

close to *U. regius* but differs by having considerably smaller scales. By the count of scales it is close to *U. tenuis* but has no elongate rays in the first dorsal fin. Length to 36 cm. (after Bean).

DISTRIBUTION. Atlantic Ocean at the coasts of North and South Carolina (from Charleston to Beaufort).

8. Genus **LOTA** (Cuvier) Oken

"Les lottes" Cuvier, *Règne animal*, éd., I, II, 1817:215 (Type: *Gadus lota* L. = *Lota lota* lota. — *Lota* Oken, "Isis," 1817:1182 (Type: *G. lota* = *Lota lota lota*, secundum Cuvier).

Two dorsals and one anal fin, in first dorsal fin 9–14 rays, second long with more than 65 rays. Pelvic fins of normal structure. Second dorsal and anal fins closely touching the caudal fin. Lower jaw shorter than upper, teeth small and bristle-like, placed in a broad strip on the premaxillary, dentary and head of vomer. Head of vomer well developed, its rear ends are pulled back in the shape of a horseshoe. One barbel at each anterior nostril. Lateral line in the forward part of the body slightly curved and located above the middle of the body, straight beyond the origin of the second dorsal fin and running uninterrupted along the middle of the body almost to the end of the anal fin. On the head only pit organs. Mucous cavity of considerable size, almost closed in front by the close approximation of the edges of the middle and lateral crests of the frontals. On the sides of the skull deep foramina for the facial nerve with the edges coming close together in front. Skull broad and low.

114 SKELETON. The skull from the side (A) is low, its greatest height is contained about 4 times in the length of its base. The base of the skull is straight, only the rear end of the basioccipital is somewhat curved downward. Head of vomer extends downward, its rear end reaching far back. The upper profile of the skull is almost straight, only slightly curved over the prootic, gradually descending toward the forward end of the skull. Crests well developed only in the rear portion of the supraoccipital, reaching far back beyond the rear of the base of the basioccipital; on the forward portion of the supraoccipital between the parietals and on the frontals there are no crests. Forward edge of mesethmoid convex, almost vertical, placed at almost a right angle to its upper edge. The orbital space, owing to fusions of the parasphenoid with the processes of the lower surface of the frontals in its forward portion, is small and narrow, its height is contained about 3 times in the length of its base. The facial nerve exits from the cranial box through a deep foramen in the forward edge of the prootic, equal in size to the orbital space; the edges of this foramen in front are brought closer to the extension of the alisphenoid from above and the upward projecting process of the parasphenoid from below. The foramen of the glossopharyngeal nerve on the opisthotic is large, placed in a crevice-like cavity on the forward part of the opisthotic. The skull from above (B) is quite broad in the rear, gradually narrowing toward the front; its greatest width is contained $1\frac{1}{2}$ to 2 times in the length of its base. The sides of the skull are limited by wavy lines, without deep notches or foramina and somewhat convergent anteriorly. The edges of the pterotic in back and

from the sides are rounded; there is a small notch in front. Between the sphenotic and the frontals on either side of the skull there is a small notch; in the interorbital space the edges of the frontals are slightly notched, the lateral ethmoids extend considerably from beneath the frontals in front and on the sides. The forward edge of the mesethmoid extends over the forward edge of the vomer. The crests over the sensory canals on the pterotic are narrow, broader on the frontals, their edges quite closely adjacent to these bones. The mucous cavity is not very deep, its edges well limited from the sides; the edges of the middle and lateral crests of the frontals in front are very close to each other, almost closing it in front but not forming canals which are closed from above forward of it. The foramen of the recurrent dorsal branch of the facial nerve on the parietal is covered by a small triangular shaped crest* from above. From beneath (C) the head of the vomer is horseshoe shaped, greatly stretched laterally and posteriorly, covered in its entirety with small closely spaced teeth. The parasphenoid is broad, its lower edge for its entire length is rounded, the shaft of the vomer is comparatively narrow. The skull from the rear (D) has the supra-occipital crest hardly extending above it, the crests above have small lateral growths on each side somewhat below its sharpened upper edge. The lateral walls of the cranial box have step-like ridges in the region of the quite convex prootic. The suborbitals are similar in length as well as in width or are somewhat broader. The lower process of the hyomandibular is broad and short; the opercular process and the preopercular process are of equal length with the lower process, but much narrower than the same; the preopercular process is located in the middle between the lower and the opercular processes, in the form of a crest extending forward across the lower process. The posttemporals are of considerable size, the upper fork almost twice as long as the lower. The postcleithrum is greatly curved at the upper end and thin for its entire stretch. The operculum is narrow and elongate, blunt at the upper end with both lower ends sharp; its lowest edge has a notch. The urohyale is short and broad. The parapophyses
116 are thin, quite long.

Description given from 5 skeletons of *L. lota lota* and one of *L. lota maculosa*.

DISTRIBUTION. One species in fresh waters of Europe, northern Asia and North America, falling into three subspecies (Figure 18). In the fossil state it is known from the Lower Pliocene.

COMPARATIVE NOTES. By external characteristics and its skeleton *Lota* is close to the genus *Molva* and forms with it a group analogous to the genera *Phycis* and *Urophycis*, *Gaidropsarus*, *Enchelyopus* and *Ciliata* and others.

The systematic location of the forms of *nalim* had been indefinite for a long time: some authors consider the *nalim* found in North America as an independent species; others—identical to the Europeo-Asiatic. L. S. Berg had segregated the *nalim* of North America, River Anadyr' and adjacent river systems into the subspecies *L. lota maculosa*. Later Hubbs and Schultz described a third subspecies of *nalim* (*L. lota leptura*) from the rivers of Alaska and northwestern Canada, and here they referred the

* On the parietals near these crests there are sometimes crevice-like openings.

FIGURE 18. Distribution of the genus *Lota*
1-L, *lota lota*; 2-L, *lota leptura*; 3-L, *lota maculosa*.

nalim from eastern Siberia to the River Kolyma. This form, according to their data, differs from *L. lota lota* and *L. lota maculosa* basically by its more elongate caudal peduncle, while the depth of the caudal peduncle was measured by them from the notches between the second dorsal and caudal fins and between the anal and caudal. Below are quoted the results of the measurements of nalims from Europe and western Siberia (*L. lota lota*), Kolyma and Anadyr' (*L. lota leptura*) and North America (*L. lota maculosa*)*.

	<i>L. lota lota</i>	<i>L. lota leptura</i>	<i>L. lota maculosa</i>
In percent of head length:			
Interorbital space	19.6-26.5	21.4-27.3	25.5-29.7
In percent of body length:			
Antedorsal distance	29.8-36.2	33.3-36.7	37.4-37.8
Anteanal distance	42.1-48.4	44.3-46.9	49.2-50.8
Base of second dorsal	45.3-48.7	41.1-46.5	40.4-40.9
Base of anal	38.5-42.6	34.9-40.0	33.4-34.2
Depth of caudal peduncle	3.8- 5.8	3.8- 4.4	4.3- 5.0
Length of caudal peduncle	6.3- 8.4	7.8- 9.0	7.6- 9.1
Length of pectoral fin	11.9-14.6	10.4-12.9	11.8-12.0
In percent of length of caudal peduncle:			
Depth of caudal peduncle	50.0-76.7	47.2-51.2	55.0-56.0
Number of specimens examined	31	7	2

L. lota maculosa has a much broader interorbital space, bases of second dorsal and anal fins placed somewhat farther back and shorter. The hiatus in some of these and other characters between this form and both others is due to the small number of specimens examined from North America. Osteologically *L. lota maculosa* differs as from *L. lota lota*, so from *L. lota leptura* by a broader skull. This distinction between them is analogous to the distinction between the subspecies of a number of cods (*Molva dipterygia dipterygia* - *M. dipterygia elongata*, *Trisopterus minutus minutus* - *T. minutus capellanus*, *Gadus morhua morhua* - *G. morhua ogac* and *G. morhua macrocephalus* and a group of others) and bears witness to the subspecies distinctness of *L. lota maculosa*. The distinctions of *L. lota leptura* from *L. lota lota* in this basic morphological character are apparently none**. The differences in them are brought down basically to the structure of the caudal peduncle and to the somewhat shorter bases of the second dorsal and anal fins in *L. lota leptura*, by the length of which this form occupies an intermediate position among the others. With this, any difference in the depth and length of the caudal peduncle, expressed in per cent of body length, is not noticed, they are sharply noted in the index of the depth of the caudal peduncle expressed in per cent of its

* All the fish examined are only adults over 300 mm in length.
** The author had opportunity to acquaint himself with the paper of Hubbs and Schultz only after the war [World War II], a number of years after the completion of this work. Therefore the author had no opportunity to study the osteology of *L. lota leptura*.

length. There are no differences in the length of the pectoral fin, according to data furnished by Hubbs and Schultz as well as by our own data, between the three forms of nalim. The pectoral fin of adult *L. lota maculosa* often does not reach the vertical of the origin of the first dorsal fin due to the prolonged antedorsal length in this form, while it is often observed in the other two forms (see figure *L. lota lota*, Table IV). If no distinctions in osteological characters between *L. lota leptura* and *L. lota lota* are found then perhaps it would be more correct to consider this form not as a subspecies but just as a natio of the latter. One of these nationes (but not a subspecies) appears apparently *L. lota kamensis* Markun from the River Kama, but presently there are no bases to segregate this form. The differences observed in the number of pyloric caeca require confirmation from a greater amount of material from western Europe and eastern Siberia; in other characteristics of the nalim from the River Kama, no distinctions are observed according to Markun's data, as well as from specimens in the collections of the zoological Institute of the Academy of Sciences. Lower limits of variation in number of rays in the second dorsal (60-85) and in the anal (44-81) fins in nalims from the River Svir' examined by Makarova (Berg, l. c.), give rise to doubt because such a number of rays in the nalim has never been reported by anyone else. The number of gill-rakers counted by Makarova, apparently not in the outer row, but in both — outer and inner — caused her to give figures doubly exceeding (13-20 as against 5-10) the normal number of gill-rakers in the outer row of first gill arch.

Diagnostic Key to the Subspecies

- 1 (4). Interorbital space narrow, 19-6-27.3% of head length. Antedorsal distance 29-8-36.7%, anteanal 42.1-48.4% of body length.
- 2 (3). Caudal peduncle elongate, its depth 50.0-76.7% of its length. Length of base of second dorsal fin 45.3-48.7% of length of body. Europe and Siberia to Kolyma. 1a. *L. lota lota* (L.)
- 3 (2). Caudal peduncle short, its depth 47.2-51.2% of its length. Length of base of second dorsal 41.1-46.5% of body length. Eastern Siberia, Alaska and northwestern Canada 1b. *L. lota leptura* Hubbs and Schultz
- 4 (1). Interorbital space broad, 25.5-29.7% of head length. Antedorsal distance 37.4-37.8%, anteanal — 49.2-50.8% of body length. North America. 1c. *L. lota maculosa* (LeSueur)

118 *1a. *Lota lota lota* (Linné)—Nalim (Tables IV, XXXIV, LXIX)

Gadus lota Linné, Syst. nat., ed. X, 1758:255 (Europe); Pallas Zoogr. rosso-asiat., III, 1811:201 (distribution). — *Enchelyopus lota* Bloch ed. Schneider, Syst. ichth., 1801:52. — *Lota vulgaris* Kessler, Ryby Sp. Ryb., 1864:63. — *Molva lota* Fleming, Hist. brit. animals, 1828:192. — *Lota communis* Rapp., Fische Bodensees, 1854:36. — *Lota linnei* Malm. Göteb, Bohusl. Fauna, 1877:491. — *Lota lota* Smitt, Scand. fish., I, 1893:532, pl. XXVI, f. 1 (ex parte: Europe, northern Asia, bibliography). — *Lota vulgaris* var. *obensis* Anikin, Izv. Tomsk. Univens., XXII, 1902:108 (Ob). — *Lota lota kamensis* Markun, Izv. Permsk. biol. inst., X, 6, 1936:211 (Kama; biometry, biology). — *Lota lota lota* Hubbs a. Schultz, Occas. Papers Mus. Zool. Univ. Michigan, 431, 1941:17 (comparison with other forms).

DISTRIBUTION, BIOLOGY. Wesenberg-Lund, Int. Rev. ges. Hydrob. Hydrogr., II, 1909:426 (eggs); Gottberg, Finn. Fiskerier, I, 1912:146 (age); Nordquist, Ark. Zool., Bd. 9, 1914:20 (larvae); Domrachev and Pravdin, Ryby Ilmen Volhov 1926:219 (Ilmen, Volhov., Msta, Vitebsk lakes); Mori, Journ. Chosen Nat. Hist. Soc., 1928, 6:20 (headwaters of the River Yalu, Korea); Scheuring, Handb. Binnenfischerei Mitteleuropas, III, 3, 1929:101; Berg, Ryby presnykhvod, II, 1933:747 (bibliography, distribution); Derzhavin, tr. azerb. ot. zakavkazsk. fil. akad. nauk, VII, 1934:120 (lower parts of the Rivers Sefidrud and Kury); Probatov, Mat. nauchno-promysl. obsled, karsk. ryby i r. kara, 1934:89 (Kara River, rare); Radchenko, tr. vsesoyuzn. nauchnoissled. inst. morsk. rybn. khob. i okeanogr., II, 1935:84 (Teletsk Lake, biology, growth); Lukin, tr. tatarsk. otb. vsesoyuzn. nauchnoissled. inst. ozern. i rechi. rybn. khoz, II, 1935:75; Menshichov and Rebin-vykh, tr. permsk. biologic. nauchnoissled. inst. VII, 3-4, 1937:170 (Irtish, growth); Lukin and Lyakhov. tr. obshch. est. Kazansk. univ., LV, 1-2, 1937:127 (sizes, sex ratio); Ostroumov, tr. polyarn. kom. dkad. nauk, 30, 1937:82 (Pyasina River); Modestov, sborn. nauchn. stud. rabot mosk. gos. univ., biology, 1939:93 (Moscow River, biology); Burmakin, tr. nauchno-issled. inst. polyarn. zemled., zhivotn. i promysl. khoz., ser. promysl., khoz., 10, 1940:44 (Gulf of Ob and branches of the middle and southern portions of the river); Logashchev, ibid., 11, 1940:55 (Lake Melkoe); Belykh, ibid.:92 (Lake Lama); Kiselev, ibid., 15, 1941:57 (Cydansky Bay and rivers flowing into it, growth); Dmitriev, ibid., 16, 1941:20 (lower Yenesei); Mikhin, ibid.: 64 (Khatanga River, scarce in the Bay).

I D (9-10) 11-14, II D 63-85, A 63-82, P 18-21, V 6-8, gill-rakers 5-10 (12), vertebrae 59-63*. Skull narrow, its greatest width contained almost twice in its length. Interorbital space narrow, 19.6-26.5% of headlength. Antedorsal distance 29.8-36.2% of body length, anteanal distance 42.1-48.4% of headlength. Bases of unpaired fins elongate, base of second dorsal fin 45.3-48.7%, base of anal fin 38.5-42.6% of body length. Depth of caudal peduncle 50.0-76.7% of its length or the length of the peduncle exceeds its depth by 1.36-2.00 times. In per cent of body length: pectoral fin 11.9-14.6, pelvic fin 7.4-9.8, base of first dorsal fin 6.8-9.8, its height 5.3-7.7, depth of caudal peduncle 3.8-5.8, its length 6.3-8.4, head length 17.7-19.7. In per cent of head length: length of snout 28.5-31.7, diameter of eye 12.3-14.4, length of upper jaw 39.4-42.9, length of lower jaw 49.2-54.2, length of barbel 20.0-26.6. Coloration quite variable, generally dark brownish or blackish-gray with large pale spots on the sides and on the paired fins. There are distinguishable gray, yellow, black and other variations in coloration depending upon habitat**. Reaches a length of over one meter, weight to 24 kilograms.

DISTRIBUTION. Fresh-waters of Europe and northern Asia westward to the eastern part of Great Britain (not found in Scotland and Ireland), basins of Loire and Seine Rivers and in western Switzerland. In western and central Europe south in the Po River, basin of the Danube and perhaps in the Fessali; on the Iberian, Appenine and Balkan Peninsulas it is absent. Rivers running into the northern portions of the Black, Azov and Caspian Seas; seldom found in lower parts of the Kura and Sefidrud Rivers. None in Asia Minor, on the Caucasus or in central Asia. Found in all river basins of the Baltic and White Seas and farther east to and including the Lena; Baikal and rivers entering into it (Selenga and its tributaries); Amur in its

* According to Markun, I D 10-16 (12.5), II D 70-93 (79), A 69-85 (7.5), vertebrae 61-66 (63.5), pyloric caeca 21-67 (41). According to Hubby and Schultz, 60-63 vertebrae.

** On this see: Sabaneev, Zhizn' ryb i rybolovstvo na zaural'skikh ozerakh (Life of Fish and Fishing in the Trans-Ural Lakes), 135. 1874.

entirety, Ussuri and Sunguri, on Sakhalin, on the Shantar Islands, in the Ud River, in the upper parts of the Yalu (Basin of the Yellow Sea). It also occurs in the Bay of Finland and in brackish sections of the sea.

BIOLOGY. In contrast with all other representatives of the family this is exclusively a fresh-water fish, very seldom found in even slightly salty sea waters. It lives primarily in rivers and lakes with clear water and rocky bottom, creeping in crevices and holes between stones and underneath banks; shows greatest activity at lower temperatures in winter; during the summer leads a very motionless form of life (according to some indications it goes into a comatose state) and is seldom found, due to which this period of its life is almost unstudied. Beginning in the fall, it is caught in considerable numbers in September and October and the catch continues through the winter through the end of April or the beginning of May. Feeding is chiefly on amphipods, larvae of some insects and only adults—partially on some small fish. Spawning occurs in winter, commencing in January and continuing through February and ends in March; occasional specimens sometimes have adult sexual products from October. Spawning apparently takes place several times. Fertility is very great—in large fish over 3 million eggs, though usually less, in medium-size fish—300 to 400 thousand eggs. Full adult size is reached in 3 to 4 years, occasional specimens mature at the age of 1 to 2 years. Young in the Pyasina River keep to the mouths of tributary springs; in Lake Teletskoe young were caught at a depth of 120 meters. Growth in various water basins occurs unevenly. In the Kama and Volga (near Kazan') and in Finland (Lake Kilpijarvi) the following measurements were taken in different years (all lengths of the body in millimeters):

Age (Years)	1	2	3	4	5	6
Volga	131	200	262	311	367	407
Kama	183	228	272	332	438	527
Lake Kilpijarvi	210	263	280	316	317	382

COMMERCIAL VALUE very small. From 16.18 (1940) to 18.76 (1937) thousands of metric centner were caught in 1936–1941 in USSR waters. The basic mass of this catch was produced in rivers and lakes of Siberia (on the average 16.9 thousand metric centner), mainly from the Ob (on the average 13.5 thousand metric centner).

*1b. *Lota lota leptura* Hubbs et Schultz—Eastern Siberian and western American nalim (Table IV)

- 120 *Lota lota maculosa* (non LeSueur) Berg, Ryby presnykh vod, II, 1933:750, Figure 721 (ex parte: Anadyr River, Penzhina River, North America). — *Lota lota* (non L.) Berg, I, c. (ex parte: Kolyma River); Drjagin, Tr. Sov. izuch. proizv. sil, Akad. Nauk, 5, 1933:55 (Kolyma River, biology, catch). — *Lota lota maculosa* (non LeSueur) Agapov, Tr. Nauchno-issled. inst. pol. zemled., zhivotnov. i promysl. khov., ser. promysl. khov., 16, 1941:97 (Anadyr River). — *Lota lota leptura* Hubbs a. Schultz, Occas. papers Mus. Zool. Univ. Michigan, 431, 1941:17 (description, synonymy).

I D 10-12, II D 69-73, A 65-69, gill-rakers 7-12*. Skull narrow as in the typical form of this species. Interorbital space narrow, 21.4-27.3% of head length. Antedorsal distance 33.3-36.7%, anteanal distance 44.3-46.9% of body length. Base of second dorsal fin shortened, 41.1-46.5% of body length, base of anal fin 34.9-40.0% of body length. Depth of caudal peduncle 47.2-51.2% of its length or length of peduncle 1.92-2.11 greater than it. In per cent of body length: pectoral fin 11.8-12.0, pelvic fin 7.2-7.5, base of first dorsal fin 5.7-6.3, its height 4.2-4.9, depth of caudal peduncle 3.8-4.4, its length 7.8-9.0, length of head 18.3-19.8. In per cent of head length: length of snout 28.3-35.7, diameter of eye 9.9-15.5, length of upper jaw 37.5-41.3, length of lower jaw 48.4-51.2, length of barbel 17.9-21.2. Average dimensions in the Anadyr' River 53 cm, weight 1 kilogram, but reaches a length to 90 cm and weight to 5 kilograms, in Kolyma River 12 to 16 kilograms and more.

DISTRIBUTION. Fresh waters of northwestern Canada, Alaska, and eastern Siberia. The Yukon River system in Canada and Alaska and rivers of Alaska (Kowak, Naknek). Anadyr' River and apparently rivers of the basin of Bering Sea from Anadyr' Bay to Bay of Korf, Penzhina River in the basin of the Sea of Okhotsk, Kolyma River, and the new Siberian Islands**. Indigirka River and the Yana this or typical subspecies.

BIOLOGY. Studied very little. In the Anadyr' River swims upstream for spawning in December, seldom enters bays; one specimen known from pre-mouth section of the Anadyr'. In the Kolyma River feeds on golyan, kolyushka, yersh, nalim, konek, chir, and karins. [Translator's note: These are various species of minnows, stickleback, whitefish, burbot and grayling.]

COMMERCIAL IMPORTANCE in our waters minimal. Comparatively small in Alaska and Canada. In the Kolyma River produced up to 3,719.7 metric centner (12% of total catch), in the Anadyr—about 8 thousand pieces (approximately 80 metric centner).

*1c. *Lota lota maculosa* (LeSueur)—American nalim (Table XXXV)

Gadus maculosa LeSueur, Journ. Acad. Nat. Sci. Phila., 1, 1817:83 (Lake Erie). — *Gadus compressus* LeSueur, l. c.:84 (Connecticut River). — *Gadus lacustris* Mitchell, Amer. Monthly Mag., II, 1818:244 (Lake Sebago). — *Molva maculosa* LeSueur, Mém. Mus. Hist. Nat. Paris, V, 1819:159, pl. 16. — *Molva huntia* LeSueur, l. c.:161 (Connecticut River). — *Lota brosmia* Storer, Boston Journ. Nat. Hist., IV, 1839:58, t. V, f. 1. (Lake Winnipiscogee). — *Lota maculosa* DeKay, New York fauna, Fishes, 1842:284, pl. 52, f. 168. — *Lota compressa* DeKay, l. c.:285, pl. 78, f. 244, 245. — *Lota inornata* DeKay, l. c.:283, pl. 45, f. 145 (Hudson River). — *Lota lota* Smitt, Scand. fish., I, 1893:532, pl. XXVI, f. 1 (ex parte: North America). — *Lota maculosa* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2550 (bibliography, synonymy, ex parte). — *Lota lota maculosa* Berg, Ryby presnykh vod, II, 1933:750, fig. 271 (ex parte: North America). — *Lota maculosa* Cahn, Copeia, 3, 1936:163 (spawning). — *Lota lota maculosa* Hubbs a. Schwartz, Occas. papers Mus. Zool. Univ. Michigan, 431, 1941:17 (comparison with other forms).

I D 11, II D 69-73, A 66-69, gill-rakers 7-10, vertebrae 60[†]. The skull is broader, its greatest width less than 1½ times in its length, antedorsal and anteanal distances greater, the bases of the unpaired fins shorter,

* According to Hubbs and Schultz, 63-66 vertebrae.

** No. 14501 of the Zoological Institute of the Academy of Sciences, one specimen in length 935 mm.

† According to Hubbs and Schultz 61-65.

than in the basic form. Interorbital space 25.5–29.7% of head length. Ante-
121 dorsal distance 37.4–37.8%, anteanal distance 49.2–50.8% of body length. Base of second dorsal fin 40.4–40.9%, base of anal fin 33.4–34.2% of body length. Height of caudal peduncle 55.0–56.0% of its length or the length of the peduncle exceeds its depth 1.79–1.80 times. In per cent of body length: pectoral fin 11.8–12.0, pelvic fin 8.1–8.6, base of first dorsal fin 4.9–7.1, its height 4.4–5.2, depth of caudal peduncle 4.3–5.0, its length 7.6–9.1, length of head 19.7–20.7. In per cent of head length: length of snout 29.7–30.3, diameter of eye 12.7–13.1, length of upper jaw 42.7–45.0, length of lower jaw 52.0–52.2, length of barbel 18.9–25.5. Coloration and measurements, same as in the typical form. (4 specimens).

DISTRIBUTION. Fresh waters of North America in the basin of the Atlantic Ocean northward from North Carolina, New England, Great Lakes basin and St. Lawrence River, Labrador, lakes and rivers tributary to James Bay and apparently directly around Hudson Bay. In the MacKenzie and Fraser River systems, Hudson Bay tributaries, and in the Rocky Mountains specimens are not identified, and according to the classification table, are intermediate between this form and *L. lota leptura*.

BIOLOGY. Studied very little. In summer it lives at depths as does the typical subspecies. During the spawning season it approaches lesser depths from 0.5 to 2 meters in lakes and shallow bays with sand or gravel bottoms. Spawning takes place from the middle of February, more often in the first decade, with temperature at 1.5° C at night. Males appear first at the spawning grounds. During the oviposition 10–12 fishes gather into a motile ball. A female 69.8 cm in length contained 1,153 thousand eggs. During the egg laying period the fish usually does not eat.

9. Genus **MOLVA** Fleming

Molva Fleming, Hist. brit. animals, 1828:197 (Type: *Gadus molva* Linné). — *Molva* Smitt, Scand. fish., I, 1893:52 (Type: *G. molva* L.). — Lotta Risso, Hist. nat. Europ. mérid., III, 1826:217 (Type: *G. elongatus* Otto = *M. dipterygia elongata*).

Two dorsals and one anal fin, first dorsal fin with 10 to 15 rays, in second 60 to 80 and more rays. Pelvic fins of normal build, second dorsal and anal fins separated from the caudal fin by a narrow space, caudal fin rounded. Lower jaw shorter or longer than upper. Teeth strongly developed on the head of vomer and on dentaries, placed in two rows; especially strongly developed, in the form of tusks, along the inner row; on the premaxillary more weakly developed, and placed in several rows. Head of vomer well developed, its rear ends in the shape of a horseshoe reaching backward. Forward nostrils without barbel. Lateral line slightly curved and located above the center axis of the body to the beginning of the second dorsal fin, continuing straight, uninterrupted almost to its end, with breaks after the end of the anal fin. On the head along the lateral line canals there are pores: 13 in the preoperculo-mandibular canal, 11 in the infraorbital canal, 3 in the supraorbital canal, and 1 in the supraorbital commissure. Mucous cavity not large, locked in front. On the sides of the skull a foramen for the facial nerve. Skull narrow.

122 SKELETON. Skull in lateral view (A) elongate, very low, its greatest height contained about 5 times in the length of its base. The lower edge of the bones of the base of the skull are placed in a straight line, only the rear end of the basioccipital slightly curved downward. The head of the vomer reaches far back. The upper profile of the skull for its entire stretch is straight or slightly curved, gradually descending in front. The supraoccipital crest is developed only in the rear portion above the exoccipitals, its rear end located at a considerable distance beyond the rear end of the basioccipital. There is no crest on the forward portion of the supraoccipital between the parietals and the frontals. The mesethmoid in front has a small notch, gradually descending, slightly rounded at the top. The orbital space is elongate, low, its greatest height contained 3 to 5 times in the length of its base. The facial nerve exits from the cranial box through a foramen, limited in front by the anterior expansions of the parasphenoid process and the lower process of the frontals and partially by the alisphenoid. The large opening for the glossopharyngeal nerve is on the opisthotic. Skull very narrow in rear (B), narrowing more in the interorbital regions (particularly in *M. dipterygia elongata*), its greatest width almost $2\frac{1}{2}$ times less than its length. Lateral edges of the rear section of the skull are limited by almost straight lines slightly convergent toward the center of the skull, with small notches in the forward portion of the pterotic and in the rear portion of the frontals. The edges of the frontals at approximately the center of the skull approach each other quite sharply, being almost parallel for the remainder of the stretch in front. The lateral ethmoids are greatly elongate in the lateral direction, and extend considerably from under the frontals on the sides and to a very great extent in front. The forward edge of the vomer projects from beneath the forward edge of the mesethmoid. The crests above the lateral line canals on the pterotic are narrow, wider on the frontals, their edges closely adjacent to these bones, and in one spot on each side they are connected to them, thereby partly locking the canal. Mucous cavity not big, shallow, closed in front by the fused edges of the median and lateral crests, thereby forming a long canal in front of it, covered from above by a thin weak bone. From each side of the skull on the parietals there is a small elongate crest, on the rear end of which there is located a foramen for the recurrent dorsal branch of the facial nerve. The edges of the head of the vomer on the skull from beneath (C) are greatly drawn backward in a horseshoe shape, on its entire stretch run two rows of sparsely placed teeth. The teeth on the inner row are greatly developed, in the outer row they are small. Parasphenoid and the head of the vomer are narrow, their lower edge rounded. The skull from the rear (D) with the supraoccipital crest projecting slightly beyond its surface or above. The supraoccipital crest, with a small slight thickening along its upper edge, is flat from above. The suborbitals narrow, elongate. The lower process of the hyomandibular short and broad; the opercular and preopercular processes are of the same length as the lower, both thin; the preopercular process is located between the opercular and the lower; in front it continues in the form of crests across the lower process. The posttemporal is of quite considerable dimensions, its lower fork half the length of the upper. Postcleithrum thin, curved at its upper end. Operculum broad, blunt at its upper end, with a notch along its lower edge. Urohyale thin, elongate.

The description is given from 2 skeletons of *M. molva*, one *M. dipterygia dipterygia* and one *M. dipterygia elongata*.

DISTRIBUTION. Two species and one subspecies along the shores of Europe in the Atlantic Ocean; western section of the Barents Sea and in the Mediterranean Sea (Figure 19). In the fossil state from the Lower Miocene deposits, *Pseudolota*, a closely related genus, is known.

COMPARATIVE NOTES. By the majority of investigated characteristics of both species and subspecies of the genus *Molva* they are placed in a series in which, by all characteristics, *M. dipterygia dipterygia* occupies the intermediate space between the other two forms. With that, the number of vertebrae, rays in both dorsal and anal fins, the bases of these fins and the diameter of the eye in the series from *M. dipterygia elongata* to *M. molva* recede; the antedorsal and anteanal distances, the depth of the caudal peduncle and the width of the skull increase. Both species of the genus, besides the externo-morphological differences, also differ distinctly osteologically, as is seen from Tables XXXVI-XXXVIII.

FIGURE 19. Distribution of the genus *Molva*

1-*M. molva*; 2-*M. dipterygia dipterygia*;
3-*M. dipterygia elongata*.

Diagnostic Key to the Species and Subspecies

- 1 (2). Lower jaw shorter than the upper. I D 14-15, II D 62-65, A 58-61, vertebrae 63-65 1. *M. molva* (L.)
- 2 (1). Lower jaw projects forward.

- 3 (4). I D 12-14, II D 74-78, A 72-74, vertebrae 76-79. Atlantic Ocean northward from Ireland. 2a. *M. dipterygia dipterygia* (Penn.)
- 4 (3). I D 10-12, II D 76-83, A 75-78, vertebrae 80-84. Mediterranean Sea, Atlantic Ocean southward from Ireland 2b. *M. dipterygia elongata* (Otto)

*1. *Molva molva* (Linné)-Sea Pike (Tables V, XXXVI, LXIX)

Gadus molva Linné, Syst. nat. ed. X, 1758:254 (Oceano Europeo); Fabricius, Fauna Groenl., 1780:148 (Greenland). — *Molva vulgaris* Fleming, Hist. brit. animals, 1828:192. — *Molva molva* et *M. rap-tor* Nilsson, Prodr. ichth. Scand., 1832:45. — *Molva linnei* Malm, Göteborg. Bohusl. Fauna, 1877:491. — *Molva vulgaris* Day, Fish. Gr. Brit. Irel., I, 1884:305. — *Lota molva* Moreau, Hist. nat. poiss. France, III, 1881:258 (Atlantic coast of Europe from English Channel to Bay of Biscay); Möbius u. Heincke, Fische Ostsee, 1883:237 (Keil Harbor). — *Molua molva* Smitt, Scand. fish., I, 1893:526, pl. XXVI, f. 1 (bibliography, distribution, biology). — *Molva molva* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2551.

DISTRIBUTION, BIOLOGY. *Mela*, Vert. Fenn., 1882:302, pl. IX (shores of Murman); Hjort, Rapp. Procès-Verb., X, 1909:62, f. 18 (spawning grounds); Damas, ibid.:203 (spawning); J. Schmidt, ibid: 98, 145, pl. VII (spawning conditions); Saemundsson, Synops. fish. Iceland, 1927:28 (at the shores of Iceland); De Buen, Fauna ictiol., 1935:76 (Atlantic Ocean opposite Gibraltar).

I D 14-15, II D 62-65, A 58-61, P 19-21, V 6-7, gill-rakers 12, vertebrae 63-65*. Lower jaw shorter than upper, antedorsal and anteanal distances great: antedorsal 26.7-28.3%, anteanal 45.3-46.5% of body length. Bases of dorsal and anal fins short, base of first dorsal 10.8-13.7%, second dorsal 45.8-47.7%, and anal 38.9-40.1% of body length. Caudal peduncle high, 4.2-4.9% of body length. Head large, 20.8-22.0% of body length; eyes small, 16.0-21.8% of head length. Skull broad, interorbital space 9.7-9.9% of head length. In per cent of body length: length of pectoral fin 9.9-10.9, length of pelvic fin 9.6-11.5, height of first dorsal fin 5.7-7.0, length of caudal peduncle 7.9-8.4. In per cent of head length: length of snout 30.7-32.8, length of upper jaw 39.7-44.7, length of lower jaw 51.2-53.0, length of barbel 28.2-28.8. Dorsum and head from above are reddish-brown, on the sides and from beneath milky white. At the rear of both dorsal and anal fins a black spot, dorsal fins orange or pale olive, with yellowish-white stripe along the edge, anal fin same color as belly. Reaches a length of over 1 and even 2 meters (2.2 meters). (3 specimens).

DISTRIBUTION. Western part of Barents Sea opposite the Murman shores. Atlantic Ocean southward to Bay of Biscay and opposite the entrance to Gibraltar sometimes**, around Great Britain, Ireland and the Faroe Islands: southwestern and southern shores of Iceland, in summer time at its northern and eastern shores. At the entrance of the Baltic Sea it is common in the Skaggerak and Kattegat, sometimes to Zundt and Kiel harbors. As to its occurrence along the coasts of North America and Greenland, there is no definite information.

BIOLOGY. Quite a deep-water fish, usually at depths of 200 meters and deeper at the bottom, primarily on rocky bottom. Keeps separately, does

*According to Smitt, I D 14-16, II D 60-68, A 57-65, P 18-19, V. 6. Vertebrae, according to J. Schmidt, 63-65.

** If the information of De Buen is accurate.

not form large groups and perhaps does not undertake extensive migrations. Mode of life predacious, living primarily on various fishes—cod, flounders, losos, herring, etc. Along with this type of food in their stomachs were found crustaceans and starfish. Spawning takes place between March and July even somewhat later than *M. dipterygia dipterygia*, at temperatures 6° to 10°C and salinity 35.2 parts per thousand, at depths primarily between 50 and 300 meters—around the 200-meter isobath. Main spawning grounds: at the southern and southwestern coasts of Iceland, at the Faroe Islands, along the western coasts of Scotland and Ireland at the southwestern entrance to the English Channel, in the northern part of the Bay of Biscay, in the northern and deep section of the North Sea, at Skaggerak, along the coasts of Norway to 30° north latitude. [This must be an error—translator's note.] Males reach sexual maturity at 80 cm, females—90–100 cm, at the age of 8–10 years, large individuals contain a great number of eggs, to 60 million.

COMMERCIAL VALUE. None in our waters. Caught in considerable quantities in western European countries. The annual catch for 1933 (together with *M. dipterygia dipterygia*) was 301,690 metric centner. The main mass is caught in the North Sea along the coasts of Norway, northwestern coast of Scotland and northern Ireland.

*2a. *Molva dipterygia dipterygia* (Pennant) (Tables V, XXXVII, LXIX)

Gadus dipterygius Pennant, Arct. zool., ed. I, I, 1784:76 (along the coast of Norway; according to Müller, Zool. Dan. prodr., 1776:42, N. 346, "G. dipterygius, cirratus, maxilla inferiore longiore, pinnis analibus LXX"). — *Gadus byrkelange* Walbaum in: Artedi, Gen. pisc., 1792:135. *Gadus abyssorum* Nilsson, Prodr. ichth. Scand., 1832:4. — *Lota abyssorum* Kröyer, Danm. Fiske, II, 1843–1845:167. — *Molva abyssorum* Nilsson, Scand. fauna, IV, Fisk., 1855:577. — *Molva byrkelange* Collett, Christ. Vidensk.-Selsk. Forh., 1874:116; Malm, Göteborg. Bohusl. Fauna, 1877:492 (along the coasts of Bohuslan Peninsula). — *Molva dipterygia* Smitt, Scand. fish., I, 1893:520, pl. XXVI, f. 3 (bibliography, distribution).

DISTRIBUTION, BIOLOGY. Collett, Christ. Vidensk.-Selsk. Forh., (1902), 1903:54 (north to Christiana Fjord); Hjort, Rapp. Procès-Verb., X, 1909:64, f. 18 (spawning grounds); Damas, ibid.: 210 (spawning); J. Schmidt, ibid.: 103, 146, pl. VII (spawning conditions); Johnsen, Bergens Mus. Arbok (1918–1919), 2, 1921:52, f. 2 (distribution, biology); Saemundsson, Synops fish. Iceland, 1927:30 (coasts of Iceland); Maslov, Tr. Polyarn. nauchno-issled. inst. morsk. rybn. khoz. i okeanogr., 8, 1944:169 (73° north latitude in the region of the Central Tongue).

I D 12–14, II D 74–78, A 72–74, P 19, V 6, gill-rakers 11, vertebrae 77*. Lower jaw projects forward. Antedorsal distance 23.7–25.3%, anteanal distance 37.9–44.2% of body length. Base of first dorsal fin 7.8–8.2%, second dorsal 52.0–58.9%, base of anal fin 47.1% of body length. Depth of caudal peduncle 2.5–3.0% of body length. Head 17.2–17.7% of body length. Eyes 23.7–26.9%, interorbital space 7.3–8.7% of head length. In per cent of body length: length of pectoral fin 10.0, length of pelvic fin 9.1, height of first dorsal fin 6.8, length of caudal peduncle 7.9. In per cent of head length: snout length 32.5, upper jaw 43.8, lower jaw 60.8, length of barbel 15.5.

* According to Smitt, I D 11–14, II D 74–83, A 70–81, P 18–20, V 6. According to J. Schmidt, 76–79 vertebrae.

Coloration from above dark brown, on the sides paler, gray-white or blue-gray, on the belly with small reddish-brown dots. Rear portion of second dorsal, anal and caudal fins and lateral sides of the pectoral fin black with a white edge. Length generally less than 1 meter though sometimes reaches 1.5 meters. (5 specimens).

DISTRIBUTION. Atlantic Ocean at the coasts of Norway (from Trondheim Fjord) and the southern and southwestern coasts of Iceland, south to the coasts of Scotland and Ireland eastward to Kattegat. In later years, due to the general warming, it has been found considerably farther to the north—at the coasts of the Scandinavian Peninsula to Sen'ja Island, in the Barents Sea to the Central Tongue (73° north latitude)*.

BIOLOGY. An even deeper water fish than *M. molva*, found at depths of 200 to 600 meters, although it is caught at lesser depths (60 meters). Spawning also takes place at great depths at about the 1,000 meter isobath, but not less than 500–600 meters. Spawning time—spring—May and beginning of June, but on a small scale was observed beginning with April until September. Spawning conditions: temperature 5 to 8° C, salinity 31.15–35.20 parts per thousand. Main places of spawning: opposite the southern coasts of Iceland, western coasts of the Faroe Islands, Scotland and Ireland, in lesser quantities spawns at Skaggerak and in some deep Norwegian fjords—Trondheim and others. Sexual maturity reached at a length of 80 cm.

COMMERCIAL VALUE. Caught generally at the coasts of Norway, but in industrial statistics it is usually counted with *M. molva*.

COMPARATIVE NOTES. *Gadus byrkelange* Walbaum, generally referred to this species, has a small number of rays, but the lower jaw projects. Smitt notes that the lower jaw in *M. dipterygia dipterygia* does not project forward. Apparently, he held in his hands only extremely large specimens in which the jaw rarely projects at all.

2b. *Molva dipterygia elongata* (Otto)—Mediterranean Pike (Tables XXXVIII, LXIX)

?*Gadus molva* (non L.) Risso, Ichth. Nice, 1810:119 (Mediterranean Sea at Nice). — ?*Phycis macrophthalmus* Rafinesque, Caratteri, etc., 1810:26, pl. IX, f. 3 (Sicily, lower jaw without barbel). — *Gadus elongatus* Otto, Conspectus anim. maritim. etc., 1821:6 (Mediterranean Sea at Nice). — *Lota elongata* Risso, Hist. nat. Eur. mérid., III, 1826:217, f. 47. — *Lota elongata* Erhardt, Fauna Cyc-laden, 1858:9 (Cyclad Islands); Canestrini, Arch. zool. anat., fisiol., II, 1863:367 (Gulf of Genoa). — *Lota molva* (non L.) Costa, Fauna Napoli, Pesci, I, 1863:15, pl. XXXVIII, f. 1. — *Lota elongata* Moreau, Hist. nat. poiss. France, III, 1881:260, f. 179 (Mediterranean Sea).

DISTRIBUTION, BIOLOGY. Hjort, Rapp. Procès-Verb., X, 1909:64, pl. 18 (spawning grounds); J. Schmidt, ibid.:107, 156, pl. VII (spawning conditions); D'Ancona, Fauna flora golfo Napoli, 38, 1933:229 (spawning); De Buen, Fauna ictiol., 1935:76 (along the shores of the Iberian Peninsula).

I D 10–12, II D 76–83, A 75–78, P 16–18, V 6–7, gill-rakers 10–11, vertebrae 80–84**. Lower jaw longer than upper jaw. Antedorsal and anteanal distances short: antedorsal 22.2–24.6, anteanal 36.4–39.6% of body length. Bases of both dorsal and anal fins long: base of first dorsal 5.3–6.5%, base of second dorsal 56.3–57.6%, base of anal 48.6–50.2% of body

* If the identification (*M. byrkelange*) is correct (Maslov, l. c.)

** According to Moreau, I D 10–12, II D 77–82, A 70–77, P 18, V 6. According to J. Schmidt, 82–84 vertebrae.

length. Caudal peduncle low, 1.7–2.3% of body length. Head small, 15.7–17.0% of body length. Eyes large, 24.5–28.2% of head length. Skull narrow, interorbital space 6.1–7.4% of head length. In per cent of body length: length of pectoral fin 8.8–9.7, length of pelvic fin 10.9–13.0, height of first dorsal fin 5.8–6.9, length of caudal peduncle 6.9–8.7. In per cent of head length: snout length 32.4–34.7, upper jaw 40.5–43.2, lower jaw 57.0–60.2, length of barbel 12.2–18.6. In juveniles the barbel is longer. Coloration grayish-pink with black dots, belly silvery-white, fins grayish, second dorsal and anal fins in the rear with a black stripe and narrow white edge. Caudal fin blackish, with a narrow white edge. Length to 70 cm (7 specimens).

DISTRIBUTION. Atlantic Ocean at the coasts of Europe from Gibraltar northward to the southwestern coasts of Ireland, European coasts of the Mediterranean Sea from the shores of Spain to the Aegean Sea (Cyclades Islands), perhaps entering the Black Sea.

127 **BIOLOGY.** Just as *M. dipterygia* *dip-ter-ygia*, it lives and spawns at great depths. Spawning takes place at depths over 1,000 meters at temperatures not lower than 8–9°C and the salinity not lower than 35.5 parts per thousand. Spawning grounds distributed in the Mediterranean, and Atlantic Ocean opposite the southwestern shores of Ireland and Bay of Biscay.

COMMERCIAL VALUE very slight.

COMPARATIVE NOTES. *Gadus molva* Risso, which has in the unpaired fins ray counts (I D 10, II D 66, A 59) characteristic of *M. molva* should apparently be referred to *M. dipterygia elongata*, inasmuch as the lower jaw is longer than the upper. In counting the number of rays there could have been error. With regard to *Phycis macrophthalmus* Rafinesque (no barbel on the chin), which is usually referred to this species, it is very difficult to state anything definite.

Molva elongata does not differ greatly from *M. dipterygia dip-ter-ygia* *externo-morphologically* or *craniologically*, and therefore it should be considered as only a subspecies. The skull of *M. dipterygia dip-ter-ygia* is just a little broader in the rear section. A hiatus which exists between them in some characteristics (bases of the first and second dorsal fins, the depth of the caudal peduncle) has been verified in only the small number of specimens examined.

2. Subfamily **MERLUCCIINAE**

Two dorsal fins and one anal fin, second dorsal and anal fins with a deep notch in the rear part, caudal fin truncate; it is not connected with anal and second dorsal. Frontals paired with a large triangular cavity, bordered on the sides and at the rear by crests, diverging from the rear section of the lateral crests of the supraoccipital. All parapophyses broadened, without ribs, with the exception of the shortened first pair which possess a small rib, and the epipleuralia on only three to four anterior vertebrae. Pelvic fins in the larvae are somewhat elongate; eggs with an oil globule.

10. Genus **MERLUCCIUS** Rafinesque

Merluccius Rafinesque, Caratteri, etc., 1810:26 (Type: *M. smiridus* Raf. * *M. merluccius*).
Onus Rafinesque, Ind. itiol. Sicil., 1810:12 (Type: *O. riali* Raf. *M. merluccius*).
Merlangus Rafinesque, l. c.:67 (Type: *G. merluccius* L., offered to replace *Onus* and *Merluccius*). — *Stomodon* Mitchill, Rept. fish. N. Y., 1814:7 (Type: *Stomodon bilinearis* Mitch.). — *Hydronus* Minding, Naturg. Fische, 1832:83 (Type: *M. merluccius*). — *Merlus* Guichenot in: Gay, Hist. fis. polit. Chile, II, 1848:328 (Type: *M. gayi* Guich.). — *Merluccius* Gronowius ed. Gray, Cat. fish., 1854:2 (Type: *M. lanatus* Gron. = *Merluccius merluccius*). — *Homalopomus* Girard, Proc. Acad. Nat. Sci. Phila., 1856:132 (Type: *H. trowbridgei* Grd. = *M. productus*). — *Epicopus* Günther, Cat. fish., II, 1860:248 (Type: *E. gayi* = *M. merluccius*). — *Trachinoides* Borodin, Bull. Vanderbilt Mar. Mus., I, (4), 1934:120 (Type: *T. maroccanus* Borod. = *M. Merluccius*).

Lower jaw projects forward, a row of well developed teeth on the head of the vomer and on the premaxillary and dentary; in addition there is a row of smaller teeth on the vomer, the dentary and between the large teeth on the premaxillary. Head of the vomer well developed and broad. Lateral line almost straight in the forward half of the body, located above the central axis of the body, continuous for its entire length. Canals of the lateral line system are found on the head, but there are no pores along it. There is a foramen for the facial nerve on the sides of the skull. The ostiatic process from the first vertebra is greatly broadened from above. Pyloric caeca absent. Second ray of pelvic fin not elongate.

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SKELETON. Skull from the side (A) low, gradually receding in front, its greatest height almost $\frac{1}{4}$ the length of its base. The lower edge of the bones at the base of the skull presents a straight line. The upper profile of the skull is straight for almost its entire length, with small notches only above the lateral ethmoids. Crests developed along the entire length of the supraoccipital, its rear end located forward of the rear end of the basioccipital. The forward edge of the mesethmoid is straight, dropping sharply, located at an obtuse angle to its upper edge. The orbital space elongate, its base more than 3 times its greatest height. Facial nerve exits from the skull through a foramen, separated from the orbital space by the alisphenoid and ascending process of the parasphenoid. The foramen of the glossopharyngeal nerve on the opisthotic is small. The skull from above (B) is not very broad, particularly not narrowed in the interorbital region, its greatest width contained little more than 2 times in its length. The edges of the skull are limited from the sides by a slightly wavy curved line with a small step on each side in the rear part of the edges of the frontals. Lateral ethmoids project on the sides and in front from beneath the frontals. The forward edge of the vomer projects from beneath the forward edge of the mesethmoid. The supraoccipital crest in front is bifurcate and runs into diverging crests on the frontals. The crests over the lateral line canals on the pterotic and frontals are short and narrow. The mucous cavity is large, deep, broadly opened in front; the lateral processes over the canal of the lateral line in front of the mucous cavity are not developed; there exists only the central crest. Parietal crests above the foramen of the recurrent dorsal branch of the facial nerve are not developed. The vomer from below (C) is broad, flat, its head broadened, the edges are drawn laterally with two rows of teeth into a horseshoe shape along the edge. The parasphenoid is quite broad, its lower surface flat. The supraoccipital crest (D) projects slightly above the skull. The lateral walls of the cranial box are convex, the base of the skull is broad and flat. The preopercular and lower processes

FIGURE 20. Distribution of the genus *Merluccius*

1—*M. merluccius*; 2—*M. bilinearis*; 3—*M. productus*; 4—*M. capensis*; 5—*M. hubbsii*; 6—*M. gayi*; 7—*M. australis*.

of the hyomandibular are brought closer to each other, both thin and long, the opercular process short, broad at the base; the auricular process is broad, extending forward above the base of the opercular process. The posttemporal is large, both forks are about equal in length. The postcleithrum is curved and broadened at its upper end. The operculum is broad, its lower edge with a deep notch and both ends sharpened. The urohyal is elongate, narrow, its lower edges broad. Parapophyses are long, wide, downward curved or curved from beneath, forming a complete bony armour from the sides of the body.

DISTRIBUTION. Temperate and subtropical waters of the Atlantic and Pacific Oceans in the northern and southern hemispheres (Figure 20). In the fossil state it is known from the Oligocene and Miocene deposits.

COMPARATIVE NOTES. Classification of the genus *Merluccius* was recently developed by Norman, who had cleared the confused synonymy of representatives of this genus and indicated differentiating characteristics between them. As can be seen from the diagnostic keys, taken almost without any change from Norman, the differences between the species of the genus *Merluccius* are based on the number of transverse rows of scales, gill-rakers on the lower limb of the first gill arch, length of pectoral and pelvic fins and ratio between them, the dimensions of the eyes and the depth of the body; all of these characteristics are overlapping, with the exception of the first two and last, having in some cases a hiatus. We cannot distinguish the various species of gadoids by the depth of the body which is greatly variable and dependent upon the fullness of the stomach and degree of sexual maturity. As for the number of transverse rows of scales and the number of gill-rakers on the lower limb of the first gill arch, these two characteristics coincide or overlap in the majority of species, and the apparent distinctions between some species are conditioned by the small number of specimens examined rather than by the actual differences between the species. The lack or absence of material discourages one from studying the osteology of all forms of this genus, but the forms studied in this respect (*M. merluccius*, *M. bilinearis*, *M. productus*) do not have in the structure of the skull and other parts of the skeleton such distinctions as exist between the other species and even subspecies of gadoids. All this indicates that even now, with the present state of knowledge, there is very little basis for dividing representatives of the genus *Merluccius* into different species. The majority of forms of this genus could be subspecies and perhaps only a few species. As they undoubtedly undertake migrations, each of the forms of the genus *Merluccius* is not isolated within the limits of its range from those forms which are geographically near it, which aids in maintaining their systematic closeness. *M. merluccius*, as indicated by Belloc, occurs at depths to Cape Blanco and perhaps even farther south*, thus having opportunity to enter the range of *M. capensis* which is geographically and systematically close. Doubts as to the specific difference between the species *M. capensis* from *M. merluccius* having sufficient basis were expressed by Barnard. *M. angustimanus* Garman, described from specimens caught almost at the Equator (opposite Panama Bay), in the opinion of Norman is identical with *M. gayi*; therefore, this form also has the opportunity of entering the range of a geographically close

* Of *Merluccius* from Cape Verde, see page 138.

form (*M. productus*). One specimen of *Merluccius*, caught at the shores of South America, Norman considers to belong to *M. australis*. Pozzi also (Annal. Soc. Cient. Argentina, 120, 1, 1935:158) indicates for the shores of Argentina, *M. hubbsi* and *M. gayi*. Based on the material present in the collections of the Zoological Institute of the Academy of Sciences hardly permits the segregation of all these forms in the diagnostic key of the genus *Merluccius*, and therefore they are provisionally considered as species.

Diagnostic Key to the Species

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- 1 (12). 100–150 transverse rows of scales. Eyes contained 4 to $7\frac{2}{3}$ times in head length.
 - 2 (3). On lower limb of the first gill arch (7) 8–12 gill-rakers. Pelvic fins equal or almost equal in length to pectoral fins. Pectoral fins almost reach or extend slightly beyond the origin of the anal fin, and are contained $1\frac{2}{3}$ to $1\frac{4}{5}$ times in head length. Atlantic Ocean at the shores of Europe and North Africa, Mediterranean Sea 1. *M. merluccius* (L.)
 - 3 (2). On lower limb of the first gill arch 10–18 gill-rakers. Pelvic fins almost always shorter than pectorals.
 - 4 (5). Pectoral fins do not reach or hardly reach the origin of the anal fin, and are contained $1\frac{3}{5}$ to $1\frac{4}{5}$ times in head length. 10–13 gill-rakers on lower limb of first gill arch. Transverse rows of scales about 130. Atlantic Ocean along the coast of South America 2. *M. hubbsi* Marini
 - 5 (4). Pectoral fins reach or extend beyond the origin of the anal fin; contained $1\frac{1}{4}$ to $1\frac{2}{3}$ times in head length.
 - 6 (7). The height of the body is contained 7 to $7\frac{2}{3}$ times in its length. The pelvic fins are contained $2\frac{1}{4}$ to $2\frac{1}{2}$ times in head length and constitute about $\frac{2}{5}$ of the distance from their base to the origin of the anal fin. 14–17 gill-rakers on the lower limb of the first gill arch. Transverse rows of scales 130–135. Pacific Ocean along the coast of North America 3. *M. productus* (Ayres)
 - 7 (6). Depth of body contained $5-6\frac{1}{4}$ times in body length. Pelvic fins contained $1\frac{2}{3}$ to $2\frac{1}{4}$ times in head length, constitute about $\frac{3}{5}$ of the distance from their base to the origin of the anal fin.
 - 8 (9). 15–18 gill-rakers on the lower limb of the first gill arch. Pectoral fins with 15–16 rays, first dorsal with 11 rays. Transverse rows of scales 110–115. Pacific Ocean along the coast of South America 4. *M. gayi* (Guich.)
 - 9 (8). 10–14 (15) gill-rakers on the lower limb of the first gill arch. Pectoral fins with 13–14 rays.
 - 10 (11). Transverse rows of scales 100–110. First dorsal fin with 12–13 rays. Pelvic fins constitute $\frac{3}{5}$ to $\frac{2}{3}$ of the distance from their base to the origin of the anal fin. Atlantic Ocean along the coast of North America 5. *M. bilinearis* (Mitch.)

- 11 (10). Transverse rows of scales 130-140. First dorsal fin with 10-11 rays. Pelvic fins constitute $\frac{2}{3}$ to $\frac{5}{6}$ of the distance from their base to the origin of the anal fin. Along the shores of South America. 6. *M. capensis* Casteln.
- 12 (1). Transverse rows of scales 155 to 165. Eyes contained 6 to $7\frac{1}{2}$ times in head length (in fishes 34-35 cm). 10 gill-rakers on the lower limb of the first gill arch. Pectoral fins reach to the origin or extend beyond the origin of the anal fin. Along the coast of New Zealand 7. *M. australis* (Hutton)

*1. *Merluccius merluccius* (Linné) (Tables VI, XXXIX, LXIX)

FIGURE 21.
Structure of pa-
rapophyses of
Merluccius.
Vertebral col-
umn from below.

Gadus merluccius Linné, Syst. nat., ed. X, 1758:254 (habitat in Oceano); Lacepède, Hist. nat. poiss., II, 1800:446. — *Gadus ruber* Lacepède, l. c., V, 1803:671. — *Merluccius smiridus* Rafinesque, Caratteri, etc., 1810:26. — *Onus riali* Rafinesque, Ind. ittiol. Sic., 1810:12. — *Gadus merluccius* Risso*, Ichth. Nice, 1810:122. — *Merluccius esculentus* Risso**, Hist. nat. Europ. mérid., III, 1826:220. — *Merluccius vulgaris* Fleming, Hist. brit. animals, 1828:195. — *Merluccius sinuatus* Lowe, Trans. Zool. Soc. London, III, 1839:13. — *Merluccius ambiguus* Lowe, Proc. Zool. Soc. London, VIII, 1840:37. — *Merluccius lanatus* Gronovius ed. Gray, Cat. fish., 1854:130. — *Epicopus gayi* Günther, Cat. fish., II 1860:248. — *Merluccius linnei* Malm, Göteborg. Bohusl. Fauna, 1877:489. — *Trachinoides maroccanus* Borodin, Bull. Vanderbilt Mus., I, (4), 1934:120, pl. II, f. 2, 3. — *Merluccius merluccius* Norman, Discovery Rept. XVI, 1937:45.

DISTRIBUTION, BIOLOGY. Möbius u. Heincke, Fische Ostsee, 1883:80 (Kiel Harbor); Smitt, Scand. fish., I, 1893:515, pl. XXVI, f. 1 (distribution, biology, synonymy); Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2530; Hjort, Rapp. Procès-Verb., X, 1909:63, f. 17 (spawning grounds); Damas, ibid.:214 (biology); J. Schmidt, ibid.:93, 145, pl. VIII (spawning); Saemundsson, Synops. fish. Iceland, 1927:28 (south-western shores of Iceland); Belloc, Rev. Trav. Off. Pêches Marit., II, 2, 1929:153 (synonymy, bibliography, distribution); D'Ancona, Fauna flora golfo Napoli, 38, 1932:288 (spawning); Belloc, Rev. Trav. Off. Pêches Marit., VI, 1, 1933:63 (distribution); Liebman, Rapp. Procès-Verb., VIII, (n. s.), 1934:321 (shores of Palestine, spawns January to March); Belloc, Rev. Trav. Off. Pêches Marit., VIII, 2, 1935:145 (number of vertebrae, races, migration); ibid. X, 3, 1937:341 (Atlantic Ocean opposite Cape Verde, vertebrae 54.09); Maiorova and Marti, Priroda, 1938:995 (Black Sea and along the coasts of Georgia).

I D† 9-10 (11), II D (36) 37-40, A 36-40, P (12) 13-14, scales 135-150††, gill-rakers (7) 8-12 on lower limb of the first gill arch, on the entire arch 10-12. Pectoral fins long, almost reaching or extending slightly beyond the origin of the anal fin, constituting 13.7 to 16.1% of body length, contained $1\frac{2}{3}$ to $1\frac{4}{5}$ times in head length. In per cent of body length: anteanal distance 38.7-41.7, antedorsal distance 26.8-29.3, length of pelvic fin 13.8-15.8, base of first dorsal fin 9.0-9.9, base of second dorsal fin 42.1-44.3, base of anal fin 41.8-43.8, height of first dorsal fin 10.1-12.3, depth of caudal peduncle 3.3-3.9, its length 8.4-10.2, head length 24.3-25.8. In per cent

* Belloc and Norman consider *Gadus maraldi* Risso to be *M. merluccius*. Actually it is *Ura-leptus maraldi* of the family Moridae.

** *Merluccius maraldi* Risso = *Uraleptus maraldi*, see above.

† The limits of variation after Norman were placed in parentheses in all examined species whenever they are more than ours.

†† After Smitt, to 154.

of head length: length of snout 34.6–36.6, lateral diameter of eye 19.0–22.0, length of upper jaw 49.3–52.4, lower jaw 61.3–64.5, width of forehead 21.2–25.7. Coloration silvery-gray, on the back blackish-gray, at the base of the pectoral fin a small black spot. Length to 1 meter and more (to 1.2 meter). (8 specimens).

DISTRIBUTION. Atlantic Ocean along the coasts of Europe; north occasionally to the Lofoten Islands and southwestern shores of Iceland*; east to Kiel Harbor, common along the southwestern shores of Norway; around Great Britain and Ireland, in the Bay of Biscay and along the shores of the Iberian Peninsula; south in considerable numbers to Cape Blanco; Mediterranean and Adriatic Seas, east to the Bosphorus and shores of Egypt, Syria and Palestine, the Marmora Sea and the southeastern part of the Black Sea along the coasts of the Caucasus (Batumi). Due to the warming of the Arctic observed in recent years, occasional specimens may penetrate into the Barents Sea.

BIOLOGY. Presumed to remain usually at the bottom, but judging by the food contents it must rise to the intermediate and surface layers of the water. Lives on fish, not benthonic ones but pelagic—herring, mackerel, sardines, and others. Maintains greatly varied depths from 20–25 to 1,000 meters, but within the limits of the continental slope. Young are sometimes found at very shallow depths. Undertakes migrations, the ways and extent of which are not as yet studied. Undoubtedly there are seasonal migrations from greater to lesser depths, tied in with reproduction and feeding, but besides these there are also undoubtedly meridional migrations along the shores although the latter are denied by some (Belloc). In some places it appears very irregularly: after a year of very rich catch comes a series of years during which it is rarely found. The occurrence of occasional specimens at the extreme limits of distribution also to a certain degree serves to support the theory of the migration of the second type. It is found occasionally, and in great aggregations as well. Mainly aggregates in the spawning period. Spawns over very broad bathymetric limits from 100 (or less) to 1,000 meters or more. Spawning takes place at the northern and western shores of Great Britain and Ireland, western part of the English Channel, Bay of Biscay and the Mediterranean Sea. Spawns in some years in the Skaggeak and the most northeastern section of the North Sea. Period of spawning extended—from spring to fall, mass spawning up north in the middle or end of summer (July–August), southward—in spring or early summer. In the Mediterranean spawns from January to June. Spawning conditions; temperature quite high, no lower than 9–10° C, salinity not less than 35.2 parts per thousand. Sexual maturity is reached at a length of 20–25 cm. Growth parallel with the changes in the stage of maturity falls into 3 periods: 1) period of rapid growth (up to 2 years in females, to 3 years in males), equal to the juvenile stage; 2) period of medium growth (to 7 years), corresponding to attainment of sexual maturity; and 3) period of delayed growth or slowed growth (after 7 years)—period of full sexual maturity. The tempo of growth within the limits of distribution is unequal; in 9 years in the Mediterranean Sea a fish has an average length of 30 cm, at Ireland 65 cm, in the Bay of Biscay 71 cm, at Morocco 78 cm. Parallel with this are changes in the number of vertebrae, decreasing on the average from north to south from 51.15 (west of Ireland) to 50.48 (at Cape

* Indications for its occurrence at the coasts of Greenland (Jordan and Evermann) are incorrect.

Blanco), which gives a basis for presuming that this fish has local forms analogous to races of *G. morhua morhua* (see comparative notes). The presence of local forms, however, does not give grounds for considering that *M. merluccius* undertakes only short migrations. *G. morhua morhua*, for example, appears to be evidence contrary to this opinion.

COMMERCIAL IMPORTANCE quite considerable. Annual catch reaches over 445 thousand metric centner, not counting the catch in the Mediterranean (1933). Main places of catch are southern, western and northern shores of Ireland and northwestern shores of Scotland.

COMPARATIVE NOTES. *Gadus merluccius (argentatus)* Faber (Naturgesch. Fische Islands, 1829:90) = *Merluccius argentatus* Günther (Cat. fish., IV, 1862:346), as indicated by some authors is *Odontogadus merlangus*. In one of our specimens of *M. merluccius* the pectoral fins extend slightly beyond the origin of the anal fin. On specimens from Cape Verde the number of vertebrae are on the average 54.09, that is considerably higher than in specimens from more northerly latitudes (at Cape Blanco 50.48, see above), which gives basis for presuming the presence here of some other species.

2. *Merluccius hubbsi* Marini

? *Merluccius gayi* (non Guichenot) Cunningham, Trans. Linn. Soc. London, XXVII, 1871:462; Perugia, Ann. Mus. Civico Stor. Nat. Genoa (2), X, (XXX), 1891:627 (Biglia Canal); Berg, Anal. Mus. Nac. B. Aires, IV, 1895:74. — *Merluccius bilinearis* (non Mitchell) Ribeiro, Arch. Mus. Nac. Rio de Janeiro, XVII, 1915, Merlucciidae: 2, fig. — *Merluccius gayi* (non Guichenot) Thompson, Proc. U. S. Nat. Mus. L, 1916:417 Devincenzi, Anal. Mus. Montevideo, (II), I, (5), 1924:272; Fowler, Proc. Acad. Nat. Sci. Phila., LXXVIII, 1927:274. — *Merluccius hubbsi* Marini, Physis XI, 1932:322, f.; Norman, Discovery Rept. XVI, 1937:46, f. 20A (bibliography).

134 I D (11) 13, II D 36 (39), A 37 (41), P (12) 14, scales about 130, gill-rakers (10) 12 (13) (on the lower half of the first gill arch, on the whole arch 16). Pectoral fins short, do not reach or hardly reach the origin of the anal fin, constituting 18% of body length, contained $1\frac{3}{5}$ to $1\frac{4}{5}$ times in head length. In per cent of body length: anteanal distance 41.6, antedorsal distance 30.9, length of pelvic fin 15.0, base of first dorsal fin 11.5, base of second dorsal 42.9, base of anal 41.6, height of first dorsal fin 10.9, depth of caudal peduncle 3.5, its length 9.2, head length 26.4. In per cent of head length: length of snout 33.7, lateral diameter of eye 22.5, length of upper jaw 50.6, length of lower 65.2, interorbital space 20.2. Length to 1.2 meters (from one not large specimen 10.1 cm in length).

DISTRIBUTION. Southern part of the Atlantic Ocean at the shores of South America from the Straits of Magellan to Brazil.

BIOLOGY. Little known but obviously does not differ from the biology of other forms.

COMMERCIAL VALUE very slight.

COMPARATIVE NOTES. The pelvic fins on our specimen are much longer than the pectoral; however, according to Norman, they should almost always be shorter than the pectoral. Likewise, the pectoral fins extend slightly beyond the origin of the anal fin.

3. *Merluccius productus* (Ayres) (Tables VI, XL)

Merlangus productus Ayres, Proc. Calif. Acad. Nat. Sci., 1855:64 (San Francisco). — *Homalopomus trowbridgii* Girard, Proc. Acad. Nat. Sci. Phila., 1856:132. — *Gadus productus* Günther, Cat. fish., IV, 1862:338. — *Merluccius productus* Gill, Proc. Acad. Nat. Sci. Phila., 1863:247. — *Gadus (Boreogadus) productus* Steindachner U. Kner, Sit Sitzungsber. Acad. Wiss. Wien. math.-naturw. Cl, LXV, 1, 1870:20 (Castis Bay). — *Merluccius productus* Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2531, f. 884; Starks a. Morris, Univ. Calif. Publ., Zool., III, (II), 1907:241; Belloc, Rev. Trav. Off. Pêches Marit., II, 1929:169, f. 11 (synonymy, distribution); Schultz a. DeLacy, Mid.-Pacific Mag., Jan. - March, 1936:65 (from California to Alaska, bibliography); Norman, Discovery Rept., XVI, 1937:47.

I D 11-12, II D 37-42, A (37) 38-42, P 14-16, scales 130-135, gill-rakers 14-17 (on the lower limb of the first gill arch; on the whole arch 19-21). The pectoral fins reach or extend beyond the origin of the anal fin, constituting 17.3-21.2% of body length, contained $1\frac{1}{4}$ to $1\frac{2}{5}$ times in head length. In per cent of body length: anteanal distance 40.0-46.0, antedorsal distance 27.3-31.1, length of pelvic fin 12.7-13.1, base of first dorsal fin 10.5-11.2, base of second dorsal fin 40.5-42.5, base of anal fin 39.6-42.0, height of first dorsal fin 10.5-12.2, depth of caudal peduncle 3.1-3.5, length of caudal peduncle 9.5-11.0, length of head 24.4-28.8. In per cent of head length: length of snout 35.0-36.5, diameter of eye 19.2-22.3, length of upper jaw 45.5-48.0, length of lower jaw 58.8-61.2, interorbital space 23.0-24.9. Length to one meter (3 specimens).

DISTRIBUTION. Northern part of the Pacific Ocean at the shores of North America from California (Pt. Loma) to Puget Sound, occasionally to Alaska. On the Asiatic coast it is recorded from DeCastris Bay (Steindachner u. Kner, l. c., see comparative notes).

BIOLOGY. Does not differ materially from the biology of the other forms. The presence in one or another locality of a considerable number of fish is inconstant. Great predator, feeds on small fish and cephalopods.

COMMERCIAL VALUE very small and in the presence of other fish it is usually discarded.

COMPARATIVE NOTES. The record given by Steindachner and Kner of finding *M. productus* in DeCastris Bay is very doubtful, even though the number of rays and description of the specimens (2 greatly damaged) corresponds to *M. productus*. If *M. productus* was actually found at the Asiatic coasts of the Pacific Ocean, then it undoubtedly would have been discovered at the eastern coast of Japan and other places. The Bay of DeCastris is too unusual a spot for this fish, not elsewhere found along the Asiatic coasts. Occasional specimens at the northern limits of the range might perhaps penetrate into our waters.

135 4. *Merluccius gayi* (Guichenot)

Merlus gayi Guichenot in: Gay, Hist. fis. polit. Chile, Zool., II, 1848:328, pl. VIII, f. 2 (off the coast of Chile). — *Merluccius gayi* Kaup, Wieg. Arch. Naturgesch., 1858:87; Günther, Cat. fish., IV, 1862:346. — ?*Merluccius angustimanus* Garman, Mem. Mus. Comp. Zool., XXIV, 1899:183, pl. XLI, f. 1, pl. LXXXVI, f. 1, (Gulf of Panama, scales 110); Delfin, Cat. peces Chile, 1901:100; Revist. Chil., VII, 1903:269, f. 7. — Evermann a. Radcliffe, Bull. U. S. Nat. Mus. XCV, 1917:156. — *Merluccius gayi* Norman, Discovery Rept. XVI 1937:48, f. 20B.

I D 11, II D 36-40, A 37-39, P 15-16, scales 110-115, gill-rakers 15-18 (on lower limb of arch). Pectoral fins long, extending back beyond the origin of the anal fin, contained $1\frac{1}{3}$ to $1\frac{3}{5}$ times in head length. Reaches over one meter (after Norman).

DISTRIBUTION. Southern part of the Pacific Ocean along the coasts of Chile and Peru south to the Strait of Magellan, north to Panama Gulf occasionally.

BIOLOGY. Very little known. Lives on small fish.

COMMERCIAL VALUE. Considerable; found and caught in considerable quantities.

COMPARATIVE NOTES. The specimens described as the individual species *M. angustimanus* Garman are closest to this form, to which Norman refers them.

5. *Merluccius bilinearis* (Mitchill) (Table XLI)

Stomodon bilinearis Mitchill, Rept. fish. N. Y., 1814:7 (New York, cited by Jordan a. Evermann). — *Gadus albidus* Mitchill, Journ. Acad. Nat. Sci. Phila., I, 1817:409 (New York). — *Merluccius bilinearis* Gill, Proc. Acad. Nat. Sci. Phila., 1863:247; Jordan a. Evermann, Fish. N. a. M. America, III, 1898:2530; Bigelow a. Welch, Fish. gulf Maine, 1925:386, f. 194, 195 (biology); Hildebrandt a. Schroder, Bull. Bur. Fisher., XLIII, 1, 1928:162, f. 85; Belloc, Rev. Trav. Off. Pêches Marit., II, 1929:165, f. 8, 9 (bibliography, distribution); Norman, Discovery Rept., XVI, 1937:47 (description, distribution).

I D 12 (13), II D (36) 39 (41), A (37) 39-40, P (13) 14-15, scales 100-110, gill-rakers (10) 13 (15) (on lower half of first arch, on whole arch 17-18). Pectoral fins reach to the origin of the anal fin or slightly farther, constituting 20.0-20.6% of the body length, contained $1\frac{1}{3}$ to $1\frac{1}{2}$ times in head length. In per cent of body length: anteanal distance 40.4-41.3, antedorsal distance 25.9-28.5, length of pelvic fin 15.6-15.9, base of first dorsal fin 11.0-11.6, base of second 41.1-41.4, base of anal 41.0-41.6, height of first dorsal 13.5-14.0, depth of caudal peduncle 3.4-4.3, its length 9.0-9.1, head length 23.6-24.3. In per cent of head length: length of snout 37.2-38.4, horizontal diameter of eye 19.8-21.5, length of upper jaw 49.0-50.5, length of lower 63.0-63.7, interorbital space 24.5-24.6. Coloration dark gray or brown, golden from above, on the sides and belly with silvery sheen. Length to 70 cm, but usual dimensions about 35 cm (2 specimens).

DISTRIBUTION. Northern part of Atlantic Ocean at the coasts of North America from Belle Isle Strait south at considerable depths occasionally to the Bahamas.

136 BIOLOGY. This form, as *M. merluccius*, is changeable within very broad limits. Mode of life depends little on depth or bottom; found at 100 meters and much less, to 550 meters and deeper; keeps at the bottom as well as in the intermediate layers. When it stays at the bottom it prefers the sand and gravel ground, not mud or rocks. Undertakes seasonal migrations, in the spring coming toward shore to lesser depths, in winter going away from shore toward deeper water. Just as in the European form it appears irregularly, years of big catch alternating with years of poor catch. In its pursuit of food it keeps in the intermediate as well as in the upper layers of the water. By its feeding, it is a predator, its basic food herring, mackerel,

aterinka [Translator's note: possibly atherines] and other small fish, occasionally eating kalmar, crabs, etc. Spawning takes place in summer beginning in June and ending in the middle of October, the height of spawning during July and August; south of Cape Cod spawning may commence earlier. Depth of the spawning grounds varies from 100 meters or less to 550 meters. The main areas are distributed from the shores of Nova Scotia to Cape Cod; They are not found southward, but perhaps exist. Conditions of spawning: temperature 5-7 to 12-15° C, salinity 31.5-32.5 parts per thousand.

COMMERCIAL VALUE extensive. Catch off the coast of Massachusetts and Maine in 1919 reached over 6 thousand metric centner.

6. *Merluccius capensis* Castelnau

Merluccius capensis Castelnau, Mém. poiss. Afr. austr., 1861:68 (at South Africa); Regan, Ann. Natal. Mus., I, 1906:4 (description); Barnard, Ann. S. Afr. Mus., XXI, 1925:320, pl. XII, f. 5 (bibliography); Norman, Discovery Rept. XII, 1933:48 (bibliography, description); ibid.: XVI, 1937:48.

I D 10-11, II D 35-40, A 37-40, scales 130-140, gill-rakers 13-14 (on lower half of gill arch). Pectoral fins long, reaching beyond the origin of the anal fin, contained $1\frac{1}{3}$ to $1\frac{2}{3}$ times in head length. (after Norman).

DISTRIBUTION. Southern part of the Atlantic Ocean at the shores of Africa south from Angola; along the eastern shores of the Indian Ocean northward to Natal. [Translator's note: Obviously refers to western shores of Indian Ocean.]

BIOLOGY. Undertakes considerable migrations as at exceedingly irregular times it appears in great quantity. Feeds on fish (Macruridae).

COMMERCIAL VALUE considerably great, one of the most valued commercial fishes along the southern shores of Africa.

7. *Merluccius australis* (Hutton)

Gadus australis Hutton, Car. fish. N. Zealand, 1872:45, 115, pl. VIII, f. 2 (Cook Strait). — *Merluccius gayi* Günther, Challenger's Rept. I, Shore fish., 1880:22; Waite, Rec. Canterbury Mus., I, 1, 1907:18; ibid., I, 3, 1911:182, pl. XXX, f. 2 (distribution). — *Merluccius australis* Norman, Discovery Rept. XVI, 1937:48 (bibliography).

I D 11, II D 36-43, A 36-42, P 13, scales 155-165, gill-rakers 10 (on the lower half of the first arch). Pectoral fins reach or extend beyond the origin of the anal fin, contained $1\frac{2}{5}$ to $1\frac{2}{3}$ times in head length. General coloration reddish-brown from above, silvery from below, mouth inside dark gray. Length to one meter (after Norman).

DISTRIBUTION. Around New Zealand. One specimen of this form was found at the shores of South America (Messier Channel).

BIOLOGY. Unstudied, but apparently similar to the biology of other forms.

INDUSTRIAL VALUE quite considerable.

COMPARATIVE NOTES. Norman indicates he had found no difference
137 between specimens caught by the "Challenger" expeditions along the Pacific

coast of South America (Messier Channel) and typical specimens of *M. australis* and on that basis he extends the range of this species to the shores of South America. Apparently, there were actually specimens of *M. gayi*, intermediate between this form and *M. australis*.

3. Subfamily **GADINAE**

Three dorsal and two anal fins either touching at their bases or separated by interspaces. Caudal fin truncate or with a notch, separated from the second anal and third dorsal. Frontals fused into one unpaired plate. Eggs without oil globule. Pelvic fins in larvae not elongate, consisting of more than 3 rays.

11. Genus **TRISOPTERUS** Rafinesque

Trisopterus Rafinesque, *Prec. d'écouv. somiologiques*, 1814:16 (Type: *Gadus capelanus* Lacep.). — *Morhua* Risso, *Hist. nat. Europ. mérid.*, III, 1826:225 (Type: *G. capelanus* Lacep.). — *Brachygadus* Gill., *Proc. Acad. Nat. Sci. Phila.*, (1862), 1863:316; *ibid.*, (1863), 1864:236 (Type: *G. minutus* L.). — *Gadulus* Malm, *Göteb. Bohusl. Fauna*, 1877:482 (Type: *G. luscus* L.).

Dorsal fins touching or separated by a small space, anal fins touching without a space. First anal fin long, its origin beneath the first dorsal fin. Caudal fin truncate or with a small notch. Lower jaw shorter or slightly longer than upper. A long barbel on the chin. Teeth on premaxillary and dentary and in one or two rows along the forward edge of the head of the vomer. Lateral line in the forward half of the body in the shape of a low arch, farther back straight, uninterrupted for its entire length. Pores on the head along the sensory canal; 12 pores in the preoperculo-mandibular canal, 8 pores in the infraorbital canal, 2 pores in the supraorbital canal, and one unpaired pore in the supraorbital commissure. Mucous cavity on the skull almost closed. The facial nerve exits through a foramen on the side of the skull.

SKELETON. Skull high (A), its greatest height contained 2 to $2\frac{1}{2}$ times in the length of the base of the skull. Parasphenoid with an arch beneath the foramen of the facial nerve approximately equal in all species. Forward of this arch the gones lying along the base of the anterior section of the skull are placed in a straight line. The rear portions of the parasphenoid and basioccipital, which constitute the base of the rear portion of the skull, are also placed in a straight line, but, due to the great convexity of the auditory area, the rear section of the base of the skull from beneath has a somewhat rounded shape. The upper profile of the skull descends forward quite abruptly. The supraoccipital crest in the rear section of the frontals is high, especially in *T. luscus*; it is lowest in *T. esmarkii* and is straight and somewhat curved upward, terminating abruptly in front approximately in the center of the skull before the mucous cavity; in the rear it extends beyond the basioccipital. The mesethmoid descends abruptly in both forms of *T. luscus*, at some angle in *T. minutus* and in *T. esmarkii*, its forward end with a notch. The orbital space is high, its height contained

FIGURE 22. Distribution of the genus *Trisopterus*

1—*T. luscus*; 2—*T. minutus minutus*; 3—*T. minutus capelanus*; 4—*T. esmarkii*.

(in *T. esmarkii*) about 2 or fewer times in its base. The facial nerve leaves the skull through a foramen, formed by a fusion of the ascending process of the parasphenoid, forward portion of the prootic and the alisphenoid. The foramen on the opisthotic is very small. The skull from above (B) is

broad, the lateral edges of its rear portion formed by the edges of the pterotic, are almost parallel with each other. Forward of the pterotics the skull narrows sharply due to a narrowing above the orbits of the forward ends of the frontals. The forward ends of the frontals are widest in *T. luscus*, narrowest in *T. esmarkii*. The lateral ethmoids are extended more to the sides than longitudinally; the part extending forward from beneath the frontals is somewhat larger than the portion covered by them. The forward end of the mesethmoid is located behind or in back of the forward end of the vomer. The crests above the sensory canals are wide; on each side of the frontals they are connected by narrow thread-like commissures with the edge of the crest which rises above them. The mucous cavity is deep, somewhat separated into two sections by lateral partitions, which rise as a low crest from its base. Forward of the mucous cavity, the canals are incorporated into a bony canal closed on all sides, formed by a fusion of the lateral crests of the frontals with the central crest of its forward section.

The parietal crests above the foramen

of the recurrent dorsal branch of the facial nerve are in the shape of long transverse processes, which are directed somewhat upward. From beneath the skull (C), teeth on the vomer are small, placed in a horseshoe-like row which is narrower at the ends and which lies along the forward edge of the head of the vomer; the very apex of the head of the vomer at times is toothless. The parasphenoid in front is slender, rounded, its lower surface behind the forward edge of the prootic has a lateral concavity. The prootic and opisthotic are greatly convex, the auditory area of the skull is considerably inflated from the sides and somewhat ventrad. In the rear of the skull (D), the supraoccipital crest extends high above its upper edge. The parietal crests above the foramen of the recurrent dorsal branch of the facial nerve are clearly visible above the dorsal surface of the skull. The rear edge of the preopercular and lower processes of the hyomandibular are parallel to each other in all species; the opercular process is shorter than the lower process, with a broad base in *T. esmarkii*; almost the same in its entire stretch in all the other species. The lower edge of the

operculum in *T. esmarkii* is greatly narrowed. The upper edge of the postcleithrum is bent and widened in *T. luscus* to the greatest extent. The urohyal is shortened and broad in *T. minutus*, somewhat more elongate and narrow in all other species. Parapophyses are quite long, particularly in *T. minutus*, shorter and broader in *T. luscus* and *T. esmarkii*. The first haemal arches are large. Craniologically this genus is well segregated from its nearest relatives.

Description based on one skeleton of *T. luscus*, two of *T. minutus* minutus, two of *T. minutus* capelanus and one of *T. esmarkii*.

DISTRIBUTION. Three species along the European coasts of the Atlantic Ocean and in the western section of the Mediterranean sea, where one of them is represented by a subspecies (Figure 22).

139 Diagnostic Key to the Species and Subspecies

- 1 (6). Lower jaw shorter than upper.
- 2 (3). First anal fin long, with 30-34 rays, the length of its base constituting 35.7-37.8 per cent of body length. Interorbital space broad, 17.9-18.1% of head length 1. *T. luscus* (L.)
- 3 (2). First anal shorter, with 27-30 rays, the length of its base constituting 27.9-31.7% of body length. Interorbital space narrower, 17.0-17.4% of head length.
- 4 (5). Gill-rakers about 28. Atlantic Ocean 2a. *T. minutus* minutus (O. Mull)
- 5 (4). Gill-rakers 17-20. Western part of the Mediterranean Sea 2b. *T. minutus* capelanus (Risso)
- 6 (1). Lower jaw somewhat longer than upper 3. *T. esmarkii* (Nilss.)

1. *Trisopterus luscus* (Linné) (Tables VII, XLII, LXX)

Gadus luscus Linné, Syst. nat., ed. X, 1758:252 (Oceano Europeo). — *Gadus barbatulus* Linné, l. c.:252 (Oceano Europeo). — *Gadus bibus* Lacepède, Hist. nat. poiss., II, 1800:365, 403 (Atlantic Ocean at the coasts of Europe). — *Morhua lusca* Fleming, Hist. brit. animals, 1828:191. — *Morhua barbata* Fleming, l. c.:191. — *Gadus colias* Gronow ed. Gray, Cat. fsh., 1854:131. — *Gadus minutus* Steindachner, Sitzungsber. Akad. Wiss. Wien, math.-naturw. Cl., LVII, 1, 1868:705 (ex parte: shores of the Iberian Peninsula). — *Gadulus luscus* Malm, Göteborg. Bohusl. Fauna, 1877:482. — *Gadus luscus* Williamson, 24th Ann. Rept. Fish. Board Scot.; pt. 3, (1905), 1906:116 (osteology); Fage, Arch. Zool. Exper. Génér., (5), VI, 1911:257 (comparison with related forms).

DISTRIBUTION, BIOLOGY. Smitt, Scand. fish., I, 1893:495, pl. LXXII, f. 2 (from the southern coasts of Scandinavia to the Iberian Peninsula, Mediterranean Sea); Hjort, Rapp. Procès-Verb., X, 1909:60, f. 16 (spawning); Damas, ibid.:27 (biology); J. Schmidt, ibid.:76, 144 (spawning); Chevey, Rev. Trav. Off. Pêches Marit., II, 1, 1929:73 (compilation of data on biology and distribution); Tortonese, Boll. pesca, piscicult., idrobiol., XI, 2, 1935:232 (at the coasts of Italy).

I D 11-14, II D 20-24, III D 18-20, I A 30-34, II A 19-22, gill-rakers 18-23, vertebrae 47*. The mesethmoid in front descends rather abruptly, its forward end is almost above the forward edge of the vomer. The leading

* According to Williamson, 48-49.

edge of the frontals is almost above the leading edge of the lateral ethmoids. In the interorbital space the skull is broad, about 3 to 4 times in its length. The mouth is inferior. Dorsal and anal fins touch, anals at the base often are fused with each other. First anal fin long, 35.7–37.8% of body length, its origin beneath the origin or somewhat behind the origin of the first dorsal fin, but no farther than its center. The body is high, the lateral line in the forward section of the body is greatly curved. In per cent of body length: anteanal distance 29.2–33.8, antedorsal distance 26.6–29.3, length of pectoral fin 15.9–19.3, the length of the pelvic fin 12.3–15.7, the base of the first dorsal fin 11.4–14.0, the base of the second dorsal fin 23.9–27.7, base of third dorsal fin 13.7–15.8, the base of the first anal fin 35.7–37.8, base of second anal 15.4–17.1, height of first dorsal 16.2–17.4, height of first anal 12.9–14.8, the depth of the caudal peduncle 4.9–5.9, its length 10.2–12.8, the length of the head 22.7–23.8. In per cent of head length: length of snout 26.9–28.8, horizontal diameter of eye 28.1–30.9, length of upper jaw 40.0–43.4, length of lower jaw 46.2–49.1, width of forehead 17.9–18.1, length of barbel 23.1–28.6. The upper part of the body is reddish-brown, the lower part lighter with a bluish-gray tint, changing on the belly to whitish; the sides are silvery, the lateral line golden yellow. Almost the entire body is covered with small blackish-brown dots. The fins are bluish-black, darker toward the top. Transverse lines of a whitish-gray color sometimes run across the body. At the upper edge of the base of the pectoral fin there is a black spot. The length is usually 15–20 cm, seldom exceeding 30 cm, but may reach 45 cm in length (11 specimens).

DISTRIBUTION. European shores of the Atlantic Ocean, at the southernmost shores of Morocco and even farther south (absent, however, at Cape Blanco), in the Bay of Biscay, common around Great Britain and Ireland, in the English Channel, at the western shores of Scotland, in Skaggerak both to Cape Skagon and southern shores of the Province of Bohuslan. Not found at Iceland or the Faroe Islands. Found occasionally in the western part of the Mediterranean along the European and African shores (Morocco and Algiers), Fage, l. c. :267).

BIOLOGY. Studied very little. Stays normally at depths of 250–300 meters, sometimes found in shallow water near shores. Spawning is mainly in the English Channel, where the greatest number of eggs and pelagic larvae are found, and also in the Bay of Biscay, at the western and northern shores of Great Britain, around Ireland, in small numbers at the southern part of the North Sea, and in the Mediterranean. Spawning takes place in comparatively shallow water within the limits of the hundred-meter isobath, primarily at depths of 50 to 100 meters, at fairly high temperatures (not lower than 8–9° C) and at normal oceanic salinities – 32.00–35.35 parts per thousand. The main time of spawning is spring, March–April, spawning in small quantities in summer in June and July and even in August; starting in January. Sexual maturity is attained in one year. A length of 21–25 cm is reached in one year, 23–27 in two years, 28–33 in three years and a length of 30–31 in four years. Feeds on mollusks, crustaceans, small fish.

2a. *Trisopterus minutus minutus* (O. Müller) (Tables XLIII, LXX)

Asellus mollis minor seu *Asellus omnium minimus* Willughby, Hist. pisc., 1686:171 (mari Mediterraneo, in "Oceano vel non omnino vel rarius inveniri"); Ray, Synops. meth., 1713:163 (litus Cornubiense). — *Gadus* Artedi, Synon., 1738:36, sp. 8; Gen. pisc., 1738:21, sp. 7 (secundum Willughby et Ray). — *Gadus minutus* Linné, Syst. nat. ed. X, 1758:25 (secundum Artedi, oc. Atlanticum, errore a Linneo non indicatum); O. Müller, Zool. Dan. prodr., 1776:42 (the shores of Denmark). — *Gadus tacaud* Lacepède, Hist. nat. poiss., II, 1800:366, 410 (Atlantic coasts of Europe). — *Gadus capelanus* Lacepède, l. c.: 365, 411 (ex parte: Atlantic Ocean and the coasts of Europe). — *Morhua minuta* Fleming, Hist. brit. animals, 1828:191. — *Brachygadus minutus* Gill, Proc. Acad. Nat. Sci. Phila., 1862:280. — *Gadus minutus* Steindachner, Sitzungsber. Akad. Wiss. Wien, math.-naturw. Cl., LVII, 1, 1868:704 (ex parte: from Viga, Koruna and Lisbon). — *Gadulus minutus* Malm. Göteborg. Bohusl. Fauna, 1877:482. — *Gadus minutus* Williamson, 24th Ann. Rept. Fish. Board Scotl., pt. 3, (1905), 1906:116 (osteology); Fage, Arch. Zool. Exper. Génér., (5), VI, 1911:257 (comparison with related forms); Chaîne et Duvergier, C.-R. Ac. Sci., 20 April, 1927:917 (difference by otoliths).

DISTRIBUTION, BIOLOGY. Möbius u. Heincke, Fische Ostsee, 1862:77 (Kiel Harbor); Smitt, Scand. fish., I, 1893:495, pl. XXIV, f. 2 (from Trondheim fjord to coast of the Iberian Peninsula); Hjort, Rapp. Procès-Verb., X, 1909:59; f. 16 (spawning); Damas, ibid.:215 (biology); J. Schmidt, ibid.:70, 143 (spawning).

I D 13, II D 23-26, III D 22-24, I A 28-29, II A 23-25, gill-rakers about 28, vertebrae 50*. Mesethmoid descending at a slight angle in front, its forward edge lying slightly behind the forward edge of the vomer. Leading edge of the frontals behind the leading edge of the ethmoids. Skull narrowed in the interorbital space, about 4.4 times in its length. Mouth 141 inferior. Anal fins touching, dorsals also touching or with small inter-spaces. First anal fin 27.9-29.8% of body length, its origin located between the middle and end of the first dorsal fin. Body shallower than in *T. luscus*, lateral line less strongly curved. In per cent of body length: anteanal distance 34.2-39.7, antedorsal distance 26.2-28.0, length of pectoral fin 15.8-16.8, length of pelvic fin 13.1-15.1, base of first dorsal fin 10.7-11.4, base of second dorsal 24.6-27.1, base of third dorsal 16.5-16.7, base of first anal 27.9-29.8, base of second anal 17.3-17.4, height of first dorsal 15.9-17.1, height of first anal 10.8-12.5, depth of caudal peduncle 4.6, its length 10.5-11.1, length of head 22.0-22.5. In per cent of head length: length of snout 23.6-26.5, horizontal diameter of eye 33.7-34.1, length of upper jaw 44.2-44.3, length of lower jaw 50.0-52.0, width of forehead 17.3-17.4, length of barbel 23.9-24.9. Body above lateral line yellowish-brown in color; the sides are lighter with a copper shading; the belly silvery-gray; fins with the same coloration as the body but somewhat darker. Body and fins are covered with small black dots. At the upper edge of the base of the pectoral fin there is a dark spot, sometimes hardly noticeable. Usual length about 15-20 cm, seldom to 23 and rarely to 26 cm (2 specimens from North Sea).

DISTRIBUTION. European shores of the Atlantic Ocean, northward to Trondheim Fjord, in the east in Zund and Kiel Harbors, common around Great Britain and Ireland; found at the Faroe Islands and southward to the southern tip of the Iberian Peninsula.

BIOLOGY. The main spawning takes place in the English Channel, at the western and northern shores of Great Britain, around Ireland and in the Bay of Biscay; spawning occurs in small quantity in the North Sea,

* According to J. Schmidt, 47-51 vertebrae.

Skaggerak, at the northeastern shores of Scotland, and at the Faroe Islands. Spawning grounds are located mainly at depths of 50-100 meters, the main time of spawning—March–April; in lesser quantities eggs are laid earlier or later, until July. Optimal spawning conditions: temperature not less than 8° C, salinity 32.0–35.4 parts per thousand.

COMPARATIVE NOTES. At present the Atlantic form of this species bears the name of *minutus* O. Müller 1776, the Mediterranean — *capelanus* Risso 1826. The form under the name of *minutus* was indicated by Linné much earlier for the Mediterranean. Lacepède in 1800 indicated *terra typica* the Atlantic Ocean and Mediterranean for *capelanus*. If we bear in mind that *G. minutus* was accepted by Linne from Artedi, and the latter from Willughby, Ray and Jago, who recorded it also for the Atlantic Ocean which Linné had not done, apparently erroneously, then we will see that both subspecies are indicated for the same places and by the rules of nomenclature neither of these names is suitable and they should be replaced by new names. However, it is doubtful that it would be wise to change the names of these forms accepted by everyone for the past 50 years and more by reversing or giving new names. Therefore, to both these subspecies, even though against the rules of nomenclature, we shall leave the well-established and generally accepted names.

G. tacaud Lacep. was accepted by all authors as *T. luscus*, even though the number of rays in the first anal fin (25 per Lacepède) indicate it should be referred more properly to *T. minutus*, but in no case to *T. luscus*.

2b. *Trisopterus minutus capelanus* (Risso) (Table XLIV)

Gadus capelanus Lacepède, Hist. nat. poiss., II, 1800:411 (ex parte: Mediterranean Sea). — *Morhua capelanus* Risso, Hist. nat. Europ. mérid., III, 1826:226 (Mediterranean Sea). — *Gadus minutus* Steindachner, Sitzungsber. Akad. Wiss. Wien, math.-naturw., Cl. LVII, 1, 1868:705 (ex parte: Trieste, Barcelona, and Gibraltar Straits). — *Gadus capelanus* Fage, Arch. Zool. Exper. Génér., (5), VI, 1911: 257 (comparison with *T. minutus* and *T. luscus*); Chaîne et Duvergier, C.-R. Acad. Sci. 20 April, 1927:917 (difference in otoliths). — *Gadus minutus* Tortenese, Boll. pesca, piscicult. idrobiol., XI, 2, 1935:232 (shores of Italy).

I D 11–13, II D 18–22, III D 17–19, I A 27–30, II A 19–20, gill-rakers 17–20, vertebrae 46. Similar to the typical form in the structure of the skull but the forward end of the frontals in the interorbital region is narrower. Mouth inferior. The anal fins touch, and the dorsals also touch or have small interspaces. The first anal fin 29.2–31.7% of body length, its origin approximately beneath the middle of the first dorsal fin. In body height this takes an intermediate position between *T. luscus* and the typical form. In per cent of body length: the anteanal distance 31.5–37.4, ante-dorsal distance 28.1–28.8, pectoral length 14.5–16.2, pelvic fin length 13.9–16.7, base of first dorsal fin 11.2–12.6, base of second dorsal 23.4–24.8, base of third dorsal 15.4–16.7, base of first anal 29.2–31.7, base of second anal 15.4–19.0, height of first dorsal 18.5–19.3, height of first anal 10.4–10.9, depth of caudal peduncle 4.3–4.6, its length 10.0–11.6, length of head 22.4–23.2. In per cent of head length: length of snout 25.0–27.3, horizontal diameter of eye 30.0–33.2, length of upper jaw 45.5–47.7, length of lower

jaw 52.2–56.7, width of forehead 17.0–17.2, length of barbel 25.7–35.3. Upper part of body pinkish-brown with small black dots on the back and sides, belly grayish-silvery. A dark spot at the base of the pectoral fin, just as in the basic form. Length to 20 cm, seldom greater (3 specimens from the Mediterranean Sea).

DISTRIBUTION. Western part of the Mediterranean Sea, at the coasts of Iberian and Apennine Peninsulas, at the coasts of Morocco, in the Adriatic Sea, Atlantic Ocean at the Straits of Gibraltar.

BIOLOGY. Stays close to shore and to a depth of 300 meters. Spawns from the end of winter to the beginning of summer. Females have ripe eggs in April and May.

INDUSTRIAL VALUE comparatively small; it is caught in not too great a quantity, but is highly prized.

COMPARATIVE NOTES. This form is very close to *T. minutus* and in a number of characteristics appears to be intermediate between this species and *T. luscus*, owing to which many authors have considered it identical with the typical form and some have placed all three forms in one species. *T. luscus* and *T. minutus* greatly differ from each other by externo-morphological characters and also by a series of osteological differences. According to the findings of Fage (l.c.), *T. minutus* and its Mediterranean form differ in a series of externo-morphological characters, but all these differences have a transgressive character, and osteologically the differences are very small, in view of which they must be considered as geographic subspecies of one species, disregarding the fact that in one character—number of gill-rakers—a hiatus exists at present (28 in *T. minutus minutus* - 1 specimen; 17–20 in *T. minutus capelanus* - 3 specimens). This hiatus will probably disappear when a sufficient number of specimens has been examined. In the structure of the otoliths these two forms also do not differ as sharply, as *T. luscus* differs from them. Both forms of *T. minutus* differ somewhat in the larval stage by having different pigmentation.

Specimens of *T. minutus capelanus* from the Adriatic Sea differ very little in some identifying features, and perhaps there is here a separate form.

143 *3. *Trisopterus esmarkii* (Nilsson) (Tables VII, XLV, LXX)

Gadus esmarkii Nilsson, Scand. fauna, IV, 1855:565 (shores of Denmark); Dunn a. Holt, Journ. Mar. Biol. Assoc., (n.s.), V, 1897–99:79 (southwestern tip of Great Britain, Cape St. Ives); Garstang, ibid., (n.s.), VI, 1900:274 (English Channel between Saltash and mouth of the Lynher River); Williamson, 24th Ann. Rept. Fish. Board Scotl., pt. 3, (1905), 1906:116 (osteology, number of rays, measurements); Hjort, Rapp. Procès-Verb., X, 1909:59 (spawning grounds); Damas, ibid.:160 (spawning); J. Schmidt, ibid.:63 (spawning); Johnsen, Bergens Mus. Arbok (1918–1919), 2, 1921:51 (one specimen from the Murman coast); Saemundsson, Synops. fish. Iceland, 1927:27 (on southern and western shores of Iceland); Medd. Komm. Hanunders., Fisk., VIII, 7, 1929:26 (biology, age); Boldovskii, Dokl. Akad. Nauk, XXIV, 3, 1939:305 (72°08' north latitude, 27°25' east longitude at a depth of 237 meters, 71°23' north latitude, 30°32' east longitude at a depth of 300 meters, 71°00' north latitude, 34°00' east longitude at a depth of 190 meters); Maslov, Tr. Polyarn. nauchno-issled. inst. morsk. rybn. khoz. i okeanogr., 8, 1944:168 (spawning at the Lofoten Islands, young at Bear Island).

I D 14-15, II D 23-26, III D 23-26, I A 29-31, II A 25-27, vertebrae 51*. Mesethmoid gradually descending forward, its leading edge much behind the leading edge of the vomer. Forward edge of the frontals much behind the forward edge of the lateral ethmoids. Skull much narrowed in the interorbital region, about 5.3 times in its length. Lower jaw slightly projects forward. Anal fins touching, dorsals with a small interspace. Beginning of first anal almost beneath the rear end of the first dorsal. Barbel not very long, 10.4% of head length. Body much lower than in all other species of this genus, lateral line less curved. In per cent of body length: anteanal distance 34.3-37.5, antedorsal distance 25.3-27.1, length of pectoral fin 16.7-17.6, length of pelvic fin 12.3-14.5, base of first dorsal fin 11.6-12.7, base of second dorsal 22.1-25.1, base of third dorsal 15.4-18.4, base of first anal 20.4-26.6, base of second anal 16.4-18.5, height of first dorsal 12.6-13.6, height of first anal 10.6-11.9, depth of caudal peduncle 3.8-4.0, its length 10.5-12.5, length of head 22.1-22.9. In per cent of head length: length of snout 27.9-31.3, horizontal diameter of eye 31.9-33.5, length of upper jaw 40.7-42.0, length of lower jaw 53.0-55.0, width of forehead 12.4-13.7, length of barbel 10.4. Dorsum grayish-brown, the sides dull silvery, belly pale. At the upper edge of the base of the pectoral fin there is a dark spot, which sometimes is not noticeable on specimens preserved in alcohol. Measurements to 25 cm, most often 15-20 cm (4 specimens).

DISTRIBUTION. European shores of the Atlantic Ocean from Iceland to the southern waters of Ireland and the southwestern tip of Great Britain (Cape St. Ives on Cornwall Peninsula); found at the Faroe Islands, east in the Skaggerak and Kattegat. At the southern and western shores of Iceland but not at the northern and eastern shores. In the English Channel it is known only in the extreme western part (between Saltach and Lynher Rivers). Recently in connection with the general warming up along the shores of the Scandinavian Peninsula, it has penetrated into the western part of the Barents Sea to 34° 20' east longitude and to Bear Island.

BIOLOGY. Studied as little as all other species of this genus. Spawning occurs almost throughout the entire area of the range, more intensively at the southern and southwestern shores of Iceland and in the northern section of the North Sea. It lays eggs in great numbers along the western shores of Ireland and Great Britain, at the Faroe Islands, and at the southwestern shores of Norway. Spawning on a minor scale also takes place in Skaggerak and the northern sections of Kattegat. Spawning individuals have been found in great numbers in recent years at the Lofoten Islands, and young at Bear
144 Island. In the very southernmost section of the North Sea and in the English Channel no spawning takes place. Spawning occurs at the same depths, at which adult fishes live mostly, — from 80 to 200 meters. Spawning time — from the end of February to July and even to August, most intensively from the end of March to the beginning of May. Optimal spawning conditions: temperature 5 to 9-10° C, most often at 6-7° C, salinity 35.0-35.2 parts per thousand. Sexual maturity is reached at two or three years of age at a length of 16-20 cm. Growth at the shores of Iceland occurs as follows:

* According to J. Schmidt, 52-55 vertebrae.

Age (in years)	2 +	3 +	4 +	5 +
Length (cm)	16.5	18.0	21.8	23.0

Females grow faster than males and live somewhat longer. Feeds on small crustaceans (*Calanus*, *Rhoda*, *Meganctiphanus*) and *Scopelus*. Does not undertake large migrations; keeps more or less constant at the same place, which apparently explains to a great extent the restricted distribution of this fish. In summer it approaches closer to shore and in winter goes into the deep waters.

COMMERCIAL IMPORTANCE insignificant; there is no special industry for it. At the shores of Iceland it plays a considerable role in the feeding of cod.

COMPARATIVE NOTES. This species is very distinct craniologically from the two preceding and externo-morphological characters distinguish it from them very much more. The width of the bony interorbital at the forward edge of the foramen of the facial nerve diminishes in *T. luscus* to *T. esmarkii*. One of the craniological distinctions between these species of *Trisopterus* — the width of the frontals and interorbital region — also changes in the same direction.

12. Genus **ODONTOGADUS** Gill

"Les merlans" Cuvier, Règne animal, éd. I, II, 1817:213 (Type: *Gadus merlangus* L.). — *Merlangus* (non Rafinesque 1810, synonym *Merluccius*) Oken, "Isis," 1817:1182 (Type: *G. merlangus* L., secundum Cuvier). — *Odontogadus* Gill, Proc. Acad. Nat. Sci. Phila., 1863:248 (Type: *G. euxinus* Nordm.).

The dorsal fins are separated by small spaces, the anals touch. The first anal fin is long; it usually begins beneath the middle of the second dorsal fin. The caudal fin is almost without a notch. The mental barbel is either absent, or, when present, small. Lower jaw slightly shorter than upper. There is a row of sharp, well-developed teeth on the premaxillary, medial to which on the premaxillary and lateral to which on the dentary there are small, irregularly arranged teeth; small teeth are present along the forward edge of the head of the vomer, the lateral teeth the longest. There is a black spot above the base of the pectoral fin. Lateral line on the forward half of the body a shallow arch above the central axis of the body, farther on straight, continuous along its entire length. There is a system of pores on the head along the sensory canal: 13 pores in the preoperculo-mandibular canal, 9 pores in the infraorbital canal, 3 pores in the supraorbital canal and 1 unpaired pore in the supraorbital commissure. The mucous cavity on the skull is closed in front. Prootic with a notch in front. Hyomandibular extended longitudinally; the opercular process is shorter than the lower process.

SKELETON. Skull not exceedingly high (A), its base more than 3 times its height. Lower profile almost straight, parasphenoid with a small curve beneath the forward end of the prootic. Upper profile of the skull gradually descending forward. The supraoccipital crest is not very high; anteriorly
145 it runs imperceptibly into the crest on the rear of the frontal, terminating suddenly in front, approximately in the middle of the skull before the mucous

FIGURE 23. Distribution of the genus *Odonogadus*

1—*O. merlangus merlangus*; 2—*O. merlangus euxinus*.

cavity, terminating behind above the rear end of the basioccipital or projecting slightly in back of it. The forward edge of the mesethmoid is almost vertical, located almost at right angles to its upper edge, straight, without a noticeable notch. Orbital space not high, elongate, its height contained $2\frac{1}{2}$ times in its base. The facial nerve leaves the skull through a quite deep notch in the forward edge of the prootic; the edges of this cavity are angular where it changes from the prootic to the alisphenoid above and to the upper processes of the parasphenoid below. The foramen on the opisthotic is small. The lateral edge of the frontals and pterotic on the skull above (B) are almost straight but placed at an angle to each other, because of which the lines forming the borders of the lateral edges of the skull are slightly curved. Lateral ethmoids extend slightly from beneath the frontals on the sides and in front, reaching far back from the sides and under the frontals. Forward end

of the vomer is located almost beneath the forward end of the mesethmoid. The crests above the canals on the frontals and pterotics are wide, and rise quite high above these bones. Mucous cavity deep, divided from top to bottom into two sections by a long narrow partition. In the front the mucous cavity enters into the paired canals which are closed from above by a fusion of the lateral crests of the frontals with the median crest of its forward portion. The parietal crests above the foramina of the recurrent dorsal branches of the facial nerves are extended farther longitudinally than they are laterally, just slightly elevated above the surface of the parietals, almost unseen on the skull from behind. On the skull from beneath (C), along the forward edge of the vomer, there is a row of small somewhat backward-hooked teeth, the posterior of which are the largest. The lower surface of the middle section of the parasphenoid is flattened, rounded in front and with a small longitudinal concavity in back. The prootic is quite convex on the sides, to such an extent that the lateral walls of the cranium when viewed from behind (D) in the otic region are definitely convex. The supraoccipital crest extends quite a bit above the skull. The preopercular process of the hyomandibular is almost the same in length as the rear portion of the lower process, its rear ends almost parallel to each other. The lower fork of the posttemporal is long, almost equal to the length of the upper. The postcleithrum has a considerable curve slightly above its middle, its upper end broadened. The urohyal is quite short and broad. Parapophyses are quite long, the first haemal arches are of small dimensions. Description given from one skeleton of *O. merlangus merlangus* and three skeletons of *O. merlangus euxinus*.

DISTRIBUTION. One species along the Atlantic and Mediterranean shores of Europe with a subspecies in the Black Sea (Figure 23).

Diagnostic Key to the Subspecies

- 1 (2). Mental barbel usually absent and if present hardly noticeable. Pectoral fins 13.8–15.6%, pelvic fins 7.4–8.6% of body length. Atlantic Ocean, North, Mediterranean and Adriatic Seas 1a. *O. merlangus merlangus* (L.)
- 2 (1). There is always a well-developed barbel on the chin. Pectoral fins 15.4–18.2%, pelvics 8.1–11.3% of body length. Black Sea. 1b. *O. merlangus euxinus* (Nordm.)

*1a. *Odontogadus merlangus merlangus* (Linné)—Merlang (Tables VIII, XLVI, LXX)

Gadus merlangus Linné, Syst. nat., ed. X, 1758:258 (Oceano Europeo). — *Merlangus vulgaris* Kröyer, Danm. Fiske, II, 1843–1845:83. — *Gadus merlangus* Steindachner, Sitzungsber. Akad. Wiss. Wien, math.-naturw. Cl., VII, 1, 1868:703 (ex parte: Copenhagen, Bergen, Viga, Adriatic Sea). — *Merlangus linnei* Malm, Göteborg. Bohusl. Fauna, 1877:485. — *Gadus euxinus* (non Nordm.) Ninni, Atti Soc. Ital. Sci. Nat., XIII, 1880:75 (Adriatic Sea); Graeffe, Arb. Zool. Inst. Univers. Wien. u. Zool. Stat. Triest, VII, 1880:10 (Adriatic Sea). — *Gadus merlangus* Williamson, 26th Ann. Rept. Fish. Board Scotl., pt. 3, (1907), 1909:97 (description of the skull). — *Gadus merlangus merlangus* Svetovidov, Dokl. Akad. Nauk, I, 6, 1935:431, f. 1 (comparison with Black Sea form).

DISTRIBUTION, BIOLOGY. Möbius u. Heincke, Fische Ostsee, 1833:235 (western part of the Baltic Sea, from Bostock east to Jutland Island); Smitt, Scand. fish., I, 1893:487 (distribution, biology); Fulton, Publ. Circonst., 8–9, 1904:4; Hjort, Rapp. Procès-Verb., X, 1909:56, fig. 15 (spawning grounds); Damas, ibid. 34 (biology); J. Schmidt, ibid. :57, 142 (biology); Derjugin, Fauna kol'skogo zaliva, 1915:588 (Kola Bay); Saemundsson, Medd. Komm. Havunders., Fisk., VIII, 1925:26 (age and growth); Bull. Journ. Mar. Biol. Assoc., XV, 1928:207 (maturity, chemical structure); Desbrosses, Rev. Trav. Off. Pêches Marit., XIII, 1–4, 1939–1943:177 (Atlantic shores of France; propagation, development, growth); Maslov, Tr. polyarn. nauchno-issled. inst. morsk. rybn. khoz. i okeanogr., 8, 1944:168 (Kola Bay in 1936 and 1937, Motovski Bay).

I D 12–15, II D 18–25, III D 19–22, I A 30–35, II A 21–23, gill-rakers 21–22, vertebrae 54*. Usually no barbel on the chin; if present hardly noticeable**. In per cent of body length: anteanal distance 34.1–38.2, antedorsal distance 28.6–30.0, length of pectoral fin 13.8–15.6, length of pelvic fin 7.4–8.6, length of base of first dorsal 11.6–14.5, length of base of second dorsal 19.8–22.1, length of base of first anal 30.4–33.1, height of first anal 30.4–3.1, [Translator's note: This is probably an error.] height of first dorsal 9.4–12.4, depth of caudal peduncle 4.7–5.5, its length 9.6–11.7, length of head 23.9–25.2. In per cent of head length: length of snout 32.2–35.6, horizontal diameter of eye 21.6–28.8, length of upper jaw 40.6–44.1, length of lower jaw 50.7–56.0, width of forehead 18.3–20.7. Coloration greatly variable, in large specimens back and upper part of head yellowish-

* According to J. Schmidt, 53–57 vertebrae.

** In 14 specimens examined six had a hardly noticeable rudimentary barbel (3 specimens 92, 107 and 265 mm in length from the North Sea; 1 specimen 202 mm in length from Coast of Murman; and 2 specimens 207 and 236 mm in length from the Adriatic Sea).

147 brown with grayish-violet shade, sides yellowish-gray, yellow dots along and under the lateral line, often fused and zigzag-like or netlike striping; belly and lower portion of head milky-white. Unpaired fins approximately the same color as the upper portion of body; dorsals somewhat darker than the anals. Pectoral fins yellowish with black dots above the base; belly fins milky-white. Usual measurements 30–35 cm, seldom to 68 cm.

DISTRIBUTION. Along the European coasts of the Atlantic Ocean and adjacent seas. North to the coasts of Murman (Dal'nezelenetskaya Bay, Ekaterininskaya Harbor) and Iceland; at the shores of Norway and Faroe Islands, in the North Sea, in the western part of the Baltic Sea occasionally to Jutland Island, around Great Britain and Ireland, occasionally around to the Iberian Peninsula in the Mediterranean and Adriatic Seas. In the Aegean and Marmore Seas the typical form or *O. merlangus euxinus*. Heuglin (Reisen nach d. Nordpolarmeer in d. Jahren 1870 u. 1871, III, 1872–74:213), apparently erroneously indicated it at Vaigach Island.

BIOLOGY. Usually keeps along shore, not only at the bottom but often in the intermediate and upper layers of water. Enters brackish estuaries and even the lower waters of rivers. Spawning takes place throughout the entire range, with the exception of the most northern limits. Basic spawning grounds are located along the shores of the southern portion of the North Sea, along the eastern and northwestern shores of Great Britain, around Ireland, and the southern and southwestern shores of Iceland along the coasts of Norway northward to 65° north latitude. Spawns less intensively in the central and northern portions of the North Sea at the Faroe Islands, at Skaggerak and western portion of the Baltic Sea, in the English Channel, and in the northern part of the Bay of Biscay. In time of spawning this is one of the latest forms of gadoids; spawning begins at the end of January and continues to the middle of July, in the northern parts of its range slightly later than in the southern. There are indications of possible spawning in the fall (in October, Fulton, l. c.). Spawning occurs at depths as little as 20 meters, usually at 40–80 meters, at temperatures of 5 to 10° C in the North Sea and 9.5–11.5° C along the coasts of the English Channel and Brittany, in waters of normal oceanic salinity, from 30 to 35.25 parts per thousand. The young are pelagic for a long time. Migrations of adults are not well studied, but apparently the species does not undertake extensive migrations, remains more or less locally, does not gather into big schools. Feeds on crustaceans and small fish (herring, etc.). Growth along the shores of Iceland occurs as follows (Saemundsson, l. c.):

Age (in years)	1 +	2 +	3 +	4 +	5 +	6 +	7 +	8 +
Length (cm)	18.1	27.0	39.3	46.6	51.4	54.7	59.2	62.5

It reaches a lesser age and grows somewhat slower along the shores of Norway. Females reach a greater age and apparently grow somewhat faster than males. The Icelandic merlang is, on the average, somewhat larger than the Norwegian; here most often are found specimens 40–55 cm.

COMMERCIAL IMPORTANCE none in our waters. About 700 thousand metric centner are caught annually along the shores of western Europe, main places of catch—North Sea, Skaggerak, Kattegat, the shores of Great Britain and Ireland.

*1b. *Odontogadus merlangus euxinus* (Nordmann)-Black Sea merlang, piksha (incorrect), merlanka (at the Batum fisheries)* (Tables VIII, XLVII).

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Gadus euxinus Nordmann, Faune pontique, 1830:526, pl. XXVI, f. 2 (everywhere along the coasts of the Black Sea). — *Gadus merlangus* (non Linné) Steindachner, Sitzungsber, Akad. Wiss. Wien., math.-naturw. Cl., LVII, 1, 1868:703 (ex parte: Black Sea). — *Gadus euxinus* Kessler, Ryby Azalo-kasp. - pont. oblast., 1877:233 (ex parte: Black Sea and at the shores of the Crimea). — *Gadus merlangus euxinus* Svetovidov, Dokl. Akad. Nauk, I, 6, 1935:426, f. 2 (comparison with basic form).

DISTRIBUTION, BIOLOGY. Kiselevich, sborn. stud. biol. kruzka novoross. univ., 3, 1908:11 (Black Sea and Dniester Delta, Odessa Port); Zernov, zap. akad. nauk, (VIII), XXXII, 1913:174 (Black Sea and at Sevastopol); Druniskii, spis. blgarsk. akad. nauk, XXV, 1928:108 (ex parte: Black Sea and Varna, Burgas, Sozopol); Vodyanitskii, Tr. Sevastopol, biol. st., V, 1936:7 (Sevastopol Harbor, eggs); Pchelina, tr. Novoross.-biol. st., II, 1, 1936:32 (young); Kosyakin, tr. Novoross.-biol. st., II, 2, 1938:26 (spawning and in the region of Novorossisk); Malyatskii, zoologich. zhurn., XVII, 4, 1938:667, 674 (role in feeding of sturgeon); Pchelina, tr. Novoross.-biol. st., II, 3, 1940:71 (young in Novorossisk Harbor).

I D 14-17, II D 16-19, III D 18-22, I A 28-32, II A 19-22, gill-rakers 20-23, vertebrae 53. Always a well developed noticeable barbel** on the chin. In per cent of body length: anteanal distance 35.6-38.2, antedorsal distance 27.6-30.2, length of pectoral fin 15.4-18.2, length of pelvic fin 8.1-11.3, length of base of first dorsal fin 12.3-15.8, length of base of second dorsal 17.3-19.9, length of base of first anal 29.0-31.6, height of first dorsal 11.7-13.8, depth of caudal peduncle 3.6-4.5, its length 10.5-12.5, length of head 23.7-25.8. In per cent of head length: length of snout 32.2-34.8, horizontal diameter of eye 22.8-26.5, length of upper jaw 38.8-43.3, length of lower jaw 49.0-52.2, width of forehead 18.1-20.1. Upper part of head and body reddish-brown or yellowish-gray with violet or pink shading. Lower part of body white with a silvery cast. Fins, particularly dorsal and caudal, are yellowish with yellow-gray stripe forward and in the center along the entire fin. First anal fin milky-white with a yellow cast. Dimensions 15-20 cm, seldom to 50 cm or more.

DISTRIBUTION. Along the shores of the Black Sea, Kerch Straits, and the adjacent portions of the Azov Sea (Kazantip)†

BIOLOGY. Studied very little. Rare. At Sevastopol it appears in the fall in great numbers, when the temperature of the water drops to 16° C and remains for October, November and December. Gametes are developed in November, December and April. Spawning opposite Novorossisk from November to May, in deep layers of the open sea (40 meters), eggs caught in September; in May of 1936 a considerable quantity of eggs were found in the deep layers of the sea. In Sevastopol Harbor eggs were found in May-July. Youngsters 9.2-28 mm in length at the surface and at a depth of 30 meters with temperature from 8 to 12° C were caught in Novorossisk Harbor and at its mouth in March-April; one young 11 mm in length was caught in the open sea at a depth of 30 meters in the end of June.

No COMMERCIAL VALUE, but it plays an important role in the feeding of beluga [sturgeon], being its basic food in winter opposite Sevastopol Harbor.

* According to information by I. I. Puzanov.

** On fishes 12-18 cm length, length of barbel 2.3-3.2 mm.

† According to information by V. Abramov.

COMPARATIVE NOTES. The main distinction of this form, at first described as an independent species, from the typical form was the presence of the barbel on the chin in the first and the absence of it from the second. Because of this, some authors (Ninni, l. c.; Graeffe, l. c.) considered the range of the Black Sea form to be much broader—inclusive of the Adriatic Sea where specimens having barbels were found, while other authors (Steindachner, l. c.) consider this form to be identical with the typical form after specimens having barbels were discovered among the latter as well. Comparison of specimens from the Barents, North, Adriatic and Black Seas (Svetovidov, l. c.) indicated that the Black Sea specimens are quite distinct from all others, and besides the constant presence of a barbel, have a group of other characters; however, all of these characteristics, as may be seen from the diagnosis of both forms, appear to be continuous because of which the Black Sea merlang is considered a subspecies. Specimens (2) from the Adriatic Sea are referred by all distinguishing characters to the typical form. Comparison of the skeletons of both forms substantiates their relationship (see Tables XLIV and XLV) and a very minor distinction was discovered only in that, in *O. merlangus merlangus* the skull is slightly broader and the forward ends of the frontals extend somewhat more forward than in *O. merlangus euxinus*; on another skull of *O. merlangus euxinus* examined the frontals in front extend forward just as in *O. merlangus merlangus*. It is possible that a form intermediate between these two will be found in the Adriatic Sea.

13. Genus **POLLACHIUS** (Nilsson) Bonaparte

Pollachius Nilsson in: Bonaparte, Cat. met. pesci Europ., 1846:45 (Type: *Gadus pollachius* L.); Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898:2534.

Dorsal and anal fins separated by interspaces. First anal fin long, beginning beneath the middle or at the rear of the first dorsal fin. Caudal fin notched. Barbel on chin hardly developed or absent. Lower jaw projects. Teeth on premaxillary and dentary and in a stripe along the forward edge of the vomer. Lateral line almost straight or slightly curved beneath the beginning of the second dorsal fin. Pores on the head along the sensory canals; 13 pores in the preoperculo-mandibular canal, 8 pores in the infra-orbital canal, 3 pores in the supraorbital canal, and 1 unpaired pore in the supraorbital commissure. The mucous cavity is closed in front on the skull. There is a notch in the forward part of the prootic. The hyomandibular is stretched lengthwise, the opercular processes shorter than the lower process.

SKELETON. Skull in profile (A) not high, its height contained little more than 3 times in its length. Parasphenoid with a curve (in *P. pollachius* slightly greater than in *P. virens*) under the forward end of the prootic; in front of and behind this curve are bones lying at the base of the skull, distributed in a straight line. The upper profile of the skull presents a wavy line gradually descending anteriorly. Supraoccipital and frontal crests not very high, slightly convex where the supraoccipital crosses over on to the frontal, extending beyond the basioccipital in the rear, the forward end

sharply diminishing in the forward half of the skull before the mucous cavity. The mesethmoid gradually descends in front, its forward edge straight (in *P. pollachius*) or convex (in *P. virens*), placed at an obtuse angle, slightly greater in *P. virens* than in *P. pollachius*, to the upper. The orbital space is lengthened and low, its base 3 or more times exceeding its height. The facial nerve exits from the skull via a notch in the forward part of the prootic; in place of the transgression of the lower edge of the notch of the prootic on to the ascending process of the parasphenoid in *P. pollachius*, there is a small convexity, and in *P. virens* this edge of the prootic and the ascending process of the parasphenoid are located at a considerable angle. The foramen on the opisthotic is of quite considerable dimensions. The outer edges of the frontals on the skull from above (B), forming, together with the pterotic and sphenotic, the lateral edges of the skull, have a notch on each side above the orbits, and in *P. pollachius* it is somewhat deeper than in *P. virens*. The lateral ethmoids extend somewhat from beneath the frontals to the sides and are lengthened longitudinally, extending a considerable distance anteriorly and especially posteriorly. The forward end of the mesethmoid is located behind the forward end of the vomer. The crests of the canals of the lateral line on the frontals and pterotic are broad, rising quite high above these bones. The mucous cavity is quite deep, separated into two sections by a high and wide longitudinal partition. Forward of the mucous cavity the lateral crests of the frontals fuse with the median crest of the forward part of the frontals and form bony canals which are locked from all sides. The crests on the parietals above the foramen of the recurrent dorsal branch of the facial nerve are extended more longitudinally, and are directed outward and upward. The vomer on the underside of the skull (C) is quite broad, the teeth are placed in a narrow stripe of two or three rows along the forward edge of the head; the outer teeth are the larger; the very apex of the head sometimes toothless. The lower surface of the parasphenoid in *P. pollachius* is flattened in the rear, in *P. virens* it is flattened somewhat forward of the forward end of the prootic. The rear ends of the lateral ethmoids from beneath are located at a shallow angle to the longitudinal axis of the skull. The auditory area has a small bulge on the sides, thus all the lateral surfaces of the skull from the rear (D) are somewhat convex. Extending crests on the parietals above the foramen of the recurrent dorsal branch of the facial nerve are readily seen from behind. Atop the skull the supraoccipital crest extends quite high. The rear edge of the preopercular and the lower processes of the hyomandibular are placed at a slight angle to each other; the preopercular process is shorter than the rear part of the lower process. The forward edge of the operculum has a lip which makes this bone rectangular; the lower part of the subopercular also has a lip, broader than the upper part. The lower fork of the posttemporal is almost the same length as the upper. Postcleithrum has a curve at a considerable distance from the upper edge, the portion above the curve greatly widened. The urohyal is quite narrow and elongate. The parapophyses are quite long in *P. pollachius*, shorter and wider in *P. virens*. The first haemal and several arches following it are quite large in *P. virens*, somewhat smaller in *P. pollachius*.

Description based on one skeleton of *P. pollachius* one of *P. virens*.

FIGURE 24. Distribution of the genus *Pollachius*
1—*P. pollachius*; 2—*P. virens*.

DISTRIBUTION. Two species in the northern part of the Atlantic Ocean (Figure 24).

COMPARATIVE NOTES. The genera *Pollachius* and *Odontogadus* are very close to each other craniologically. Also, they differ very slightly externo-morphologically. The greatest material external difference between them is in the structure of the mouth: in *Pollachius* the upper jaw extends forward, in *Odontogadus* the lower jaw. It is possible that these are subgenera of one genus.

Diagnostic Key to the Species

- 1 (2). Barbel absent from the chin, lateral line with a sharp curve beneath the origin of the second dorsal fin, gill-rakers 26–27 1. *P. pollachius* (L.)
- 2 (1). On the chin a hardly noticeable barbel, lateral line without a sharp curve beneath the second dorsal fin, gill-rakers 35–40 2. *P. virens* (L.)

1. *Pollachius pollachius* (Linné) (Tables IX, XLVIII, LXX)

Gadus pollachius Linné, Syst. nat., ed. X, 1758:254 (Oceano Europeo). — *Gadus lycostomus* Faber, Tidskr. Naturv. Kbnhvn, V, 1828:215, 251. — *Merlangus pollachius* Kryer, Danm. Fiske, II, 1843–1845:123 (at Danish shores, biology). — *Pollachius typus* Bonaparte, Cat. met. pesci Europ., 1846:45. — *Gadus viridus* Gronow ed. Gray, Cat. fish., 1854:133. — *Pollachius linnei* Malm, Göteb. Bohusl. Fauna, 1877:487. — *Gadus pollachius* Williamson, 20th Ann. Rept. Fish. Board Scotl., pt. 3, (1901), 1902:228 (osteology).

DISTRIBUTION, BIOLOGY. Steindachner, Sitzungsber. Akad. Wiss. Wien., math.-naturw. Cl., LVII, 1, 1868:706 (Korunja, Vigo, western coast of Portugal); Moreau, Hist. nat. poiss. France, III, 1881:241 (length to 130 cm); Möbius u. Heincke, Fische Ostsee, 1882:236 (western part of the Baltic Sea, eastward to Mecklenberg Harbor); Smitt, Scand. fish., I, 1893:504 (from Varanger Fjord to Iberian Peninsula, western part of the Baltic Sea, biology); Hjort, Rapp. Procès-Verb., X, 1909:54, f. 16 (spawning grounds); Damas, ibid.:217 (biology); J. Schmidt, ibid.:44, 142 (biology); Dannevig a. Sörenson, Rept. Norw. Fish. Mar. Invest., IV, 4, 1934:9 (age and growth).

I D 12, II D 19-20, III D 17-19, I A 29, II A 17-20, gill-rakers 26-27, vertebrae 54*. The frontals in the interorbital region have a considerable notch in the sides, the lateral ethmoid extends in front from beneath the forward end of the frontals. The barbel is absent from the chin, the lateral line has a sharp curve beneath the origin of the second dorsal, the caudal fin has a weak semilunar notch. Eyes quite large, 21.6-22.6% of the head length; jaws elongate, the upper jaw 37.7, the lower 57.2% of head length; interorbital space narrow, 15.2-15.7% of head length. In per cent of body length: anteanal distance 37.3-38.2, antedorsal distance 32.5-33.2, length of pectoral fin 12.8-15.0, length of pelvic fin 5.1-5.8, depth of caudal peduncle 5.6, its length 10.9-12.0, length of head 24.8-24.9. In per cent of head length: length of snout 36.0-36.8. Coloration highly variable, back and top of head dark, olive-brown, sharply set off from the silvery-gray sides and belly; on the upper part of the body in adults there are scattered dark yellow or orange dots or stripes. With the exception of the pelvics, all the fins are the same color as the dorsum; pelvic fins are usually light yellow. Lateral line greenish. Measurements of the largest 45-60 cm, usually slightly less, but there are indications that some reach a length of 130 cm (2 specimens).

DISTRIBUTION. Along the European coast of the Atlantic Ocean, common in the northern section to Trondheim Fjord, occasionally to Varanger Fjord, in small numbers in the western part of the Baltic Sea to Mecklenburg Harbor and occasionally somewhat farther (northward from Simbrism, opposite Bornholm Island), at the southern shores of Iceland, occasionally also along the northern shores, at the Orkney Islands, around Great Britain and Ireland, in the Bay of Biscay, occasionally around the Iberian Peninsula and in the western part of the Mediterranean Sea (at Nice and Sicily), which, however, D'Ancona (Arch. Zool. Ital., 1930) considers doubtful. It is found in places so close to us (Varanger Fjord) that we can expect to find occasional specimens in our waters.

BIOLOGY. Exclusively a marine fish although occasionally it enters the lower estuarine parts of rivers. Keeps close to shore at somewhat lesser depths than the saida. Judging by its distribution and spawning grounds, this is a more warm-loving fish than the saida. Like the saida, it not only keeps to the bottom but also occurs in the intermediate and upper layers of water. Spawning takes place mainly along the western shores of Great Britain and Ireland, in the English Channel, along the coast of France to the Bay of Biscay, less intensively in the Bay of Biscay, in the northern and central portions of the North Sea, at Skaggerak, along the shores and in some fjords of Norway to 60° north latitude and at the Faroe Islands. Spawning time falls in the end of winter and in spring—from February to May; the height of spawning is in March; in the north somewhat later.

* According to J. Schmidt 52-55 vertebrae.

Spawns at lesser depths than the saida, but at greater depths than the North Sea cod. Most spawn within the limits of the 100-meter isobath, fewer to a depth of 200 meters. Spawning takes place at temperatures of 8° and higher, mainly around 10° C and a salinity from 32–35 parts per thousand. Migrations of adults and young have not been studied. In summer the adults occur further north, in winter they return. Feeds primarily on small herring. Growth according to data derived from scale studies occurs as follows (mean figures):

Age (in years)	1	2	3	4	5
Length (cm)	13.5–17.1	26.2–31.2	37.3–40.2	45.4–47.6	52.3

COMMERCIAL VALUE is very small.

COMPARATIVE NOTES. Krøyer (l. c.) indicates the identity of *Gadus lycostomus* Faber.

*2. *Pollachius virens* (Linné)—Saida (Tables IX, XLIX, LXX)

Gadus virens Linné, Syst. nat., ed. X, 1758:253 (Oceano Europeo). — *Gadus carbonarius* Linné, l. c.:254 (Oceano Europeo). — *Gadus colinus* Lacepède, Hist. nat. poiss., II, 1800:366, 416 (adult). — *Gadus sey* Lacepède, l. c.:367, 417 (young) — *Gadus arbonarius* et *G. virens* Risso, Ichth. Nice, 1810:112. — *Gadus purpureus* Mitchill, Trans. Lit. Phil. Soc. N. Y., I, 1815:370. — *Merlangus carbonarius* Sabine, Suppl. Pary's voy., 1824:211 (western shores of Davis Strait, young 10–13 cm in length). — *Merlangus virens* et *M. carbonarius* Fleming, Hist. brit. animals, 1828:195. — *Merlangus virens* Reinhardt, Kngl. Danske Vidensk. Selk., Nat. Afh., VII, 1838:115, 128 (coast of Greenland). — *Merlangus leptocephalus* DeKay, New York fauna, IV, 1842:288, pl. LXV, f. 146. — *Merlangus carbonarius* Krøyer, Danm. fiske, II, 1843–1845:102 (identified *P. virens* with *P. carbonarius*). — *Merlangus purpureus* Storer, Synops. fish. N. America, 1846:220 (coast of North America). — *Pollachius carbonarius* Gill, Proc. Acad. Nat. Sci. Phila., 1863:231 (synonymy). — *Gadus virens* Williamson, 20th Ann. Rept. Fish. Board Scotl., pt. 3, (1901), 1902:228 (osteology, number of rays, comparison of *G. morhua* and *P. pollachius*).

DISTRIBUTION, BIOLOGY. Danilevskii, Issled. rybol. Rossii, VI, 1862:10 (coast of Murman); Möbius u. Heincke, Fische Ostsee, 1882:286 (western part of the Baltic Sea); Smitt, Scand. fish., I, 1893:500 (distribution, biology); Hjort, Rapp. Procès-Verb., X, 1909:52, f. 13 (spawning grounds); Damas, ibid.:167 (biology); J. Schmidt, ibid.:134, 140 (biology); Deryugin, Fauna Kol'skogo zaliva, 1915:588 (Kola Bay, adults and juveniles); Bigelow a. Welsh, Fish. gulf Maine, 1925:296 (from Chesapeake Bay to Hudson and Davis Straits, biology); Sund, Rept. Norw. Fish Mar. Invest., III, 5, 1925:1 (experimental spawning along the northern shores of Norway); Fischer, Mitt. Deutsch. Seefischerei-Ver., XLII, 1926:19 (larvae in the western portion of the Baltic Sea); Saemundsson, Medd. Komm. Havunders., Fisk., VIII, 7, 1929:26 (growth); Gurvich, Izv. ikht. inst., XIII, 2, 1931:104 (young in the stomach of cod from the coast of Novaya-Zemlya); Jensen a. Hansen, Rapp. Procès-Verb., LXXII, 1931:39 (from western coast of Greenland); Murmanskii, za. rybn. Industr. Severa, 9, 1934:8 (commercial value); Dannevig, Journ. Conseil, VIII, 3, 1933:355 (vertebral counts); Berg, Probl. Fizichesk. geogr., II, 1935:77 (White Sea); Agapov and Toporkov, Probl. Arktiki, 2, 1937:107, Figure 3 (young from the western coast of Novaya Zemlya); Maslov, tr. polyn. nauchno-issled, inst. morsk. rybn knoz. i okeanogr., 8, 1944:169 (with matured eggs and gametes in February at the Lofoten Islands, in July, 1936 at Saida Lip of Kola Bay).

I D 13–14, II D 20–22, III D 20–24, I A 25–28, II A 19–23, gill-rakers 35–40, vertebrae 54*. The frontals in the interorbital region are almost without a notch, their forward edges on either side partially reach the forward edges of the lateral ethmoids. A barely noticeable barbel on the chin,

* According to J. Schmidt 53–56 vertebrae. According to Dannevig average from various localities in Skaggerak varied from 53.40 to 53.68.

lateral line almost straight without a sharp curve beneath the origin of the second dorsal fin, caudal fin with a considerable notch. Eyes not large, 15.3–21.4% of head length; jaws shortened, upper 33.0–35.1, lower 48.7–52.0% of head length. Interorbital space broad, 19.3–23.8% of head length. In per cent of body length: anteanal distance 38.1–41.5, antedorsal distance 29.5–32.4, length of pectoral fin 11.7–14.0, length of pelvic fin 6.5–7.7, depth of caudal peduncle 4.2–5.5, its length 10.4–12.8, length of head 23.0–24.0. In per cent of head length: length of snout 31.4–36.6. Coloration very changeable, in adults the dorsum and upper portion of the head is olive-green or gray, sides yellowish-gray, belly silvery-gray or milky white. All unpaired fins are olive gray except the anal which is white at the bases. Pelvic fins are reddish-white, pectorals dark. Forehead, snout and lips are blackish. Lateral line is white, anteriorly greenish-gray for some distance. Usual measurement 60–90 cm, the longest over 115–120 cm.

154 DISTRIBUTION. On both sides of the north portion of the Atlantic Ocean. At the shores of Europe south to the Bay of Biscay*, in the North Sea, around Great Britain, Ireland, Orkney Islands, Shetland Islands, Faroe Islands, and Iceland. At the southern tip of Greenland, western part of the Baltic Sea east to Zund Strait, seldom to Mecklenburg Harbor (Travermund), here also the larvae are carried; at the shores of Norway, in the Barents Sea, along the western shores of Murman, in small numbers east to the Kanin Banks; young 5 to 7 cm in size were found along the shores of Murman (Dal'nezelenetskaya Bay)** and at the western shores of Novaya-Zemlya, where it occurs northward to Krestov Bay. Records from along the shores of Spitzbergen (Petr. Geogr. Mitt., XVIII, 1872:463; Heuglin, Reisen nach d. Nordpolarmeer in d. Jahren 1870–71, III, 1872–74:221) are not true. In recent years it has been found in quite large numbers in the White Sea†, at the shores of North America south to Chesapeake Bay; common from Cape Cod to Cape Breton; occasionally found in Hudson and Davis Straits.

BIOLOGY. Judging by the places and conditions of spawning, more warmth loving and requiring somewhat deeper water and greater salt content than treska or piksha. Basic spawning grounds are located on both sides of the Norwegian Channel, in the northern part of the North Sea and along the shores of Norway from almost its southern tip to Trondheim Fjord, around the Faroe Islands and at the southern shores of Iceland. Spawning occurs less intensively along the western shores of Scotland and the western and southwestern shores of Ireland. In more recent years spawning may have taken place along the shores of Greenland (western), Murman, and Novaya Zemlya, where in the coastal zone young saida stays en masse although spawning has not been directly observed; adult saida have not been found along the coast of Novaya Zemlya. In 1936 it was discovered in February at Lofoten Island and in July at Saida Lip (Kola Bay) with completely mature sexual products. Spawns along the shores of North America largely between Cape Cod and Nova Scotia. Spawning continues from the beginning of January until May, most intensively in March. Along the shores of North

* Some authors (Risso, Canestrini) indicate this species in the Mediterranean Sea, which D'Ancona (l.c.) considers to be doubtful. De Buen (1935) does not indicate this species for even the Atlantic coast of the Iberian Peninsula.

** Numbers 30970, 30980 and others of the Zoological Institute of the Academy of Sciences of the USSR.

† In the Zoological Institute of the Academy of Sciences of the USSR there are two small specimens of *P. virens* (154 and 157 mm in length), delivered in 1848 by Hoffmann, apparently from the White Sea inasmuch as the accompanying label was marked "Archangelsk."

America reproduction occurs earlier, beginning in the fall—end of October and terminating in the beginning of March, with the greatest intensity from mid-November until mid-January. Fecundity averages about 225 thousand eggs, maximally to 4 million. Spawning occurs at depths of 100 to 200 meters, mean depth about 150 meters, at temperatures of 5.5 to 10° C, mean temperature about 7° C and salinity from 35.2 parts per thousand and higher. Along the shores of North America saida spawns at lesser depths—from 45 to 110 meters and slightly deeper, at a salinity of about 32 parts per thousand and at temperatures of 3 to 10° C, more often 8 to 9° C. Incubation period at 6° C extends to 9 days, at 9° C, 6 days. Pelagic eggs, larvae and young are carried far from the spawning grounds by the currents. In transferring to a bottom form of life one-year olds keep along shores in large schools. Adults lead a very mobile mode of life, staying not only at the bottom but rising to the intermediate and upper levels of the water in pursuit of food. Extensive migrations, not yet studied, are undertaken. In the beginning of summer they migrate northward, in the fall they return southward; caught from June to September along the shores of Murman. Feeds mainly on fish—herring, capelin, young cod and other fishes, crustaceans, sometimes even copepods; along the shores of North America crustaceans play a greater role in its sustenance. Most reach sexual maturity at an age of 5 to 6 years at a length of 60–70 cm, a fewer earlier at age 4 and even 3.

155 Growth is very rapid but it is not equal in various parts of its range (Damas, l. c.; Saemundsson, l. c.), if the differences are not conditioned by incorrect definition of age:

Age (year)*	5	6	7	8	9
Shores of Norway (Romsdal)	-	66.5	67.0	69.7	71.1
Southwestern shores of Iceland	73.2	78.7	88.9	92.8	103.1
	10	11	12	13	14
	75.5	77.1	78.8	79.7	82.6
	104.5	-	113.5	-	-

At the southern and western shores of Iceland (Saemundsson, l. c.) saida grows somewhat faster than along the eastern shores and undoubtedly faster at the northern. Females obviously grow somewhat faster than males.

COMMERCIAL VALUE. In the Atlantic Ocean along the coasts of Europe the annual catch exceeds 1,100 thousand metric centner. Most are caught in the North Sea at the shores of Norway and Iceland. Along the shores of North America about 160 thousand metric centner are caught annually. In our waters small quantities are caught at present; at the end of the last century during various separate years up to 30 thousand metric centner were caught. In the beginning of October, 1937, at the entrance to Motov Bay not less than 20 metric centner of small and medium size saida were caught in each trawl haul (Maslov).

COMPARATIVE NOTES. Because of the great morphological changes in pigmentation that take place with growth in this species, all of the quoted synonyms are due to their variability, which have been indicated by a number of authors (Kröyer, l. c. and others).

* In the first case fish were caught in February, in the second in March or April.

14. Genus **MELANOGRAMMUS** Gill

Melanogrammus Gill, Proc. Acad. Nat. Sci. Phila., (1862), 1863:280 (Type: *Gadus aeglefinus* L.). — *Aeglefinus* Malm, Göteb. Bohusl. Fauna, 1877:481 (Type: *G. aeglefinus* L.). — *Melanogrammus* Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898:2542 (Type: *G. aeglefinus* L.).

Dorsal and anal fins separated by interspaces. First anal fin short, beginning beneath the origin of the second dorsal fin or slightly behind it. Caudal fin slightly notched. Barbel on chin weakly developed, shorter than the diameter of eye. Mouth small, rear end of lower jaw beneath the center of the eye, upper jaw extending beyond the lower. Teeth in one-two rows on the dentary, in several rows on the premaxillary, a group of a few teeth at the apex of the vomer. Lateral line dark, in the shape of a shallow arch, to the beginning of the third dorsal fin placed above the central axis of the body, extending without interruption to the end of the body. There are pores along the lateral line canal on the head: 13 pores in the preopercular-mandibular canal, 7 pores in the infraorbital canal, 1 pore in the supraorbital canal and 1 pore in the supraorbital commissure. Mucous cavity on the skull closed in front. Prootic with a notch in front on the sides of the skull. Crests over the foramen of the recurrent dorsal branch of the facial nerve scarcely developed. Supraorbital with a high crest. Bones of the pectoral girdle greatly thickened. The opercular process of the hyomandibular somewhat shorter than the lower process.

156 **SKELETON.** The skull is high (A), its height contained in its length a little over 2 times, the upper profile descending sharply anteriorly. The base of the skull has a small curve in the parasphenoid beneath the forward edge of the prootic. In back and in front of this curve the bones lying at the base of the skull are placed in a straight line. The supraoccipital crest and frontal crest are high, somewhat rounded on top, extending considerably beyond the basioccipital, terminating in front approximately in the center of the skull. The forward edge of the mesethmoid is located at an obtuse angle to the upper, descending almost vertically to the vomer, with a notch at the top. The orbital space is quite high, contained about twice in its base. The facial nerve exits from the skull through a notch in the forward edge of the prootic, which from below presents a straight line with the ascending process of the parasphenoid. There is a large foramen on the side of the skull in the opisthotic. The lateral edges of the skull from above (B) present a curved line along the edges of the pterotic and a wavy line along the edges of the frontals. The lateral ethmoids project slightly from beneath the frontals from the sides, extending far forward and backward from the forward edge of the frontals. The forward edge of the mesethmoid is under the forward end of the vomer. The crests above the lateral line on the frontals and pterotics are broad; their edges rise quite high above these bones. The mucous cavity is quite deep, divided to the top in two sections by a longitudinal partition; due to fusion of the lateral crest of the frontals with the median crests of its forward part, it changes anteriorly on each side into a bony canal. The foramina on the parietals of the recurrent dorsal branch of the facial nerve are scarcely covered by crests from above; the crests are poorly developed. The apex of the head of the vomer on the skull from below (C) is armed with a bunch of long and slender teeth, in back of them along the forward edge of the head of the vomer there are no

teeth or if teeth are present they are very poorly developed. The lower surface of the forward portion of the parasphenoid is in the shape of a sharp angle; back of the forward edge of the prootic it is flattened and even somewhat concave longitudinally. The sides of the skull when viewed from behind (D), due to the bulging of the prootic and opisthotic, are somewhat rounded. In the rear only the supraoccipital crest rises high above the skull. The opercular process of the hyomandibular is wide, somewhat shorter than the preopercular or lower processes. The operculum is thickened, and to a somewhat lesser degree, so are the other bones of the gill cover. The operculum has a notch along its lower edge and has sharp angles. All bones of the pectoral girdle and especially the posttemporal and cleithrum are thickened, the postcleithrum with a characteristic curve and broadened at its upper end. The urohyal is short and broad. The parapophyses are thin, long and begin at the fourth vertebra.

Description given from 26 skeletons.

FIGURE 25. Distribution of *Melanogrammus aeglefinus*

DISTRIBUTION. One species along both shores of the north part of the Atlantic Ocean (Figure 25).

*1. *Melanogrammus aeglefinus* (Linné)—Piksha (Tables X, L, LXXI)

Gadus aeglefinus Linné, Syst. nat., ed. X, 1758:251 (in Oceano Europeo). — *Morhua aeglefinus* Fleming, Hist. brit. animals, 1828:191. — *Morhua punctatus* Fleming, l. c.:192. — *Melanogrammus aeglefinus* Gill, Proc. Acad. Nat. Sci. Phila., (1862), 1863:280. — *Morhua aeglefinus*

Storer, Hist. fish., Mass., 1867:124, pl. XXVIII, f. 1. (at the coast of North America). — *Aeglefinus linnei* Malm, Göteborg. Bohusl. Fauna, 1877:481. — *Gadus aeglefinus* Brooks, Proc. Dublin Soc. Sci., IV, 1885:166 (osteology); Williamson, 26th. Ann. Rept. Fish. Board Scotland, pt. 3, (1907), 1908:97 (description of the skull); Welsh, Copeia, 1915, 15:2 (comparison of piksha from European and North American shores); Vladykov, Progress Rept. Atlant. Biol. St., St. Andrews, N.B., 14, 1935:3.

DISTRIBUTION, BIOLOGY. Smitt, Scand. fish., I, 1893:466 (on both sides of the northern part of the Atlantic Ocean, biology); Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898:2542, f. 892, 892a; Hjort, Rapp. Procès-Verb., X, 1909:54, f. 14 (spawning grounds); Damas, ibid.:127 (biology); J. Schmidt, ibid.: 51, 42 (eggs, larvae); Bleitfus and Gebel, Mat. po estestv. ist. treski i pikshi 1908:150 (adult and ripe specimens on Kola meridian below 71° north latitude); Bigelow a. Welsh, Fish. gulf Maine, 1925:432 (from Cape Hatteras to Belle-Isle Strait, ecology); Saemundsson, Medd. Komm. Havunders., Fish., VIII, 1925:3 (age and growth); Fischer, Mitt. Deutsch. Seefischeri-Ver., 1926:16 (western part of the Baltic Sea, adults and larvae); Suvorov, Tr. Inst. izuch. Severa, 38, 1927:48 (age); Averintsev, Tr. nauch. inst. rybn. khoz., II, 3, 1927:18 (Barents Sea, specimens close to spawning); Rass, Rab. Murm. biol. st., III, 1929:26 (Ekaterinskaya Harbor, young in June); Thompson, Rapp. Procès-Verb., LIV, 1929:135 (biology); Mikhin, Izv. Otd. prikl. ikht., IX, 1, 1930:49 (dimensions, age, growth rate, food); Zenkevich and others, Dokl. I sessii Gos. Okeanogr. inst., 4, 1931:36 (feeding); Jensen a. Hansen, Rapp. Procès-Verb., LXXII, 1931:39 (western Greenland); Suvorov and Vadova, Sb. nauchnopromysl. rabot na Murmane, 1932:91 (age, growth); Suvorov, Izv. Ikht. inst., XIII, 2, 1932:64 (Barents Sea, spawning); Jeffers, Contrib. Canad. Biol. Fisher., (n. s.), VII, 15-23, 1932:8 (Belle-Isle Strait); Ritchie, Rapp. Procès-Verb., LXXX, 1932:1 (North Sea, feeding); Rass, Dokl. I sessii Gos. Okeanogr. inst., 5, 1933:8 (spawning in Motovsk Bay); Vladykov, Contrib. Canad. Biol. Fisher., (n. s.), VIII, 27-31, 1934:409 (vertebral number); Rass Karelo-Murmansk. krai, 3-4, 1934: 57 (spawning along the coast of Murman); Tâning, Rapp. Procès-Verb. XCIII, (1933), 1935:36 (number of vertebrae); Berg, Problemy fizich. geogr., II, 1935:77 (western coast of the White Sea); Rass, Int. Rev. ges. Hydrob. Hydrogr., 33, 1936:254 (spawning); Agapov and Toporkov, Problemy Arktiki, 2, 1937:107 (Belus'ya Guba, Cape Karmakuly, Lagerno on Novaya Zemlya); Ogilvie, Rapp. Procès-Verb., CVII, 1938:57 (feeding of young); Zatsepin, Tr. Polyarn. nauchno-issl. inst. morsk. rybn. khoz. i okeanogr., 3, 1939:39 (feeding); Maslov, Tr. Polyarn. nauchno-issl. inst. morsk. rybn. khoz. i okeanogr., 6, 1939:3 (biology, commercial value); ibid, 8, 1944:3, 141 and following (biology, commercial value, Alif, ibid.:187 (utilization, biology, bibliography)*.

I D 15-16, II D 19-21, III D 19-22, I A 23-24, II A 22-23, gill-rakers 24-27, vertebrae 52-57. First dorsal fin high and sharp tipped. Jaw bones greatly shortened, length of the upper jaw 28.6-33.1, length of lower jaw 35.3-39.1% of head length. In per cent of body length: anteanal distance 41.7-45.5, antedorsal distance 26.1-28.2, length of pectoral fin 14.1-16.6, length of pelvic fin 8.9-10.9, base of first dorsal fin 12.2-13.8, base of second dorsal fin 19.7-23.5, third 13.6-16.4, base of first anal fin 21.1-22.8, base of second anal 13.8-16.5, height of first dorsal fin 13.4-18.5, height of first anal fin 9.6-10.6, length of caudal peduncle 4.3-5.3, its depth 10.4-12.4, head length 24.6-25.7. In per cent of head length: length of 158 snout 34.5-38.9, lateral diameter of eye 20.0-28.2, width of forehead 17.9-22.8. Upper part of body and head dark gray with violet shading, sides lighter, belly and lower part of head milky white. Lateral line black. A large black spot under the lateral line in the region of the pectoral fins on each side. Pectoral and dorsal fins same color as the dorsum, somewhat lighter at the base; anal fins silvery-gray, also paler at their base; pelvic fins milky white; caudal fin same color as the dorsum. Measurements more often 50-75 cm, mean length about 60 cm, the greatest almost one meter (97 cm).

DISTRIBUTION. Northern part of the Atlantic Ocean. Along the shores of Europe from the Bay of Biscay to North Cape, at the shores of North America from Cape Hatteras to Newfoundland (Strait of Belle-Isle) and

* The last four articles were utilized to a very small degree.

perhaps in small numbers somewhat farther north; occasionally at the southern tip of Greenland; around Iceland, Orkney, Faroe and Shetland Islands; at the shores of Great Britain and Ireland; in the North Sea; in the western part of the Baltic Sea east to Mecklenburg Harbor; in the Barents Sea at Bear Island north to Spitzbergen; eastward to Goose Bank; in small numbers in Yugorskii Shar and at the shores of Novaya Zemlya to Matochkin Shar. In recent years it has been found in considerable numbers along the western coast of the White Sea, and dead specimens in the Kara Sea.

BIOLOGY. Biologically close to the Atlantic cod, but somewhat more warmth loving; found at temperatures of about 6° C and usually keeping at depths of 60–200 meters, with a limit of 1,000 meters; usually keeps to water of normal oceanic salinities, not able to withstand great freshening and never entering fresh water. Spawning occurs mainly in the southern section of its range, mainly in the northern part of the North Sea of 58° north latitude; less concentrated in the central portion of the North Sea, in Skagerrak, at the southwestern shores of Norway to Trondheim Fjord, at the north and southwestern shores of Great Britain, at the western and southern shores of Ireland, at the Faroe Islands, at the western and southern shores of Iceland; at the shores of North America breeding occurs throughout the entire range. In the Barents Sea piksha was found with mature and running sexual products (Breitfuss and Goebel, 1. c. Suvorov, 1. c.; Rass, 1. c.). In recent years spawning of piksha was discovered along the western shores of Murman and Finmark. In particular, large numbers of eggs and larvae in early stages of development were discovered along the northwestern coast of Norway from Ande Island to Sorø Island (Maslov, 1. c.). Spawning usually occurs at depths of 60–250 meters, more often at depths of 100–150 meters at temperatures from 5.5 to 10° C, most often at 6° C and at a salinity not lower than normal oceanic. At the shores of North America piksha spawns at somewhat lower temperatures (2.5–6.5° C) and at a salinity of about 32–32.5 per thousand). The beginning of spawning occurs at the end of January, terminating in the second half of June and even July, the height in March–April, at the shores of Iceland somewhat later, in the region of islands of Sorø–Ande March to June, the height at the end of January to the beginning of May. An incubation period of 2.8° C lasts 15 days, at 5.4° C 13 days. Larvae and young are carried by the currents from the spawning grounds northward—to the shores of Murman and to the western part of the Baltic Sea; in the latter, in connection with the increased flow of the Atlantic waters and the rise in salinity, in 1925–1926 it produced catches of piksha which were unheard of in size. The life cycle of piksha in the northeastern
159 part of the Atlantic Ocean, according to studies of recent years, in general presents the following picture. The main mass of the Barents Sea piksha is derived from the spawning grounds along the northwestern shores of Norway. Larvae stay at first in the upper layers of the water, then, judging from all the data, live under the bells of medusae. There is no littoral stage of the piksha and the general mass of young remains in the open sea with only a few coming close to shore and into the estuaries. The basic range of the young piksha appears to be the western regions of the Barents Sea, and in some warm years they penetrate farther east to Goose Bank and the shallow waters of Kanin. With the autumn cooling of the water, the young descend into the bottom layers and those which remain in coastal areas retreat to greater depths. In the spring young piksha which are one-year old

by that time rise again to the surface layers, approach the shores and enter the estuaries en masse; they depart from the shores in the fall and become by this time wholly a bottom fish. In the second year of life the piksha winters in the central regions of the Barents Sea, and some depart for the west. Beginning with the third year of life and until the onset of sexual maturity the Barents Sea piksha undertakes seasonal migrations, departing with the autumnal cooling of the waters from the eastern to the western sections of the sea. The smallest piksha in the second year of life keeps primarily to the western regions of the Barents Sea; medium sized piksha (to 45 cm) predominate in the central part of the Barents Sea; and large piksha (over 45 cm) in the eastern part of the Barents Sea (Maslov, l. c.). The young feed basically on growing and adult copepods, their nauplii and on eggs. The main food of the adults appears to be benthonic animals (echinoderms, mollusks, gephyreans, polychaetes); fish play a small role in their feeding, but at times their basic food fish is capelin. Bottom fish is often found in the stomachs in great quantity; in the North Sea in the spawning season herring feed heavily on their eggs. Piksha feed most intensively at temperatures of 1–2° C. They reach sexual maturity at 4–5 years and a length of about 50 cm, in the Barents Sea—in the sixth year of life, but generally 8–10 years of age. The smallest specimen of a sexually mature adult was 47 cm. The limit of age, as it is presently known, appears to be 12½ years; at the shores of North America somewhat higher. Growth of piksha migrating into the Barents Sea occurs as follows (Suvorov and Vadova, l. c.):

Age (years)	3+	4+	5+	6+	7+	8+	9+	10+
Length (cm)	38.2	47.4	55.7	62.1	69.8	76.6	80.5	82.4

Over the years it was established that the generations of separate abundant years predominate in the catch. In the Barents Sea and adjacent portions of the northern Atlantic Ocean, the 1925 generation was abundant; the last prolific generation in catches in the Barents Sea was credited to 1933. In the North Sea the piksha, by character of growth in the first year of life, is of two types: northern, with a mean growth for the first year of 16.1 cm and southern, with a mean growth for the same year of 17.8 cm. The limit between these two types of growths in piksha appears to be the 100-meter isobath. Thus, piksha in deeper waters of the North Sea, as well as opposite the northwestern shores of Scotland, Faroe Islands and Iceland have slower growth rate in the first year of life. This difference in growth rate is smoothed out by 2 or 3 years. In addition, piksha from the North Sea grow a little slower than piksha from other parts of the range (Thompson, l. c.). Piksha grow unevenly at the coast of Iceland; the fastest growth occurs at the southern and western shores and the slowest growth at the northern and eastern shores (Saemundsson, l. c.).

160 COMMERCIAL VALUE very great, in catches of gadoids piksha holds first place after cod. The annual catch reaches nearly 2 million metric centner and higher (2.13 million metric centner in 1933). Our trawling industry in the period of time from 1934 to 1938 produced annually from 84 (1935) to 770 (1938) thousand metric centner*. Besides, lesser quantities in comparison with the quoted figures were caught by coastal fisheries.

* The figures, just as for the treska, according to Tables 1 and 3 of Maslov's article (1939).

COMPARATIVE NOTES. Variation in vertebral count in piksha (Tåning, l. c.) from the shores of North America (average from 53.88 to 54.12) and at the coasts of Europe (average 53.84 to 54.15) is very small and does not disclose differences as in treska. Welsh (l. c.) obtained close figures. Vladikov (l. c.), however, distinguishes three races on the shores of North America; Newfoundland (average 52.5–52.9 vertebrae), Nova Scotia (53.5–54.3 vertebrae), and New England (average 53.1–53.2 vertebrae). The difference in number of vertebrae in piksha from different places at the shores of Europe is not great either, although a similar trend for changes in mean figures exist (average: Ireland 53.84, Faroe Islands 53.88, Iceland 53.86–54.05, North Sea 54.01–54.07, Norway south of the Lofoten Islands 54.10–54.15). It is not likely that such insignificant distinctions will characterize separate races of piksha if we bear in mind the possibility of numbers of vertebrae changing under various influences on development of the larvae (see comparative notes on treska).

15. Genus **GADUS** Linné

Gadus Linné, Syst. nat. ed. X, 1758:251 (Type: *Gadus morhua* L.). — "Morhues" Cuvier, Règne animal, éd. I, II, 1817:212 (Type: *G. morhua* L.). — *Morhua* Oken, "Isis," 1817:1182 (Type: *G. morhua* L., secundum Cuvier). — *Morhua* Fleming, Hist. brit. animal, 1828:190 (Type: *G. morhua* L.).

The dorsal and anal fins are separate. The first anal fin is short, beginning beneath the origin of the second dorsal fin or behind the second dorsal fin. Caudal fin truncate. Barbel well developed on the chin, slightly shorter or longer than the horizontal diameter of the eye. Mouth large, rear end of the lower jaw beneath the rear of the eye or behind it. Upper jaw extends beyond the lower. Teeth in one to two rows in dentary, in a broad band of several rows along the premaxillaries and on the head of the vomer; palatines without teeth. The lateral line is pale, gradually descending toward the mid-axis of the body beneath the second dorsal fin and continuing without interruption to the middle or end of the third dorsal fin and interrupted beyond. On the head along the sensory canals are pores: 13 preoperculo-mandibular pores, 9 infraorbital pores, 3 supraorbital pores, and 1 pore in the supraorbital commissure. The mucous cavity on the skull is closed in front. The prootic is notched anteriorly. Crests above the foramen of the facial nerve are scarcely developed. The supraoccipital crest is not high. Bones of the pectoral girdle are of normal structure, without any thickening. The opercular process of the hyomandibular is longer than the lower process.

SKELETON. The skull is not high (A), its height contained 3 or more times in the length of its base. The bones forming the base of the skull are placed in an almost straight line; parasphenoid usually straight. The profile of the skull from above presents a somewhat wavy line, gradually descending anteriorly. The mesethmoid in front is slightly inclined, its forward edge with a small notch, placed at almost right angles to the upper. The basioccipital extends somewhat from beneath the exoccipitals posteriorly. The supraoccipital crest is not high, straight on top and extending somewhat beyond

FIGURE 26. Distribution of the genus *Gadus*

1- *G. morhua morhua*; 2- *G. morhua callarias*; 3- *G. morhua morhua n. hiemalis*; 4- *G. morhua kildinensis*; 5- *G. morhua maris-albi*; 6- *G. morhua ogac*; 7- *G. morhua macrocephalus*.

the basioccipital barely merging in front with the frontal crest, which terminates in the forward half of the skull. The orbital space is elongate and narrow, its base exceeding its height $2\frac{1}{2}$ to 4 times; it is lowest of all in *G. morhua morhua*, higher in all other subspecies. The facial nerve exits from the skull through a notch in the forward section of the prootic. The foramen on the opisthotic is of quite considerable size. The lateral sides of the skull when viewed from above (B) gradually converge toward the forward section of the skull. The lateral edges of the frontals are almost without notches over the orbits. The lateral ethmoids extend slightly lateral from beneath the frontals, are strongly stretched longitudinally, and extend quite some distance forward and back from the front ends of the frontals. The forward edge of the mesethmoid is over the forward end of the vomer or slightly behind it. The crests covering the sensory canals on the frontals and pterotics are closely applied to the bones. The mucous cavity is shallow and wide; a longitudinal bony partition divides it into two parts. Forward of the mucous cavity are crests covering the canal, which fuse with the central crests of the frontals and form a bony canal which is closed on all sides. The crests on the parietals above the foramen of the recurrent dorsal branch of the facial nerve are small, triangular in shape, and do not extend over the surface of the parietals. The vomer on the skull from below (C) is quite broad; teeth are placed in a broad stripe in 4 to 5 rows along the forward edge of the head; the lateral teeth are largest. The lower surface of the parasphenoid behind the vomer is flattened. The auditory region of the skull when viewed from behind (D) is narrow, without convexities on the sides; the upper and lateral surfaces of the skull are limited by almost straight lines. The parietal crests overlaying the foramen of the recurrent dorsal branch of the facial nerve are not seen from behind. The supraoccipital crest scarcely extends above the skull. The lower process of the hyomandibular is somewhat shorter than the opercular process and preopercular process, the rear end of the latter is placed at an angle to the rear edge of the lower process. The lower surface of the operculum has a deep notch and sharp angles; the suboperculum is broad, posttemporal cleithrum and other bones of the pectoral girdle are not thickened, lower fork of posttemporal much shorter than the upper. Postcleithrum more or less curved and broadened at the upper edge. Urohyal short and broad. Parapophyses elongate, but not very broad.

This description is based on 150 specimens of *G. morhua morhua*, one skeleton of *G. morhua callarias*, one *G. morhua kildinensis*, five *G. morhua morhua n. hiemalis*, five *G. morhua maris-albi*, one *G. morhua ogac* and two *G. morhua macrocephalus*.

DISTRIBUTION. One species in the northern portions of the Atlantic and Pacific Oceans and adjacent seas, divided into several subspecies (Figure 26).

COMPARATIVE NOTES. Schultz and Welander (Copeia, 1935 (3):127) consider the Atlantic, Greenland, and Pacific cods as independent species, basing this mainly on the structure of the horn-like processes in the forward portion of the swim bladder. However, fishes measuring to 30 cm are not distinguishable on this character, inasmuch as their horn-like processes are shortened and have the same appearance as in adult Pacific Ocean cods. Besides, the size and form of these processes are variable and individual; the White Sea winter cod (*G. morhua morhua n. hiemalis*) normally

FIGURE 27. Structure of hornlike appendages on front of swim bladder in *Gadus morhua* and subgenera

a— *G. morhua morhua*, length 53.6 cm; b— *ibid*, length 20.0 cm; c— *G. morhua callarias*, length 49.3 cm (right appendage straightened and stretched lengthwise); d— *ibid*, length 25.2 cm; e— *G. morhua morhua n. hiemalis*, length 31.2 cm; f— *ibid*, length 27.4 cm; g— *G. morhua kildinensis*, length 58.4 cm; h— *ibid*, length 52.1 cm; i— *ibid*, length 51.2 cm; j— *G. morhua maris-albi*, length 34.6 cm; k— *ibid*, length 16.9 cm; l— *G. morhua macrocephalus*, length 52.3 cm; m— *ibid*, length 24.3 cm; n— *ibid*, length 14.0 cm; o— *G. morhua ogac*, length 26.0 cm.

has processes similar to the Atlantic cod (*G. morhua morhua*) and the White Sea Coastal cod (*G. morhua maris-albi*) (Figure 27 a, j); the processes sometimes have the appearance of some specimens of the Kildin cod (Figure 27, cp. e, i); in Pacific cod normally the horn-like processes are bent toward the center line, sometimes, however, not only in adults but even in young ones, they are directed forward after the bend (Figure 27 m); sometimes the horns have a generally irregular form (Figure 25 n); in other words, the structure and dimension of the horn-like processes of the swim bladder vary quite broadly but roughly each form has its own definite structure. The structure of the horn-like processes of the swim bladder is most closely associated with the habitat of the cod. In the Baltic Sea (*G. morhua callarias*) and Kildin (*G. morhua kildinensis*) cods which live in considerably freshened water, the swim bladder processes are long. In coastal forms of cod the swim bladder is larger in dimensions.

Cod are divisible into two groups by the shape of the skull: narrow-headed, with a few morphologically close forms (*G. morhua morhua*, *G. morhua morhua n. hiemalis* and the closely related *G. morhua callarias* and *G. morhua kildinensis*) and broad-headed cod with a few forms more sharply distinguishable from each other (*G. morhua maris-albi*, *G. morhua ogac* and *G. morhua macrocephalus*). All of the broad-headed forms of cod appear to be coastal, local forms not undertaking large migrations, and geographically isolated from each other (Figure 26); the narrow-headed Atlantic cod undertake distant migrations; however, each is inclined to form local coastal (fjord) forms with limited migrations. With this we must point out that in local coastal forms (nations) of narrow-headed cod the skull, however insignificantly, is still slightly broader as we can see in per cent relations to the width of the interorbital space and the length of the head (I), the greatest width of the skull (II), the distance between the rear wings of the frontals* (III), and the width of the skull in the interorbital space (IV) to its length**.

Thus, craniologically *G. morhua morhua* and the narrow-headed forms related to it, *G. morhua morhua n. hiemalis*, *G. morhua callarias* and *G. morhua kildinensis*, are almost totally indistinguishable while the broad-headed cod differ greatly from the narrow-headed by the form of skull (Figure 28). The skull of *G. morhua maris-albi* is somewhat narrower in the forward portion than the skull of other broad-headed forms of cod, occupying the intermediate position between these two forms and the narrow-headed cods. This form of cod is also close to *G. morhua morhua* in the structure of the swim bladder as well.

* According to the sketch of measurement of the skull by Dement'eva and Tanasiichuk.

** The number of skulls are indicated in parentheses. The width of the interorbital space is taken from the description of each form.

<i>G. morhua morhua</i>	<i>G. morhua callarias</i>	<i>G. morhua kildinensis</i>	<i>G. morhua morhua n. hiemalis</i>	<i>G. morhua maris-albi</i>	<i>G. morhua ogac</i>	<i>G. morhua macrocephalus</i>
I. 15.8-20.7	16.2-21.0	17.5-22.0	14.9-18.5	18.4-24.1	22.6-23.1	20.3-25.3
II. 40.8-54.5	48.1	49.1	46.2-49.2	49.5-53.5	55.5	52.5-55.9
III. 29.6-40.6	38.4	37.4	35.3-38.1	35.2-38.8	43.5	42.3-42.7
IV. 19.6-28.2	25.1	25.4	22.3-25.3	25.5-28.6	31.1	31.5-31.6
(150)	(1)	(1)	(5)	(5)	(1)	(2)

FIGURE 28. Outline of dorsal view of skull of narrow-headed cod (*Gadus morhua morhua* dotted line) and of the broad-headed cod (*G. morhua macrocephalus* full line)

Based on the structure of the skull, swim bladder and some other characteristics, the division of *G. morhua* into six subspecies is here adopted: 1) *G. morhua morhua*, which in turn breaks down into a group of morphologically closely related forms of which only *G. morhua morhua n. hiemalis* is here treated; 2) *G. morhua callarias*; 3) *G. morhua kildinensis*; 4) *G. morhua maris-albi*; 5) *G. morhua ogac*; and 6) *G. morhua macrocephalus*, which in turn also breaks down into several close as yet unstudied forms. Of all broad-headed forms of cod the closest to *G. morhua morhua* is *G. morhua maris-albi*, which very possibly is derived from it, as is indicated by the similarity of structure of the swim bladder as well.

Diagnostic Key to the Subspecies

- 1 (8). Head narrow, interorbital space represents 15–22% of head length.
- 2 (5). Horn-like processes of swim bladder in adults generally long, bent at the base toward the mid-line and at the apex, then directed laterally (Figure 27 a). Coloration not bright, without sharp dark spots.
- 3 (4). Fishes reaching large dimensions and possessing rapid growth rate. Pectoral and pelvic fins short. Northern part of the Atlantic Ocean 1a. *G. morhua morhua* L.
- 4 (3). Fishes not reaching over 50 cm in length and possessing slower growth rate. Pectoral and pelvic fins and barbel longer. White Sea 1a. *G. morhua morhua n. hiemalis* Tal.
- 5 (2). Horn-like processes of the swim bladder in adults generally still longer with their whole processes coiled in balls. (Figure 27 c, g.). Coloration bright with distinct brown spots.
- 6 (7). Head narrow, interorbital space 16–21% of its length. Coloration spotty. Baltic Sea 1b. *G. morhua callarias* L.
- 7 (6). Head somewhat wider, interorbital space represents 17.5–22% of its length. Coloration still more spotty. Mogil'noe Lake on Kil'din Island 1c. *G. morhua kildinensis* Derjug
- 8 (1). Head broad, interorbital space constituting 18–25% of its length.

- 9 (10). Horn-like processes of the swim bladder in adults generally long, bent at the base toward the mid-line and at the apex laterally. Coloration usually dark. White Sea 1d. *G. morhua maris-albi* Derjug
- 10 (9). Horn-like processes of the swim bladder short, bent only toward the center line.
- 11 (12). Caudal peduncle deep, about 4.5–5% of body length. Coloration usually dark. Hudson Bay and western coast of Greenland 1e. *G. morhua ogac* Richardson
- 12 (13). Caudal peduncle somewhat lower, 3.5–4.5% of body length. Coloration paler. Northern part of the Pacific Ocean and adjacent seas 1f. *G. morhua macrocephalus* Til.
- [Translator's note: The author mentions choice 13, but there is no choice 13 given.]

*1a. *Gadus morhua morhua* Linné—Atlantic cod (Tables X, LI, LXXI)

Gadus morhua Linné, Syst. nat. ed. X, 1758:252 (Atlantic Ocean and the coasts of Europe). — *Gadus callarias* Linné, l. c.: 251 (ex parte: Atlantic Ocean and coasts of Europe). — *Gadus vertagus* Walbaum in: Artedi, Gen. pisc., III, 1792:143. — *Gadus heteroglossus* Walbaum, l. c.:144. — *Gadus ruber* Lacepède, Hist. nat. poiss., V, 1803:671, 673. — *Gadus arenosus* Mitchell, Trans. Lit. Philos. Soc. N. Y., I, 1815:318 (New York). — *Gadus rupestris* Mitchell, l. c.:368. — *morhua punctata* Fleming, Hist. brit. animals, 1828:192. — ? *Gadus nanus* Faber, Fish. Iceland, 1829:113 (Iceland). — *Morrhua americana* Storer, Mem. Amer. Acad. Art. a. Sci., (n. s.), VI, II, 1858:343, pl. XXVII, f. 4 (coasts of North America). — *Gadus callarias* Williamson, 20th Ann. Rept. Fish. Board Scotl., pt. 3, (1901), 1902:228 (description of the skeleton).

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growth rate); Suvorov and Vadova, *ibid.*: 67 (dimensions, weight, age complement); Kuchina, *ibid.*: 103 (feeding); Dement'eva and others, *dokl. 1 sessii gos. okeanogr. inst.*, 2, 1932:49 (measurements of the skull); Suvorov, *izv. ikht. inst.*, XIII, 2, 1932:61 (Motov Bay, spawning, eggs); Synkova, *ibid.*: 89 (Novaya Zemlya, comparison of Novaya Zemlya cod with the Murman cod); Gurvich, *ibid.*: 101 (shores of Novaya Zemlya north to Krestov Bay, feeding, measurements, age, biometry); Tanasiichuk, *kare lo-murm. krac*, 1932, 3-4:52 (racial analysis); *ibid.*: 5-6:46 (spawning); Jeffers, *Contrib. Canad. biol. fisher.*, (n. s.), VII, 15-23, 1932:7 (Belle-Isle Strait); Dannevig, *Journ. Conseil*, VII, 1, 1932:60 (change in number of vertebrae with different conditions of development of larvae); Vladykov, *Contrib. Canad. biol. fisher.*, (n. s.), VIII, 1-8, 1933:2 (Davis Strait, feeding); Esipov, *Tr. arktich. inst.*, VII, 1933:71, figure (at the shores of Novaya Zemlya to Krestov Bay, comparison of Novaya Zemlya cod with Murman turyanka); Rass, *dokl. 1 sessii gos. okeanogr. inst.*, 5, 1933:4 (spawning); Graham, *Fishery Invest.*, (2), XIII, 4, (1933), 1934; Provotov, *mat. nauchno-prom. obsled. karsk. gubyi r. Kary* 1934:94 (1 specimen from Kara Bay); Rass, *Karelo-Murm. Kray*, 1934, 3-4:57 (spawning on the Murman coast); McKenzie, *Contrib. Canad. biol. fisher.* (n. s.), VIII, 27-31, 1934:435 (spawning on the coast of Nova Scotia, New Brunswick, and Prince Edward Island); Rolfeisen, *Rapp. Proces-Verb.*, LXXXVIII, 1934:1; Hansen, Jensen a. Taning, *Medd. Komm. Havunders.*, Fisk., X, 1935:3 (spawning of cods on Greenland coast); Vladykov, *Progress Rept.*, Biol. Board Canada, 14, 1935:3, 2 figs.; Dement'eva and Tanasiichuk *za rybn. industr. Severa*, 1935, 5:40 (races of cod, literature on criticism of the question); Rass, *Int. Rev. ges. Hydrob. Hydrogr.*, 33, 1936:251 (spawning); Agapov and Toporkov, *probl. Arktiki*, 2, 1937:107 (western shores of Novaya Zemlya); Marti, *Tr. polyarn. nauchno-issled. inst. morsk. rybn. khoz. i okeanogr.*, 3, 1939:3 (tabulation of information and literature on biology and races); zatsepin and Petrova, *ibid.*, 5, 1939:2 (feeding); Maslov, *ibid.*, 6, 1939:3 (commercial); *ibid.*, 8, 1944:3, 50 and following (biology, commercial utilization); Glebov, *Praroda*, 1941, 4:87 (biology); Dubrovskii, *ibid.*, 6:74 (Bay of Krotov on Novaya Zemlya in Kara Sea, 72° north latitude)*.

I D 14-15, II D 18-22, III D 17-20, I A 19-23, II A (15) 17-19, gill-rakers 21-28, vertebrae 49-53. Head small and narrow, its length 24.6-26.6% of the body length**, interorbital space 15.8-20.7% of head length. Barbel usually shorter than the horizontal diameter of the eye, rarely equal to it. Caudal peduncle elongate and not deep, its length 11.6-13.1%, its depth 4.2-5.1% of body length. The appressed rays of the first dorsal fin generally reach considerably beyond the origin of the second dorsal fin, less frequently terminating at its beginning or not reaching it. The horn-like processes at the forward end of the swim bladder are usually elongate and after the bend toward the center line are directed forward and curved laterally at the tips; in young short, and curved only to the center line (Figure 27 a, b). Peritoneum silvery-leadened or leadened black. In per cent of body length: anteanal distance 41.2-48.8, antedorsal distance 28.1-31.5, length of pectoral fin 12.1-13.8, length of pelvic fin 9.1-11.1, height of first dorsal fin 10.0-12.0, height of first anal fin 8.9-12.3. In per cent of head length: length of snout 33.9-38.4, horizontal diameter of eye 15.5-21.7, length of upper jaw 39.2-44.2, length of lower jaw 49.0-54.8, length of barbel 11.7-15.6. Coloration very highly variable. Upper part of body dark, ashen or olive gray, often with brownish or grayish round spots. Spots are present on sides of body and head but absent from the forward part of the head. Lower part of body whitish, without spots. Lateral line lighter than the sides of the body. Vertical fins gray with dark spots, sometimes forming transverse rows, pectoral and pelvic fins lighter, pelvics often of the same color

* The latter works were not utilized fully as they were published after the completion of this work.

** From information by Dementeva averages based on a large number of specimens, variation in I D from 14.37 to 14.75, II D from 19.49 to 20.12, III D from 18.76 to 19.39, I A from 21.13 to 22.39, II A from 18.48 to 19.32, number of vertebrae from 52.14 to 52.55 (limits of individual variation 50-55, without the last vertebrae which we counted).

as the belly. Depending upon the habitat, the coloration of cod varies strongly. The most common color variant in cod appears to be reddish or orange (aberr. erythrina), which at our shores are called turyanka. The coloration is unstable, the young cod acquires it while living among *Laminaria* fronds and with change of habitat or while kept in an aquarium this coloration disappears. Small cod keeping close to shore, sometimes (Jeffers, 1. c.) take on a dark color such as *G. morhua maris-albi* and *G. morhua ogac*. The measurements are most often 50–80 cm, about 75 cm average, maximal to 1.8 meters*.

DISTRIBUTION. Northern part of the Atlantic Ocean. At the shores of Europe from the Bay of Biscay to North Cape; at the shores of North America from Cape Hatteras to Hudson and Davis Straits; southwestern and southeastern shores of Greenland; around Iceland and, apparently, northward from Iceland almost to Jan Mayan (to 69° 13' north latitude, 8° 23' east longitude, where otoliths were found); Faroe Islands, Shetland and Orkney Islands in the North Sea; in the Barents Sea along the coasts of Spitsbergen almost to its northern tip, shallows off Bear Island to the latitude of Hope Island, in the central portion to 77° north latitude; at Novaya Zemlya to Admiralty Peninsula and very possibly northward; in Kara Sea to Kara Bay**. It enters within the distributional limits of its nations and geographically close subspecies – in the White and Baltic Seas and in Hudson Strait.

168 **BIOLOGY.** The Atlantic cod, as seen from its distribution, is somewhat less warmth loving than saida and piksha, but considerably more than the navaga. It occurs at temperatures of 0 to 16° C; however, the optimal temperatures for it appear to be 4–7° C; coastal (fjordal) forms are found at somewhat lower temperatures; in the Barents Sea it is found in greater numbers at temperatures from 1 to 5° C. Atlantic cod live, as a rule, in waters of normal oceanic salinity; cases of entry into fresh water are rare, but have been known repeatedly†. It generally keeps to banks or along submarine slopes within the limits of the continental shelf at depths of 10–250 meters, most often 40–100 meters, with a limit of 500 meters. Spawning occurs throughout the entire range, but the basic spawning grounds are located along the shores of Norway, mainly at the banks of the Lofoten Islands, where cod gather in great numbers during spawning. Spawning occurs less intensively in the North Sea, at the eastern shores of Great Britain and at the banks in the middle of the sea, around Ireland and at the western shores of Great Britain, at the Faroe Islands, at the southern and western shores of Iceland, at the shores of Newfoundland, at the western shores of Greenland (to 67° north latitude), in Norwegian fjords, at the shores of Murman from Finmark and to Holy Nose, and in some years in the western portion of the Barents Sea (at Bear Island). Spawning possibly occurs along the shores of Novaya Zemlya, where it has not been directly observed, but where young were found††. Fertility

* A 24-year-old female cod 169 cm in length, weighing 40 kilograms, was trawled in July 1940 in the Barents Sea.

** Possibly to the mouth of the Pyasina River where a small cod was found in the stomach of an omul (Ostroumov, Tr. Polyarnoy kom., 30, 1937:53), if it was really a cod. [Translator's note: Pyasina River mouth is on the Taimyr Peninsula. Omul – *Coregonus autumnalis*.]

† Several cases of cod entering fresh water are known at the shores of North America and Europe. In the Elba River a 30 cm long cod was caught (to 15 kilometers above Hamburg this fish differs greatly from the typical cod). Three cods were caught at the Luga River 1 kilometer from the mouth at the beginning of January, 1931.

†† In the opinion of Rass, these young cod were carried here from elsewhere.

of cod is quite great, from 570 to 9,300 thousand eggs. The number of eggs in cod as large as 100 cm reaches 3-4 million; in large fish the number of eggs reaches 9 million or more. Eggs in the ovaries do not ripen all at once and are cast intermittently. Spawning basically occurs within the limits or near the 100-meter isobath, in spots in the North Sea and around Great Britain at lesser depths (20-80 meters and even less). Spawning does not take place beyond the limits of the 200-meter isobath, at the western shores of Scotland and Ireland—deeper than 100 meters. Spawning of the oceanic form of cod at the Lofoten Islands occurs at temperatures of 4-6° C and even 7° C; however, local coastal (fjoldal) forms at the shores of Greenland and western Murman cast their eggs at considerably lower temperatures (1-2° C and even at negative temperatures from -0 to -4° C). Spawning occurs mainly in February-April, reaching maximum intensity in March, and in some years may occur even earlier and be greatly prolonged as well; but generally there are cases known of cod spawning at almost any time of year, beginning in the fall (August-September) and terminating in summer (June-July). Duration of the development of eggs 20-35 days. Young cod are found everywhere throughout the entire range; however, in some places it is difficult to say whether they were derived from eggs spawned locally or were brought in as pelagic larvae or young. Young cod undertake seasonal migrations to and from the shores. Experiments in tagging showed that grown cod undertake similar limited migrations in the North Sea, at the Faroe Islands, in Kattegat and Belt, at the shores of Nova Scotia, New England and a whole group of other places—although in fjord cod and Murman coastal cod there are known individual cases of distant migrations of fishes which had been marked in some of those places. After spawning at the Lofoten Islands, cod, as shown by tagging experiments, undertake distant migrations, entering in the streams of the North Atlantic currents far to the north, into the Barents Sea to the shores of Novaya Zemlya. These cod generally represent the basis of our cod industry, inasmuch as the local Murman cod is present in much lesser quantities. Lofoten cod approaches the shores of Murman in May-June, shortly after their appearance in the southern part of the Barents Sea at Finmarken-Fishermens Banks. In the fall cod begin to depart and in November completely disappear from the coastal waters, moving farther into the western regions of the Barents Sea. They remain on the Bear Island Banks throughout the year, constituting the basis of the winter industry. Cod arriving in the Barents Sea after spawning differ by having less fat than the local Murman cod. Large cod undertake distant migrations, as similarly established through numerous marking experiments, between the shores of Iceland and Greenland. The number of cod coming to the shores of Greenland, into the Barents Sea and to the shores of Norway, is generally unstable and subject to periodic variations. Sexual maturity is not reached at the same age in different portions of the range: in the North Sea cod begin to spawn in the 4-5 year upon reaching a length of 65-75 cm average; at the Lofoten Islands (Rollefsen, l. c.) at 6-15, more often at 10-11 years at an average length of 60-100 cm. The age limit of cod should be considered 24, possibly more. Spawning occurs annually, upon reaching sexual maturity. Food of adult cod is quite variable, but the basic item of sustenance appears to be fish-herring, capelin, sand launces, young and small cod. Besides these they feed on pelagic Euphausiidae and Hyperiidæ and to a lesser extent on benthonic crustaceans (Schizopoda, Amphipoda and Decapoda). The young, leading a pelagic existence, feed on plankton (Calanus). In the central and western regions of the Barents Sea from October

to April the greatest food item is herring. From February to June in the same regions and in shallow coastal waters they feed on capelin. Young cod and piksha serve as food throughout the year: from the end of spring in the western industrial region; at the same time, and also in the beginning of fall and from the end of December and in January—in the central regions; in autumn—in the eastern industrial regions and in the shallows of Novaya Zemlya. Sayka *Boreogadus saida* plays a great role in the feeding of cod in the eastern industrial regions of the Barents Sea, in the shallows of Novaya Zemlya and partially along the northern and southern slopes of Goose Bank in the fall—winter months. Euphausiidae and Hyperiidæ are of greatest importance in feeding cod during summer. Bottom crustaceans and a number of mollusks and worms serve as food in the eastern industrial regions. The central and eastern industrial regions have great importance in feeding, the western, less. In the western regions the average index of filled stomachs is not great (35–173), in the central higher (86–173), highest in the eastern regions (170–224). It now appears that cod does not feed in great concentrations in our industrial regions. According to research findings the causes of such an occurrence remain to be elucidated. Intensive feeding occurs in the non-industrial regions and at non-industrial times, when cod travels in broken-up units. Cod keep in schools at the approaches to the feeding grounds but during spawning practically cease eating. The growth of cod in various parts of its great range is uneven; the coastal (fjord) cod grows slowest. The limits of variation of average size of sexually mature Atlantic cod from the Barents Sea is as follows: 4 years old—35.0–38.4 cm; 5 years old—41.8–44.9 cm; 6 years old—50.7–55.2 cm; 7 years old—60.1–64.0 cm; 8 years old—69.7–73 cm—9 years old—80.6–82.5 cm; 10 years old—89.7–91.4. The age contingent, the dimensions and size of catch of Atlantic cod are unstable, and vary, being dependent upon the number of individuals in the generation ("the crop") during various years. The generation of a good crop year enters the industry after 5 to 7 years and appears to predominate in the catches for several years following. In the Barents Sea the generations of 1919, 1929, 1930, and 1933 were good crop years, the generation of 1931, poor crops. The fat content in the liver of cod also undergoes considerable variation from year to year. Thus, for example, in cod caught at the shores of Norway the comparative weight of the liver varied considerably in the period 1900–1911, being minimal in 1903 and maximal in 1900 and 1907. Likewise, the fatness (weight of the liver as per cent of body weight) undergoes periodic changes similarly in the Barents Sea. Large cod over 70 cm in length contain the greatest amount of fat in the liver; their fatness varies on the average from 4.0–9.2%, while in smaller—from 2.5–6%.

COMMERCIAL VALUE. Very great. Holds first place among the gadoids in size of catch. Annual catches along the shores of Europe, Greenland and North America (Newfoundland) during recent years exceeded 10 million metric center; before World War I over 6 million metric center were caught annually. In the period of time from 1934 to 1938 our trawling fleet brought in annually from 558 (1934) to 1,750 (1937) thousand metric center. Besides, quite a considerable amount of cod was caught by Dement'eva and Tanasiichuk,

COMPARATIVE NOTES. The Atlantic cod within the limits of its range comprises several forms (races) as yet not studied too closely and scarcely distinguishable from each other morphologically, but with characteristically

differing growth rates and dimensions and segregation of spawning grounds. The most widely distributed and powerful appears to be a form of cod whose main spawning grounds are located near the Lofoten Islands; it also spawns in small numbers in Motovsk Bay. It is characterized by a high vertebral number (according to Dement'eva and Tanasiichuk, the average 52.5 vertebrae), gill-rakers (average 24.9) and fin rays (19.9 in II D). At our shores the Lofoten cod predominates in the southern part of the Barents Sea, and it is found in the purest form in the spring in the western regions (Finmarken-Fishermens Bank), and especially at the times of approach of fish. It is found in the central regions in purest form during summer and late fall, and at all other times it is found here in mixed groups; it remains at Bear Banks the year round. Its numbers along our shores vary in different years; in warmer years it comes in greater numbers; in colder years, in lesser numbers. Besides the incoming Lofoten cods the other local form which spawns on the shores of Murman was indicated by the earliest explorers (Breitfus and Goebel, l. c.); later the independence of this form of cod was denied (Esipov, l. c.), but in recent years we have received new data (Dement'eva and Tanasiichuk, l. c.) confirming the segregation of this as yet unstudied form*. The Murman cod spawns along the Murman coast, 171 mainly in Motovsk Bay, in lesser numbers at its eastern coast (to Rinda); in some years spawning takes place in great numbers. It is characterized by a lesser number of vertebrae (average 51.8**) than Lofoten cod, gill-rakers (average 23.7), fin rays (II D average 19.4), greater fat content and weight, lower growth rate. Does not undertake great migrations. In lesser numbers this cod is continuously distributed along the coasts of Murman, the schools mixing with all schools of cod coming in from the sea†. In the spring sexually immature cod of this form keep to the southern shores of Motovsk Bay, at Kildin Island and east of it; in the winter they remain in reduced numbers in the deeper parts of the bays and in the shallows. In the open portion of the Barents Sea it is not found in pure form; in some coastal regions it predominates over the Lofoten cod. The Murman cod is more cold loving than the Lofoten cod. Maximal approach of the Murman cod to the shores occurs during the hydrological winter, maximal of Lofoten cod during hydrological summer. The Murman cod, beyond any doubt, represents an independent as yet not closely studied form (natio) of the Atlantic cod; it is possible that it is identical to the White Sea winter cod. There are data indicating the presence of another form of cod with fewer vertebrae and a higher gill-raker count, spawning, apparently, in the northern fjords of Norway. This cod does not travel far to the east to the Barents Sea. In some years it appears to be the main item of the summer industry at Bear Bank, and in the southern part of the Barents Sea apparently joins the contingent of summer schools of cod and does not present any great significance in catches here. A form of cod similar to or perhaps identical with the Murman cod is found in Trondheim Fjord. A cod with a lower vertebral count and fin ray (J. Schmidt, l. c.) also occurs in the Gulf of St. Lawrence. Spitsbergen cod differs by its small size and some external distinctions (Ehrenbaum, l. c.). Generally in the bays and fjords the Atlantic cod forms

* More detailed information on the biology of the Murman cod is given by T. E. Glebov (1941), who also indicates that among the Murman cod in recent times there are two distinguishable forms.

** Without the last counted by us.

† According to Dement'eva, in summer and fall, as shown by marking experiments, Murman cod moves eastward (Goose Bank and the shallows of Novaya Zemlya) where it mingles with the arriving Lofoten cod.

as yet unstudied local races with limited migrations and local spawning. Besides, cod varies along the entire stretch of the Atlantic Ocean; in the western part it has a greater number of vertebrae and fin rays in the II D than in the eastern part; the cod remaining around Great Britain and Ireland have still fewer vertebrae and fin rays in II D. At present it is difficult to state what all these above enumerated forms of cod are. In all these cases we must remember the dependence of vertebral number in cod upon the conditions under which the eggs and larvae develop; as shown by Dannevig (1. c.), it varies greatly. More definitely geographically segregated and better studied forms are formed by the Atlantic cod and the White Sea and Baltic Sea cods and the cod of Lake Mogil'noe in Kildin Island.

*1a₁. *Gadus morhua morhua* n. *hiemalis* Taliev—White Sea Winter Cod (Table XIII)

Gadus callarias hiemalis Taliev, izv. otd. prikl. ikht., XI, 2, 1931:113, Figure 2 (Kandalakshaya Gulf). — *Gadus morhua hiemalis* Evropeitseva, rasovyi analiz belomorskoj treski, izd. Leningr. Gos. univ., 1937 (biometric characterization, feeding spawning, growth rate). — *Gadus callarias* Il'in and Pevzner, Sborn., Posvyashch. Knipovichu, 1939:320–322 (biometry).

172 I D 12–13, II D 18–20, III D 18–20, I A 20–22, II A 17–23, gill-rakers 21–22, vertebrae 52–55*. Head comparatively short and narrow, its length 25.2–27.2% of body length, the width of the interorbital space 14.9–18.5% of head length. Barbel generally shorter than the horizontal diameter of the eye, seldom equal. Caudal peduncle elongate and low, its length 10.8–13.2% of body length, depth 4.5–5.0% of body length. Body and unpaired fins not high. The rays of the first dorsal fin when appressed generally reach beyond the origin of the second dorsal to 1/7–1/3 of its length. The horn-like processes at the anterior end of the swim bladder are generally the same as in the typical form. The peritoneum coloration varies from leadened-black to blackish. In per cent of body length: anteanal distance 44.6–49.3, ante-dorsal distance 27.9–32.1, length of pectoral fin 13.3–14.7, length of pelvic fin 10.4–11.5, height of first dorsal fin 11.0–13.1, height of first anal fin 10.0–12.2. In per cent of head length: snout length 40.5–42.8, horizontal diameter of the eye 19.7–23.6, length of the upper jaw 40.5–42.8, length of the lower jaw 48.4–52.2. Coloration as in typical form. Usual measurements 20–40 cm, the greatest to 50 cm (8 specimens).

A form very close, morphologically almost indistinguishable from the Atlantic cod. Differs only biometrically (on averages) in lengths of pectoral and pelvic, second dorsal and first anal fins, longer barbel. Craniologically likewise indistinguishable. Apparently identical to Murman coastal cod**. The most material distinction from the typical form is in the growth rate and in general in the small size of this cod. B. S. Il'in and V. I. Pevzner, comparing this doubtful form with specimens of the Murman cod (from Polyarnoe, Eina Bay, Uritsa and near the bird colonies of the Rybachii Peninsula), discovered differences only in the length of the head, diameter of the eye and rate of growth.

DISTRIBUTION. The White Sea, where it enters Kandalaksha Bay. In Kandalaksha Bay it is found in the greatest numbers in fall and winter;

* According to data of N. V. Evropeitseva, I D 12–16 (14.3), II D 17–21 (19.5), III D 17–21 (19.0), I A 19–25 (21.6), II A 16–21 (18.6), gill-rakers 20–26 (23.3), vertebrae 51–54 (52.3) (without including the last vertebra, which is counted by us).

** According to Dement'eva this cod is definitely closest in all characteristics to the Murman coastal form of cod.

in summer it leaves. Return to Kandalaksha Bay begins in June and later, depending upon the location; arrivals to places nearer the mouth of the bay are observed earlier. In the White Sea, however, it undertakes a considerable migration, possibly going beyond the limits of the sea*.

BIOLOGY. Spawns partially or entirely in the White Sea. Only two specimens are known close to spawning (fourth stage of maturity), females 5 years old caught the 11th of April, 1936 in or at Pedunikha Bay at a depth of 6 meters. A male (not fully typical) with sexual products at the fifth stage of maturity was caught in 1935 at Pedunikha Bay. The summer young keep in a coastal strip, together with the one-year-olds of *G. morhua maris-albi*, feeding with them on *Harpacticus*, benthonic crustaceans, larvae of shrimp, amphipods, brachyura and others. Larger fish, measuring 15–25 cm (2–3 years) eat primarily *Nereis*, *Caprella*, fin fish (herring, capelin and others) and decapods. Fish measuring 25–50 cm (4 years old and older) feed primarily on fish—capelin (and not sticklebacks, as *G. morhua maris-albi*), then *Nereis pelagica*, amphipoda and decapoda. In the spring it feeds on food similar to the food of larger (25–50 cm) *G. morhua maris-albi*. It differs in delayed growth in comparison with Murman cod and somewhat faster growth in comparison with *G. morhua maris-albi*. After data from scale studies collected in 1933, N. V. Evropeitseva gives the following figures for the growth and gain:

Age (years)	1	2	3	4	5
Growth (mm)	83	161	219	278	341
Gain in growth (mm)	83	77	72	60	49

INDUSTRIAL OF COMMERCIAL VALUE is comparatively small, but greater than *G. morhua maris-albi*, as the greatest mass of cod caught in Kandalaksha Bay belongs to this form. The catch of both forms of cod in Kandalaksha Bay during the period 1895–1915 did not exceed 100 metric centner; in later years the primitive form of industry was discontinued. It is caught primarily by women, mainly with rod and line (Deksbach, Rybn. khoz, SSSR, 1925, 8–9:13).

*1b. *Gadus morhua callarias* Linné—Baltic cod (Table XI)

Gadus callarias Linné, Syst. nat., ed. X, 1758:251 (ex parte: Baltic Sea); Pallas, Zoogr. rosso-asiat., III, 1811:182 (Baltic Sea and coasts of Latvia, Lithuania and Estonia). — *Gadus morhua* Kessler, ryby spb. gub., 1864:61 (ex parte: sometimes at Kronshtadt, one specimen from Neva Bay). — *Gadus callarias* Smitt, Scand. fish., I, 1893:473 (ex parte: Baltic Sea); J. Schmidt, C.-R. Trav. Lab. Carlsberg, XVIII, 6, 1930:15 (ex parte: Baltic Sea east from Bornholm Island). — *Gadus morhua callarias* Berg, ryby presnykh vod., II, 1933:744 (Baltic Sea east from Bornholm Island to Neva Bay, in the Luga River at one kilometer from the mouth).

DISTRIBUTION, BIOLOGY. Mälgren, Kritisk Öfvers. Finnl. fisk. - fauna, 1863:27 (Gulf of Bothnia to Ujeaburg); Möbius u. Heincke, Fische Ostsee, 1883:233 (biology); G. Schneider, Acta Soc. Fauna Flora Fennica XX, 1, 1900:24; ibid., XXII, 4, 1901:43; ibid. XXII, 2, 1902:67 (feeding, incidence of parasitic infection); Sandmann, Rapp. Procès-Verb., V, 1906:41, pl. IV (Gulfs of Bothnia and Finland, growth, dimension); Hesse, Meddel. Kungl. Lantbruksstyrels., 243, (2, 1923), 1923:8 (coasts of Sweden, growth, feeding); 278 (7, 1929), 1929:3, 35 (coast of Sweden, spawning experiments); Kandler, Kieler Meeresforsch., II, 2, 1938:272 (western part of the sea east of Bornholm Island, spring and fall spawning, comparison of spring and fall spawning cod); Berg, Izv. vesesoyuzn. nauchno-issled. inst. ozern. i rechn. rybn. khoz., XXIII, 1940:23 (Gulf of Finland, dimensions); Zieciak, Arch. Hydrob. Rybact., Suwalki, XI, 1938:51; Glebov, Rybn. khoz., 1946, 4–5:9 (Baltic Sea south of Jutland Island, trawling).

I D 14–16, II D 16–20, III D 17–20, I A 18–22, II A 18–21, gill-rakers 18–23, vertebrae 53**. Head comparatively short and narrow, its length

* At Kanin Point cod with a growth rate characteristic of this form was caught, partially substantiating the opinion expressed above as to the identity of this with the Murman coastal form of cod.

** The number of vertebrae in one specimen only; according to J. Schmidt, 50–56 vertebrae.

25.4–27.8% of body length, width of interorbital space 16.2–21.0% of head length. Barbel usually shorter, seldom somewhat longer than the horizontal diameter of the eye. Caudal peduncle elongate and low, its length 9.5–12.4, depth 4.1–4.8% of body length. Body and unpaired fins not high. Rays of first dorsal fin when appressed usually reach beyond the origin of the second dorsal fin, seldom reach only to the origin. Swim bladder most often somewhat larger in dimension and less elastic than in the typical form, the horn-like processes at its front end in adults usually very long, rolled in a ball (Figure 27 c). In per cent of body length: anteanal distance 45.7–48.2, antedorsal distance 29.5–33.3, length of pectoral fin 13.6–14.9, length
174 of pelvic fin 9.9–12.0, height of first dorsal fin 11.2–13.6, length of first anal fin 9.4–12.1. In per cent of head length: height of snout 35.4–39.0, horizontal diameter of eye 15.9–20.5, length of upper jaw 40.7–44.5, length of lower jaw 48.8–52.9, length of barbel 13.8–18.6. Coloration olive or greenish-gray often with grayish, brownish or brown spots, generally more spotty than the Atlantic cod; often the coloration is darker. Usual measurements 40–50 cm, in the eastern portion of the sea smaller, 30–45 cm. Weight in the Gulf of Finland averages 0.5 kilograms, in exceptional cases 3–4 kilograms. Larger specimens, almost 100 cm in length and weighing up to 7.75 kilograms, are sometimes found in the Gulf of Finland, and are presumed to be Atlantic cod which have accidentally entered the Baltic.

DISTRIBUTION. Baltic Sea east of Bornholm Island, more often in its central part and to the middle of the Gulfs of Finland and Bothnia (Kvarken Straits), less frequently in the northeastern part of the Gulf of Bothnia (at Uleaburg) and in the eastern part of the Gulf of Finland, in the latter even occasionally to Neva Bay.

BIOLOGY. Similar to the biology of the coastal forms of the Atlantic cod, as tagging experiments have shown that it remains locally, undertaking only very limited migrations. All marked fish were caught, at least during the current year, at distances of 1–2 nautical miles from the place of spawning. In the middle part of the northern section of the Baltic Sea it apparently concentrates primarily at the greater depths; the best catches are usually on the inclines of these depths or in those spots near shore which are close to the depths. South of Jutland Island (55° 50' north latitude, 19° east longitude) in 1941 the greatest gatherings were in the bottom layers of water at a temperature of 4–5° C. It prefers rocky bottom and is seldom found on soft mud or sandy bottom. It is characteristic of this form that it lives and breeds at lower salinity; indeed, at the western part of the Baltic Sea east of Bornholm Island, salinity drops to 13–18 parts per thousand and even lower; in the central and eastern parts of the Baltic Sea it is still lower (about 10–12 parts per thousand); however, spawning occurs even here. For spawning it comes closer to shore, in some places in the fall and stays here until May. In the western portion of the sea, spawning begins in January and ends in May; the most intensive part occurs in March. In the eastern part of the sea, shedding of the eggs occurs to a lesser degree and is continuous through summer; its main period falls at a later time. In the deep western part of the sea east of Bornholm Island, spawning continues from March to September inclusive, and two periods of it are observed—spring, stretching from April to July with greatest intensity in June, and a shorter autumn period ending in September, with the greatest intensity in the middle of that month. Spawning here occurs on slopes of the depths, at depths of 70 to over 100 meters with a bottom water temperature in September of 4.3–4.6° C and a salinity of 12.9–17.8 parts per thousand. At Jutland Island, Aland

Islands and opposite Stockholm spawning occurs with greatest intensity in April-June, in the Gulf of Bothnia in July and August. Maturity is already reached at 3 years of age. In the central portion of the Baltic Sea it matures at a length of less than 40 cm at 3 to 4 years of age. The number of females is always greater than the number of males. Eggs and larvae are found at depths of 100-300 meters. In the Gulf of Bothnia growth is faster than in the more southerly portions of the sea. It feeds on crustaceans and fish; at depths food consists of *Mesidothea entomon*, *Mysis oculata*, *Pontoporeia temerata*, *Lumpenus lampetiformis*, and her-
175 ring; at lesser depths—*Gammarus locusta*, fish (herring, belduga, sticklebacks, and sand launces).

COMMERCIAL IMPORTANCE. Comparatively minor. In recent years about 170 thousand metric centner (1936) were caught west of Belt Strait. During this year in particular the catch was: Denmark—19.3; Sweden—59.3; Germany—45; Poland—9.3 (1932—38.1); Latvia—29.7 (1939—54.6); Estonia—6.7 (1939—27.7); Lithuania—6.9 thousand metric centner (1939)*. In the Gulf of Finland it has no commercial value. Procured mainly in nets, yarus, partially on rod and line and nets. At the open shores of the sea the catch begins in March, the period when the fish approach the shores for spawning, and continues until winter. It is caught in greatest numbers from June to October. In winter it is caught at greater depths distant from shore.

COMPARATIVE NOTES. Externally and craniologically similar to the Atlantic cod, having only a lesser number of rays in the second dorsal fin (according to J. Schmidt, average about 17.5, while oceanic cod has a mean average usually above 19), a lesser number of gill-rakers and a smaller size but a material difference is in having the long and soft horn-like processes of the swim bladder coiled into a ball. There are indications of the presence in the Baltic Sea of a form of cod with a shortened skull and a sharp profile of the head.

*1c. *Gadus morhua kildinensis* Derjugin—Kildin cod (Tables XI, LII)

Gadus callarias kildinensis Derjugin, Tr. Petrogr. obshch. est., LI, 1, 1920:26 (Mogil'noe Lake on Kildin Island); Tr. Petergofsk, inst., 2, 1925:78 (measurements, biology); Rass, Rab. Murm. biol. st., III, 1929:25 (measurements of two specimens); Esipov, hidro biol. zhurn. SSSR, IX, 4-6, 1930:131 (comparison with the Atlantic cod).

I D 12-14, II D 17-20, III D 17-20, I A 18-20, II A 17-20, gill-rakers 20-24, vertebrae 54**. Head not large but quite broad, its length 24.4-26.9% of body length, width of interorbital space 17.5-22.0% of head length. Caudal peduncle elongate, length 11.9-13.3%, depth 4.2-4.8% of body length. Rays of the first dorsal fin when appressed scarcely pass beyond the origin of the second dorsal fin. The horn-like growths at the anterior end of the swim bladder in adults are usually very long, most often coiled into a ball (Figure 27, g, h, i). Peritoneum leadened silvery or leadened black. In per cent of body length: anteanal distance 44.1-49.1, antedorsal distance

* According to published data of the enumerated countries.

** According to Esipov (17 specimens), I D 12-14 (12.8), II D 16-20 (18.4), III D 17-20 (18.3), I A 18-22 (20.1), II A 17-20 (18.3), gill-rakers 21-24 (22.0), vertebrae 51-52 (51.8), without the last vertebra, which we counted.

27.7–31.5, length of pectoral fin 13.2–14.4, length of pelvic fin 9.4–11.2, height of first dorsal fin 11.2–12.0, height of first anal fin 10.7–11.5. In per cent of head length: length of snout 34.0–37.7, horizontal diameter of eye 16.0–20.3, length of upper jaw 40.0–42.1, length of lower jaw 48.8–50.3, length of barbel 14.5–17.7. Coloration dark and very spotted. The basic color of the upper portion of the body is brownish, often with numerous scattered round dark brown spots; similar spots occur on the dorsal and caudal fins; pelvic and anal fins dark with small black dots. Pectoral fins somewhat darker. Largest known measurements 79.7 cm (8 specimens).

176 DISTRIBUTION. Lake Mogil'noe on Kildin Island west of the entrance to Kola Bay.

Biology of this form is quite individual. It lives in a small closed lake with a maximal depth of 17.5 meters, with a salinity in the bottom layers of the water (below 10 meters) from 22 to 32 parts per thousand and greatly freshened, almost fresh, surface layers. It remains in the lower layers of water, but cases are known of catching them at 1.5–2.0 meters, that is in the water with a salinity of about 1–5 parts per thousand. Spawning of this cod, which is as yet not studied too closely, offers great interest, as the pelagic eggs must be located either in freshened surface layers of water or at depths of 10 meters. Females with ripe eggs and males with well-developed testes were found in mid-February; but spawning apparently occurs in March. Young 7.3 and 9.5 mm in length were caught at the end of June. One hundred forty specimens of cod not over 7 cm in length were caught with nets in the beginning of September. Feeds on crustaceans. Growth of this form of cod, apparently, is close to the growth rate of the Atlantic cod; at 5 years of age the average length is about 60.7 cm, at 6 years 65.1 cm.

COMMERCIAL VALUE almost none, inasmuch as the supply in such a small lake is insignificant.

COMPARATIVE NOTES. This form of cod is undoubtedly derived from *G. morhua morhua*, and, judging by one skull and the interorbital distance in measured fish, its skull is broader than in the Atlantic cod. The Kildin cod differs more strongly from the broad-headed forms of cod (*G. morhua maris-albi*, *G. morhua ogac*, *G. morhua macrocephalus*) in the shape of the skull and a group of other characteristics.

*Id. *Gadus morhua maris-albi* Derjugin—White Sea coastal cod (Tables XII, LIII)

Gadus callarias maris-albi Derjugin, Tr. Petrogr. obsch. est., LI, 1, 1929:27 (White Sea); Mikhin, Izv. otd. prikl. ikht., III, 2, 1925:191 (Kandalaksha Gulf, biometric characteristics); Taliev, ibid., XI, 2, 1931:103, Figure 3 (Kandalaksha Gulf and region of Kandalaksha from the village of Kolvitz to Pirju Bay, biometric characteristics, biology); Yanushevich, Karelo-murm. krai, 1933, 5–6:61 (biology and utilization). — *Gadus morhua maris-albi* Evropeitseva, Rasovyi analiz belomorskoi treski, izd. Leningr. Gos. univ., 1937 (biometric characteristics, feeding, spawning, growth rate). — *Gadus maris-albi* Il'in and Pevzner, Sbom. posvyashch. Knipovichu, 1939:316 (biometry, comparison with the Murman and White Sea winter cods, growth, feeding).

I D 13-14, II D 18-19, III D 18-19, I A 17-22, II A 16-19, gill-rakers 19-22, vertebrae 52-55*. The head is large and broad, its length 25.0-28.3% of body length, the width of the interorbital space 18.4-24.1% of head length. Barbel short, equal or greater than the diameter of the eye. Caudal peduncle short and high, its length 9.2-11.6% of body length, depth 4.9-6.0% of body length. Body and unpaired fins are high. Appressed rays of first dorsal fin reach beyond the origin of the second dorsal fin from $\frac{1}{4}$ to $\frac{1}{2}$ its length. The horn-like processes at the forward end of the swim bladder are usually longer after the curve toward the mid-line and have a curve to the sides at the tip, in young ones short and with a curve to the mid-line only (Figure 27 j, k). Coloration of peritoneum from leadened black to blackish. In per cent of body length: anteanal distance 46.7-51.2, antedorsal distance 29.8-32.8, length of pectoral fin 13.8-14.8, length of pelvic fin 9.3-11.9, height of first dorsal fin 12.2-13.7, height of first anal fin 11.5-12.3. In per cent of head length: length of snout 34.8-39.0, horizontal diameter of eye 16.2-20.2, length of upper jaw 40.2-44.5, length of lower jaw 47.5-53.0. Coloration dark, sometimes almost black, often with ill-defined spots and stripes. Length most often 20-35 cm, not exceeding 60 cm (7 specimens).

This form does not have too great a distinction from *G. morhua morhua*, as can be seen from all stated above (see comparative notes); therefore there is absolutely no basis to consider it as a separate species (Ilin and Pevzner, 1. c.).

DISTRIBUTION. White Sea, where it keeps primarily in coastal zones and in the inlet of Kandalaksha Bay, also found in adjacent regions—at Solovetski Islands**. In spring and summer it predominates in Kandalaksha Bay, and *G. m. morhua n. hiemalis* is found only occasionally, while in regions closer to the entrance, the number of the latter increases. It does not undertake large migrations, remaining, as far as is known, in Kandalaksha Bay and in portions of the White Sea adjacent to it.

BIOLOGY. Spawning (according to observations of Evropeitseva on 1935-1936) occurs in the coastal zone and in the inlets (Pirju-, Umba-, Sosnovka-, Kolvitsa-, Pil'skaya inlets) of Kandalaksha Bay at shallow depths, from 1.5 to 12 meters, with soft (sandy-muddy) and hard (rocky) bottom. Spawning occurs beneath the ice at negative temperatures from -0.5 to -1.0° C; it commences in March and perhaps earlier, is most intensive at the end of March and the beginning of April; the end of spawning stretches to the end of May and even to June. They first begin to spawn at the age of 3 years, more infrequently at 2 years; the main mass of spawning cod consists of 3-, 4-, and 5-year old specimens. The oldest age of spawning cod is 9 years. In addition, spawning cod on the spawning grounds spawned from the 14th of May to the 15th of June, 1935, and the 15th to 18th of April, 1936; the escape of larvae from the eggs at that time was not observed, which bears witness to a more delayed hatching in this form as compared with the oceanic. The eggs in the adult ovaries are unequal in volume and dimensions; in addition to very small eggs, set on pedestals and seen only under the microscope, there are also large eggs which are transparent or semi-transparent, and non-transparent eggs of smaller diameter. Apparently, a partial

* According to the data of Evropeitseva, I D 12-16 (13.7), II D 16-22 (19.1), III D 15-21 (18.3), I A 18-25 (21.7), II A 15-21 (17.8), gill-rakers 18-24 (21.4), vertebrae 49-53 (51.2) (without the last vertebra which was counted by us). Similar values were obtained by Ilin and Pevzner.

** Number 9521 and 10090 of the collections of the Zoological Institute of the Academy of Sciences SSSR.

egg-laying occurs in this form of cod. The fecundity is not high; from 57.5 to 840 thousand, the mean about 60 thousand eggs*, which obviously reflects the smaller dimensions of the White Sea cod. Young measuring 9–15 cm are caught quite often in Pirju Inlet. At a young age (9–15 cm in length) it keeps to coastal strips and feeds primarily on *Harpacticus* sp., benthonic crustaceans, shrimp larvae, amphipods, brachyura and other organisms. Somewhat larger fish (15–25 cm) eat mainly *Nereis pelagica*, then *Caprella* sp., young fish, sticklebacks, decapods, schizopods. Large fish measuring 25–50 cm (4 and more years) feed basically on fish, mainly sticklebacks, then echinoderms (*Ophiopholis aculeata*), amphipods and decapods. In the spring, fish 15–25 cm eat mainly amphipods, then polychaeta and schizopods. In large fish the role of fish feeding (*Gasterosteus aculeatus*) is most important, then follows *Sagitta*, schizopods and amphipods.

In comparison with oceanic cod this one has a delayed growth with smaller annual gain in growth; but compared with *G. morhua morhua* n. hiemalis, it grows somewhat faster. From the investigations of Evropeitseva the growth rate and the growth increment in this form as derived from scale studies are as follows:

Age (years)	1	2	3	4	5	6	7	8
Growth (mm)	74	143	206	266	311	350	393	429
Gain in growth (mm)	74	69	64	57	47	41	37	31

COMMERCIAL VALUE very little. The catch is usually conducted primitively with rod and line.

*1e. *Gadus morhua ogac* Richardson—Greenland coastal cod (Tables XII, LIV)

Gadus barbatus (non L.) Fabricius, Fauna Groenl., 1780:146. — *Gadus ogac* Richardson, Fauna Bor.-Americ., III, 1836:246 (coast of Greenland). — *Gadus ovak* Reinhardt, kngl. Danske Vidensk. Selsk., Nat. Aft., VII, 1838:127. — *Gadus ogat* Krøyer, Voy. Scand. Lapponie, 1847, pl. 19. — *Gadus ogac* Dresel, Proc. U. S. Nat. Mus., VII, (1884), 1885:246 (shores of Greenland, Godhavn); Smitt, Scand. fish., I, 1893:497 (coast of Greenland, comparison with specimens from the Atlantic Ocean and Baltic Sea); Williamson, 26th Ann. Rept. Fish. Board Scotl., pt. 3, (1907), 1909:97 (skull); Vladikov, Contrib. Canad. biol. fisher., (n. s.), VIII, 1–8, 1933:28 (Hudson Strait, Hudson Bay, James Bay); Schultz a. Welander, Copeia, 1935 (3):131 (structure of swim bladder).

I D 14–15, II D 19–20, III D 19–20, I A 21–23, II A 18–21, gill-rakers 20–30, vertebrae 56**. Head elongate and broad, its length 25.0–25.2% of body length, width of interorbital space 22.6–23.1% of head length. The upper jaw is elongate, 44.0–46.6% of head length. Barbel shorter than the diameter of the eye. Caudal peduncle short and high, its length 11.5–11.7% of the body length, height 4.6–4.9% of body length. Body and median fins are high, rays of the first dorsal when appressed pass beyond the second dorsal. Horn-like processes of the anterior end of the swim bladder usually shortened and curved toward the center line with a slight bend at the tip (Figure 27 o). Peritoneum leadened black or blackish. Eyes large, the horizontal diameter of the eye 21.4–23.1% of head length. Snout and jaws elongate. In per cent of body length: anteanal distance 45.8–49.2, antedorsal

* According to B. S. Il'in and B. E. Pevzner, from 23.4 to 467.1 thousand eggs.

** According to Vladikov (8 specimens), I D 14–16, II D 16–21, III D 16–19, I A 19–21, II A 17–20.

distance 31.7–32.0, length of the pectoral fin 15.3–16.0, length of pelvic fin 11.5–11.9, height of first dorsal fin 13.6–14.4, height of first anal fin 10.5–12.1. In per cent of head length: snout length 37.0–39.4%, length of upper jaw 44.0–46.6, length of lower jaw 53.1–53.8. Coloration dark blackish from the top, below yellow with marble-like markings. The tips of the unpaired fins are black, pectoral and pelvic fins dark brown or black. Barbel black, lateral line dark. Length 35–45 cm and somewhat more but less than in the typical form (2 specimens).

DISTRIBUTION. At the western shores of Greenland to 72.5–73.5° north latitude, Hudson Bay, James Bay, Hudson Strait and perhaps southward along Labrador. At Cape Isabel (Boothea, Richardson, l.c.), if it is not *Boreogadus agilis*.

179 **BIOLOGY.** Stays along shore. Spawns at the shores of Greenland (Richardson, l.c.), occurring in February–March under the ice. In June the mass of young the size of sticklebacks keeps at the shores. Feeds on fish and amphipods.

COMMERCIAL VALUE negligible, but plays a material role in local catches.

COMPARATIVE NOTES. At the shores of Greenland *G. morhua* has a form (subspecies) ecologically and morphologically analogous to *G. morhua maris-albi*; both differ from the typical form in the same characteristics — deeper body and fins, deep and short caudal peduncle, broad forehead, etc. This form differs from *G. morhua maris-albi* only by the large eyes, somewhat longer jaws and snout, and structure of the horn-like processes of the swim bladder. This form cannot be a separate form as there is no material distinction between it and the typical form; the hiatus existing between them in some characters is due to the few specimens that have been examined in this case just as in the preceding researches (Dresel, l.c.; Vladikov, l.c.).

*1f. *Gadus morhua macrocephalus* Tilesius — Pacific Ocean Cod (Tables XIII, LV)

Gadus macrocephalus Tilesius, Mém. Acad. Sci. Petersb., II, 1810:350 (Bering Sea). — *Gadus morhua* Pallas, Zoogr. rosso-asiat. III, 1811:181 (ex parte: Pacific Ocean between Kamchatka and North America). — *Gadus pygmaeus* Pallas, l.c.:199 (coast of North America, Cape Ili). — *Gadus pseudomorrhua* Bleeker, Nederl. Tijdschr. Dierk., IV, 4-7, 1873:151 (description from figure). — *Gadus auratus* Cope, Proc. Amer. Philos. Soc., 1873:30 (Unalaska, golden-brown coloration). — *Gadus brandtii* Hilgendorf, Mith. Deutsch. Gs. Natur.-Völkerkunde Ostasiens, I, 1875, pt. 7:3. — *Gadus callarias* Eigenmann a. Eigenmann, Ann. N.Y. Acad. Sci., VI, 1892:358 (Alaska, Puget Sound); Smitt, Scand. fish., I, 1893:472 (ex parte: northern part of Pacific Ocean). — *Gadus callarias* var. *macrocephalus* Smitt, ryby vostochnykh morey, 1904:217 (Sea of Japan, western shores of Sakhalin, Genzan, Fusan). — *Pollachius brandtii* Jordan a. Metz, Mem. Carnegie Mus., VI, 1, 1913-14:64 (Fusan). — *Gadus callarias macrocephalus* Rendahl, Ark. Zoologi, XXII A, 10, 1931:60 (Avachin Bay at Petropavlovsk on Kamchatka). — *Gadus morhua macrocephalus* Berg, Rybypresnykh vod, II, 1933:746.

DISTRIBUTION, BIOLOGY. Steindachner u. Kner, Sitzungsber. Akad. Wiss. Wien, math.-naturw. Cl., LXI, 1, 1870:20 (DeCastris Bay); Jordan a. Gilbert, Proc. U.S. Nat. Mus., III, 1880:453 (Bay of Puget Sound); Alexander, Rept. U.S. Fish Comm., (1888), 1892:450 (Yaquina Bay); Jordan a. Starks, Proc. Calif. Acad. Sci., (2), V, 1895:849 (Cape Flattery); Grebetskii vestn. rybopr., XII, 6-7, 1897:323 (coast of Kamchatka, Commander Islands); Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898:2541 (Bering Sea south to Oregon); Jordan a. Gilbert, Fish. Bering Sea, 1899:486, 508 (coast of Alaska, Aleutians, Pribilof and Commander Islands); Jordan a. Starks, Proc. U.S. Nat. Mus., XXXI, 1906:526 (Port Arthur); Evermann a. Goldsborough, Fish. Alaska, 1907:348 (Bering Sea and coasts of Alaska and Kamchatka); Jordan, Tanaka

a. Snyder, Cat. fish. Japan, 1913:406 (Bering Sea, Kurile Islands, Tulen Island, Kamchatka, Hokkaido, Sakhalin); Jordan a. Metz, l.c., VI, 1, 1913-14:65 (Chinnampo, Port Arthur); Jordan a. Hubbs *ibid.*, X, 2, 1925:326 (Kushiro, Osaka ?); Cobb, Rept. U.S. Comm. Fisher., App. VII, 1926:389 (from Cape Flattery to St. Lawrence Island and around it, biology, commercial importance, description of the industry); Inaba, Rec. Oceanogr. Works Japan, III, 2, 1931:51 (vicinity of Asamuchi, Ishikawa, Mutsu Bay, spawning); Smitt, *vestn. dalnevost. fil.* an, 1-3, 1933:79 (eggs, larvae); Mori a. Uchida, Journ. Chosen Nat. Hist. Soc., 19, 1934:22 (Chin-kay, Genzan and western shores of Korea); Moiseev, Rybn. khoz. Kamchatka, 1934:94 (biology); Schultz a. Welander, Copeia, 1935 (3):131 (structure of the swim bladder); Polutov, Rybn. khoz. Kamchatka, 1935:1 (eastern coasts of Kamchatka, biometrics, biology, commercial importance); Vinogradov, *ibid.*, 1935:45 (Aleutian Bay, feeding); Andriashev, *Issled. morei SSSR*, 23, 1935:135 (Bering Sea and Commander and Aleutian Islands, coasts of Kamchatka and Koryakland, northward to the Bay of St. Lawrence); Schultz a. Delacy, Mid-Pac. Magaz., Jan.-March, 1936:65 (Bering Sea, south to Oregon, bibliography); Andriashev, *Issled. morei SSSR*, 25, 1937:257 (distribution, size); Polutov, *Vestnik dal'nevost. fil. AN*, 27, 1937:95 (migrations); Morsaev, *Izv. tikhookeansk. nauchno-issled. inst. morsk. rybn. khoz. i okeanogr.*, 14, 1938:37 (western Kamchatka); Maturbara, Bull. Jap. Soc. Sci. Fish. Tokyo, VI, 5, 1938:249; *ibid.*, VIII, 1, 1939 (age, size, weight); Morsaev, Rybn. khoz. 1940, 3:27 (western shores of Kamchatka, distribution, migration, fecundity); Polutov, rybn. khoz., 1946, 6:37 (Avachin Bay, measurements, maturity, feeding, migration catch); Krivobok, *Materialy, k poznaniyu treski yaponskogo morya*, APKH. TNIRO, No. 961 (Sea of Japan, biometry, biology, commercial value); Suvorov and Shchetinina, *Treska i ee promysel v vodakh Tikhogo okeana* (materials on the biology of the cod in the Sea of Okhotsk), apkh. TNIRO, No. 676 (Sea of Okhotsk, biometry, biology, utilization); Shurin, *Materialy po pitaniyu treski dal'nevostochnykh morei*, arkh. TINRO No. 908 (Japan, Okhotsk, and Bering Seas, feeding).

I D 12-16, II D 15-19, III D 17-20, I A 19-23, II A 18-21, gill-rakers 18-23, vertebrae 53*. Head large and broad, its length 26.7-28.6% of body length, interorbital space 20.3-25.3% of head length. Upper jaw elongate, 43.2-47.7% of head length. Barbel longer or slightly shorter than the horizontal diameter of the eye. Caudal peduncle low, 3.4-4.5% of body length. Appressed rays of first dorsal fin scarcely reach the origin of the second dorsal, seldom passing it. Horn-like processes at the anterior end of the swim bladder generally are short and bent only toward the mid-line with a slight outward curve at the tip, less frequently elongate and after the curve to the mid-line are directed forward with a curve at the tip (Figure 27 l, m, n). Peritoneum leaden-black or black. In per cent of body length: anteanal distance 46.8-54.3, antedorsal distance 32.7-36.2, length of pectoral fin 13.5-15.4, length of pelvic fin 9.3-12.9, height of first dorsal fin 8.0-13.0, height of first anal fin 8.9-11.4. In per cent of head length: length of snout 33.4-37.4, horizontal diameter of eye 15.8-20.6, length of lower jaw 50.2-55.6, length of barbel 14.4-20.7. Coloration similar to that of the Atlantic cod — golden yellow aberrations are also known. Size somewhat smaller than the Atlantic cod, average length of body in different years varies from 45.5 to 90 cm. Cod from the Sea of Japan are smaller than those from the Sea of Okhotsk. Average measurements of the body through the series of years for the first vary from 43 to 70 cm, for the second from 62 to 80 cm; measurements within the limits of the Sea of Japan diminish from north to south, the greatest known length is 1.2 meters, somewhat heavier in body weight than the Atlantic cod.

* Number of vertebrae based on one specimen. According to Suvorov and Shchetinina (l.c.) for cod (100-104 specimens) from the western shores of Kamchatka: I D 13-16 (14.4), II D 14-20 (17.18), III D 17-21 (18.5), I A 18-25 (20.9), II A 17-22 (18.7), gill-rakers 18-24 (20.1), vertebrae 50-55 (53.2 without the last vertebra which is counted by us). In cod from the Avachin Bay, vertebrae average 53.6, from the Sea of Japan 52.1 (Polutov).

DISTRIBUTION. Northern part of the Pacific Ocean and adjacent seas. Found occasionally along the Asiatic shores, beginning in the Yellow Sea (Darien, Chin-Kai, western Korea), at the western shores of the Sea of Japan, along the coast of Korea (Gensan, Pusan, in winter) and farther north, along the eastern shore of Hondo to the north of the Gulf of Toyama-Van and apparently southward (Sanin-do, Province of Tottori ?)*; at the northern and eastern shores of Hokkaido; around Sakhalin, along the Kurile Islands and all the coasts of the Okhotsk Sea around Kamchatka; in the Bering Sea, in the open sea opposite the Asiatic shores north of Providence Harbor, along the harbors of the Chuckchi Peninsula to St. Lawrence Bay, at the Commander and Pribilof Islands and along the Aleutian Islands; at the Alaskan shores northward to the latitude of St. Lawrence Island, around 181 St. Lawrence Island (Cobb, l. c.), along the Pacific coast south to the shores of Oregon (Yaquina Bay).

BIOLOGY. Pacific cod, regardless of its broad range, does not undertake such extensive migrations as the Atlantic cod. All of the known facts indicate that it migrates only short distances to and from the shores or from one bank to the other within the range of a limited region. A characteristic peculiarity appears to be the fact that in summer, as far as is known to us, it keeps separate and does not form such great aggregations as do the Atlantic cod. It is found in greatest numbers at a temperature of 3-4°C (Sea of Japan); at higher temperatures it is found in lesser numbers and at 9°C it is no longer caught; at temperatures below 3°C there are lesser quantities but occasionally it is caught at even negative temperatures (to -1.5°C) and under the ice (at St. Lawrence Island, Cobb, l. c.). In the Bering Sea the greatest concentration takes place at the meeting point of warm and cold currents at temperatures from 0.5 to -0.2°C. In the summer months the main mass keeps near the shore and at banks at depths of 50-100 meters; it is found in lesser numbers beyond the limits of the 100-meter isobath; in winter it retreats to depths of 150-200 meters, but generally the winter period has been studied very little. In summer, cod is distributed along the western shores of Kamchatka in two parallel rows at depths of 10-50 and 70-100 meters with separate concentrations of commercially exploitable size within each. At the end of September and the beginning of October the cod which heretofore have kept within the limits of the coastal strip begin to retreat to greater depths, mixing with cod coming from the second strip off the coast and proceeding into greater depths where they remain through the winter at depths of 150 to 250 meters. In January, in some places at depths of 180 to 230 meters, cod was caught in considerable numbers (from 6.1 to 8.5 metric centner in one hour's trawling). Spawning, just as in the Atlantic cod, apparently occurs almost everywhere, but in the absence of observations during the spawning period this is practically unstudied. As shown by Yrebnitskii and Cobb, spawning takes place in January-February; egg-laden cod are caught less often in March, and as presumed by Suvorov in April-May; and individual females with unshed eggs were caught in the latter half of May, but generally there are known cases of finding such females throughout the summer. At the western shores of Kamchatka fish close to spawning condition were found from

* As indicated by Okada and Matsubara (Keys to the Fishes and Fishlike Animals of Japan, 1938:442), it is also found farther south — at the shores of Guandong Province [Canton].

December to April, in March — already discharging eggs. At the shores of Japan spawning occurs from December to February. Isolated sporadic observations indicate spawning occurs at the Commander Islands, along the eastern coast of Kamchatka from Cape Lopatka to Karaginskii Island and without pinpointing exact localities — at the shores of North America. Fecundity varies from 1,809 to 5,722 eggs, mean average about 2.5–5 millions. In Kronotskii Bay the main mass of spawning cod consists of 5 and 6 year olds. The growth of Pacific cod in various places of its great range is unequal. From data quoted by Krivobok, Suvorov and Schetinina growth occurs as follows (in cm):

Age (in years)	4 +	5 +	6 +	7 +
Bering Sea:				
Navarinsk Region	54.3	61.4	71.3	77.9
Olyutorsk Region	45.7	54.2	64.1	72.2
Sea of Okhotsk	46.1	55.8	67.0	75.2
Japan Sea	40.6	50.4	60.8	68.6

182 From these data it is seen that cod from regions farther south have a more retarded growth rate than northern cod, which are also slightly larger in dimensions, thus indicating a preference for cold and their northern origin. Longevity of cod is 10 to 12 years; 8 year olds predominate in catches. The food is greatly varied: fish, crustaceans (large and small), worms, echinoderms, mollusks. The basic food of cod over 70 cm in length is fish and then crustaceans; cod less than 70 cm long feed mainly on crustaceans and to a lesser degree on fish (herring, Theragra, capelin, salmon, flounders, and sculpins). There are cases on record of finding even water birds (ducks) in the stomachs of Pacific cod. Generally Pacific cod is less fastidious in its feeding habits than the Atlantic cod.

COMMERCIAL VALUE. Much less than the Atlantic cod. Our commercial catch of cod began comparatively recently. The maximal catch was 4, 180.6 thousand units (168 thousand metric centner in 1930); in recent years the catch has declined. The cod industry along the shores of North America began earlier (in the '60's of the last century) and gradually increased, reaching in 1916 (Pacific Fisherman, 1936:225) 3,892 thousand units (about 160 thousand metric centner); in recent years the catch has declined somewhat, and in 1931–35 the annual catch was from 1,264 to 1,676 thousand units (about 56–67 thousand metric centner). The catches of Japan, according to inaccurate and contradictory sources of information, exceeded 1.5 million metric centner. The total catch of Pacific cod, judging by the approximate data quoted above, varies from 1.5 to 2 million metric centner. At the American shores cod is caught mainly in Alaska; at the shores of Canada there is no industry to be considered. The trawl fishery for cod in the Pacific Ocean did not succeed due to the inability to find the cod in great numbers, and the fishing is conducted from small vessels with hook and line, set lines and long lines.

COMPARATIVE NOTES. Arriving in the Pacific and not finding much competition from many other forms as in the Atlantic Ocean, this form of cod had the opportunity to spread broadly to the south and form within its entire range a whole group of local forms, varying in size (growth) and some morphological characters, while forms in the southern portions of the range were much more warmth loving than closely related subspecies — G.

morhua ogac and *G. morhua maris-albi*, as well as the northern forms of *G. morhua macrocephalus*. Cod of the Japan Sea, judging from the small number of specimens in the collections of the Zoological Institute of the Academy of Sciences, differs from the Bering Sea cod by its much shorter barbel and some other features. Suvorov and Schetinina indicate a series of differences between cod of the Sea of Okhotsk and cod of the Gulf of Peter the Great and the northern section of the Tartar Straits. Krivobok found differences between cod of the west coast of Sakhalin and the shores of the Maritime Provinces. Cod from the southern regions are considerably smaller than cod from the northern regions; they also have a slower growth rate and this, to a certain degree, indicates their origin in the more northerly regions where they have the best growth. The restriction of Pacific cod to a narrow range in habitat and its limited migrations offer broad possibilities for the formation of local forms.

Gadus brandti Hilgendorf = *Pollachius brandti* Jordan a. Metz appears to be undoubtedly *Gadus morhua macrocephalus* according to the number of rays, ratios between the lengths of the bases of the unpaired fins and other characteristics.

16. Genus **GADICULUS** Guichenot

Gadiculus Guichenot, Expl. Sci. Algérie, Zool., V, 1850:101 (Type: *Gadiculus argenteus* Guich.).

- 183 The dorsal and anal fins are separated by spaces. First anal fin begins slightly forward of the second dorsal. Caudal fin has a small notch. The barbel on the chin is not developed. The lower jaw projects forward and is bent upward at an angle. The teeth are very small, located on the premaxillary and dentary and on the head of the vomer; on the latter in larger specimens they are hardly noticeable. Lateral line continues without interruption to approximately the middle of the third dorsal fin*. On the head along the canals of the sensory system** and along the lower jaw there is a row of pores. The mucous cavity on the skull is closed in front. The prootic in front is almost without a notch. The eyes are large; scales are large, about 60 in the lateral line.

SKELETON. The skull is high (A), its greatest height contained about 2 1/2 times in the length of its base. The base of the skull is greatly curved under the forward end of the prootic; before and behind this curve the lower edge of the bones of the base of the skull are placed in a straight line. The upper profile of the skull is straight, descending quite sharply at its

* The lateral line on the body of *Gadiculus*, generally lacking scales, appears to be interrupted, in the form of individual pores. On one specimen examined which retained partial squamation, the lateral line extends to about the middle of the third dorsal fin, however, in the shape of an uninterrupted line. As to the structure of the lateral line on the caudal peduncle — it is difficult to judge inasmuch as it was absent on all examined specimens and only individual pores were visible.

** The sensory canals on the head of *Gadiculus* usually appear as broad, widely-opened mucous channels, owing to the fact that the overlying skin is often torn. Actually, as can be seen on less damaged specimens pores are distributed along these canals as in many cods. To count an exact number of them on the examined specimens happened to be impossible.

forward edge. The supraoccipital crest and frontal crest are quite high, straight, bifurcating in front, thus forming the rear walls of the mucous cavity. Its rear end is located over the rear end of the basioccipital and slightly behind. The mesethmoid has a large notch in front, gradually descending. The orbital space is high, oval in shape, its height contained less than twice in the length of its base. The notch in the prootic for the exit of the facial nerve is insignificant, the forward end of the alisphenoid, prootic and ascending process of the parasphenoid form a slightly curved almost vertical line. The foramen on the opisthotic for the exit of the glossopharyngeal nerve is quite well developed. The skull from above (B) is quite broad in the rear section, narrowing toward the interorbital space, slightly spreading again in front; its greatest width is contained almost twice in its length; in the interorbital space, as in the rear, the skull of *G. argenteus thori* is somewhat broader than *G. argenteus argenteus*. From each side of the skull there is a small notch in the lateral edge of the pterotic and a deep notch between the sphenotic and the frontal. The lateral ethmoids are stretched lengthwise, somewhat broadened in front, extending far forward from beneath the forward edge of the frontals. The forward edge of the mesethmoid lies at a considerable distance behind the forward edge of the vomer. The crests of the sensory canals are raised high above the pterotics and frontals, very short; the crests on the rear portion of the frontals have a deep notch in the center. The mucous cavity is deep, not separated in half by a transverse partition; each side of it has a wide and short canal, formed by a narrow bridging between the edges of the lateral and central crests of the frontals. There are no parietal crests over the foramina of the recurrent dorsal branches of the facial nerves. The shaft and head of the vomer from beneath the skull (C) is flat, with one row of small teeth on a slight elevation along the forward edge of the head; the very apex of the head of the vomer is toothless and without elevation. The parasphenoid is thin, somewhat compressed from the sides; its lower surface is behind the forward end of the prootic, with a small lengthwise curve. The auditory region of the skull when viewed from the rear (D) is inflated from the sides; the lateral walls of the cranial box are rounded. The supraoccipital crest extends quite high over the skull. The opercular process of the hyomandibular is broad, short, more than twice as broad as the lower process; the preopercular process for its entire length is fused with the lower process, short. The fork of the posttemporal forms a wide angle; both limbs are of almost equal length. Parapophyses are long, quite wide at their base, sharpened at the tips.

The description is given from one skeleton of *G. argenteus argenteus* and one of *G. argenteus thori*.

DISTRIBUTION. One species is found at depths in the Atlantic Ocean opposite the shores of Europe and North Africa and in the western part of the Mediterranean Sea, divided into two subspecies (Figure 29).

COMPARATIVE NOTES. The distinctions between the two forms were shown to be transgressive according to the data of J. Schmidt, who distinguished them by vertebral number. Transgressive distinctions between the two are seen in other characteristics, even from the small number of specimens examined; in *G. argenteus argenteus* the unpaired fins have a somewhat lower number of rays and a shorter base, a greater antedorsal and anteanal distance. From the width of the skull these two forms differ

as much as in the subspecies of *Lota lota*, *Molva dipterygia* and broad-headed and narrow-headed forms of *Gadus morhua*; the width of the skull in the interorbital space, expressed as percentage of head length, is much smaller in *G. argenteus argenteus* than in *G. argenteus thori*. Distribution of these subspecies closely coincides with the distribution of subspecies of *Molva dipterygia*.

Gadus blennoides Pallas (Spicil. zool., 1774:47, pl. V, f. 2) = *Lep togadus blennoides* Gill (Proc. Acad. Nat. Sci. Phila., 1863:248) neither in the description nor in the figure has anything in common with the genus *Gadiculus*. This species is closest to the genus *Odontogadus*. This species was found by no one after Pallas.

Diagnostic Key to the Subspecies

- 1 (2). Skull narrow, the interorbital width about 17.9% of the head length. Vertebrae 39-41. Mediterranean, Atlantic Ocean south from the Bay of Biscay 1a. *G. argenteus argenteus* Guich.
- 2 (1). Skull broader, interorbital space constituting 17.9-19.6% of head length. Vertebrae 41-43. Atlantic Ocean northward from the Bay of Biscay 1b. *G. argenteus thori* J. Schmidt

185 1a. *Gadiculus argenteus argenteus* Guichenot (Tables LVI LXXI)

Gadiculus argenteus Guichenot, Expl. sci. Algérie, Zool. V, 1850:102, pl. VI, f. 2a, b (opposite the coast of Algeria). — *Gadus argenteus* Belloti, Atti Soc. Ital. Scient. Natur., XXII, 1879:33 (at Naples); Vinciguerra, Ann. Mus. Civ. Stor. Nat. Genova, XIV, 1879:614 (at Genoa and Messina). — *Merlangus argenteus* Vaillant, Exp. sci. "Travailleur" and "Talisman," Poiss., 1888:302, pl. XXV, f. 7, 7a, pl. XXVI, f. 5 (Bay of Biscay, Atlantic coasts of Morocco and Sudan).

DISTRIBUTION, BIOLOGY. Giglioli, Espos. Intern. Pesca Berlino, Spez. Italiano, Appendice, 1880:96 (at Nice, Palermo); J. Schmidt, Mindeskr. Jap. Steenstr., 1914:1 (southward from the western shores of France, Gulf of Cadiz, the Atlantic shores of Morocco, Bay of Biscay).

I D 10, II D 14, III D 16, I A 16, II A 16, gill-rakers 26, vertebrae 39*. In per cent of body length: anteanal distance 45.7, antedorsal distance 30.4, base of first dorsal fin 11.7, base of second dorsal fin 15.2, base of third dorsal 14.4, base of first anal fin 19.0, base of second anal 16.6, depth of caudal peduncle 4.8, length of head 29.6. In per cent of head length: length of snout 30.3, diameter of eye 39.7, length of upper jaw 41.4, length of lower jaw 50.0, width of forehead 17.9. Coloration of large specimens dull silvery. Fishes of about 70 mm in length have dots of dark chromatophores on the top and toward the back; head from the sides and belly silvery. In fishes about 25 mm in length dark chromatophores are arranged in five short diffused transverse bands. The usual dimensions about 90 mm (one specimen).

DISTRIBUTION. Atlantic Ocean south from the Bay of Biscay to the shores of Sudan, Gulf of Cadiz, opposite the shores of Morocco, at the Straits of Gibraltar. In the western part of the Mediterranean at the shores

* According to J. Schmidt, vertebrae 39-41.

of Algeria, at Messina, Palermo, Naples, Genoa and Nice. The center of distribution of the subspecies, according to the research of the "Thor Expedition," is situated in the utmost western portion of the Mediterranean between the Straits of Gibraltar and the Island of Alboran.

BIOLOGY. Is not materially distinct from the biology of *G. argenteus thori*. Spawning takes place in the western portion of the Mediterranean Sea and on both sides of the Straits of Gibraltar. In the Mediterranean, adult females were found in December-January.

COMMERCIAL VALUE none.

1b. *Gadiculus argenteus thori* J. Schmidt (Tables XIV, LVII)

Gadus argenteus (non Guich.) Günther, Ann. Mag. Nat. Hist. (4), XIII, 1874:138 (west of the British Isles, 55°10' north latitude, 10°59' west longitude); Holt and Calderwood, Sci. Trans. Royal Dublin Soc., (II), V, 1895:434 (opposite the western shores of Ireland); Collett, Arch. Mathem. Naturvidensk., XXIII, 7, 1901:3 (fjords, located within and near Christiania Fjord, within Trondheim Fjord, bibliography); J. Schmidt, Medd. Komm. Havunders., Fisk., I, 4, 1905:66; *ibid.*, II, 2, 1906:16 (young numerous between Faroe and Shetland Islands, west of the British Isles, Skagerrak); Damas, Rapp. Procès-Verb., X, 3, 1909:208 (pelagic young northward of the Shetland Islands, and to the southeast of the Orkney Islands, in deep Norwegian fjords). — *Gadiculus thori* J. Schmidt, Mindeskr. Jap. Steenstr., 1914:1 (north from the western shores of France, to the coasts of Norway, Skagerrak).

FIGURE 29. Distribution of the genus *Gadiculus*

- 1— *G. argenteus argenteus*;
- 2— *G. argenteus thori*.

together with *G. argenteus argenteus*, west from the British Isles, between the Faroe and Shetland Islands, northern part of the North Sea, deep

I D 11–12, II D 14–15, III D 15–18, I A 15–19, II A 17–19, vertebrae 42*. In per cent of body length; anteanal distance 41–5–44.8, antedorsal distance 28.0–30.4, base of first dorsal fin 11.6–14.3, base of second dorsal fin 15.0–16.9, base of third dorsal 13.8–16.4, base of first anal fin 19.0–21.8, base of second anal 13.7–16.8, depth of caudal peduncle 4.2–5.2, its length 10.7–12.3, length of head 26.2–29.9. In per cent of head length: snout length 25.0–31.8, diameter of eye 33.9–40.8, length of upper jaw 37.0–42.6, length of lower jaw 45.5–50.7, width of forehead 17.9–19.6. Coloration of the largest fish dull silvery. In fishes about 75 cm in length [this must be a misprint and should probably read mm] the head from above and behind with dots of dark chromatophores, sides of the head, and belly, silvery. In fishes about 25 mm, dark chromatophores are placed in five diffused short transverse bands. Does not reach large size, 115–130, seldom to 150 mm and slightly larger.

DISTRIBUTION. Atlantic Ocean north from the Bay of Biscay in which it occurs, together with *G. argenteus argenteus*, west from the British Isles, between the Faroe and Shetland Islands, northern part of the North Sea, deep

* According to J. Schmidt, 41–43 vertebrae.

fjords of Skagerrak, opposite the shores of Norway to Trondheim Fjord and farther north to the Lofoten Islands*, perhaps entering the western portion of the Barents Sea. The center of distribution of this subspecies, judging from the results of the investigations of Danish expeditions, is located in the Atlantic Ocean opposite the northern part of the British Isles.

BIOLOGY. Deep-water fish, staying at depths of 400-600 meters and more. It is very seldom found at depths of less than 200 meters; however, not descending beyond the limits of the continental shelf. Like other cod, not remaining solitary, but apparently occurring in small schools. Reproduction also occurs at greater depths. Pelagic young were found almost throughout the entire range, even in Norwegian fjords, but were found in greater quantities over depths of 1,000 meters and more. Spawning occurs in the spring with temperatures of 6-9° C and salinity of 35.3 parts per thousand. Pelagic young were found in April-May-June.

COMMERCIAL VALUE none.

17. Genus **MICROGADUS** Gill

Microgadus Gill, Proc. Acad. Nat. Sci. Phila., 1865:69 (Type: *Gadus proximus* Girard); Jordan a. Evermann, Fish N. a. M. Amer., III, 1898:2538.

Dorsal and anal fins separated from each other by broad spaces. First anal fin begins at the end of the first or in front of the second dorsal fin. Caudal fin truncate of slightly notched. Barbel on chin small, shorter or slightly longer than the pupil of the eye. Lower jaw shorter than the upper. Palatine without teeth, teeth on only premaxillary, dentary and on the head of the vomer. Lateral line gradually descending beneath the second dorsal fin toward the middle of the body and continuing without interruption to the end of the third dorsal fin; interrupted on the caudal peduncle. Only pit organs on the head. Mucous cavity on the frontals not closed in front. A small notch on the prootic in front. Parapophyses of normal structure, without inflated tips and without any processes of the swim bladder entering into them.

SKELETON. The skull is not high (A), its height contained little more than three times in its base. The lower edges of the vomer, parasphenoid and basioccipital form a straight line (in *M. tomcod*) or a line with slight curves (in *M. proximus*); parasphenoid under the forward edge of the prootic. Due to the convexity of the prootic and opisthotic the rear portion of the base of the skull, especially in *M. tomcod*, is slightly rounded. The supraoccipital crest and frontal crest are not too high, terminating in the forward half of the skull, descending quite sharply to the mucous cavity, in the rear extending somewhat farther than the rear end of the basioccipital, its upper edge rounded. The forward end of the mesethmoid sharp, descending almost vertically, especially in *M. tomcod*, straight, with a hardly noticeable or slightly rounded notch, located at almost a right angle to the upper edge. Orbital space not high, its height contained more than 3 times in the length of its base. In the forward edge of the prootic a shallow notch through which exits the facial nerve. The edges of the notch above

* No. 27135 of the collection of the Zoological Institute of the Academy of Sciences. One specimen from Senjen Island.

along the prootic are straight, curved only at the alisphenoid, slightly bent below. On the opisthotic a prominent foramen for the glossopharyngeal nerve. Skull from above (B) is as wide in the rear as in the forward section, the distance between the rear ends of the pterotic is contained less than twice in the length of the base of the skull, slightly wider in *M. tomcod* than in *M. proximus*. The lateral edges of the pterotic are located at a slight angle to each other, the lateral edges of the frontals appear almost a straight continuation without notches in the interorbital space, on *M. proximus* converging somewhat in front, on *M. tomcod* parallel with each other. Lateral ethmoids somewhat more expanded laterally than longitudinally, extending farthest from beneath the forward edge of the frontals on the sides, extending front only in *M. tomcod*, in *M. proximus* concealed beneath the frontals. Forward end of the mesethmoid located almost over the forward end of the vomer. Crests over the sensory canals on the pterotic and frontals are broad, on the pterotic not too long, on *M. proximus* touching the crests on the frontals, on *M. tomcod* separated by a space. Mucous cavity broader than in *Eleginus*, connected by notches on the inner walls of the lateral crests of the frontals with the canals of the lateral crests open in front, edges of the lateral and central crests of the frontals not fused forward and not forming canals which are closed from above. Crests on the parietals in the form of small, hardly noticeable steps over the foramen of the recurrent dorsal branch of the facial nerve. Along the forward edge of the head of the vomer on the underside of the skull (C) 188 or in two rows (*M. proximus*). The underside of the parasphenoid is rounded in front, with a small longitudinal concavity behind; from the sides the inflated opisthotic and prootic extend slightly downward (in *M. proximus* and a little more in *M. tomcod*). The basioccipital and parasphenoid in *M. tomcod* are slightly broader than in *M. proximus*. The auditory region, when looking at the skull from behind (D), is inflated from the sides and slightly downward. The supraoccipital crest along its upper edge extends upward in *M. proximus* more than in *M. tomcod*. The distance between the outer edges of the epiotics is slightly wider in *M. tomcod* than in *M. proximus*. Width of the first two suborbitals is equal to (in *M. tomcod*) or slightly greater than (in *M. proximus*) their length. Parapophyses are quite long, yet somewhat shorter than in *Eleginus*, and without inflated tips. In the structure of the other bones, as in the structure of the skull, close to *Eleginus*.

Description based on two skeletons of *M. proximus* and one of *M. tomcod*.

DISTRIBUTION. Two species, one at the Atlantic, the other at the Pacific shores of North America (Figure 30).

Diagnostic Key to the Species

- 1 (2). Gill-rakers on the first arch 16-21. Length of the base of the second anal 12.0-12.5% of body length . . . 1. *M. tomcod* (Walbaum)
- 2 (1). Gill-rakers on the first arch 26-28. Length of the base of the second anal 16.1-16.7% of body length . . . 2. *M. proximus* (Girard)

1. *Microgadus tomcod* (Walbaum) (Tables LV, LVIII, LXXI)

Gadus tomcod Walbaum in: Artdi, Gen. pisc. 1792:133 (according to: tomcod Schöpf, Schrift, Ges. Naturf. Freunde, VIII, 1780:140). — *Gadus frost* Walbaum l. c.:134 (frost-cod, frost fish, Pennant, Arctic zool., Supplement, 1784:114). — *Gadus tomcodus* Mitchill*, Trans. Lit. Phil. Soc. N. Y., I, 1815:368 (New York). — *Gadus pruinosis* Mitchill, l. c.:368 (New York). — *Gadus tomcodus fuscus* Mitchill, l. c.:369 (New York). — *Gadus tomcodus luteus* Mitchill, l. c.:369 (New York). — *Gadus tomcodus mixtus* Mitchill, l. c.:369 (New York). — *Gadus polymorphus* Mitchill, l. c.:369 (New York). — *Morrhua tomcodus* Storer, Rept. fish. Mass., 1839:126 (Atlantic coast in the vicinity of Boston). — *Morrhua pruinosa* Storer, Mem. Amer. Acad. Art. a. Sci., (n.s.), VI, II, 1858:357, pl. XXVII, f. 5 (from New York to the State of Maine). — *Gadus tomcodus* Gill, Proc. Acad. Nat. Sci. Phila., (1863), 1864:235 (from New York to Newfoundland). — *Microgadus tomcod* Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898:2540, f. 890 (from Virginia to Labrador).

DISTRIBUTION, BIOLOGY. Jeffers, Contrib. Canad. biol. fisher., (n.s.), VII, 15-23, 1932:7 (from Belle-Isle Strait, in stream emptying into Pistolet Bay); Bigelow a. Welsh, Fish. gulf Maine, 1925:460 (biology).

FIGURE 30. Distribution of the genus *Microgadus*

1— *M. tomcod*; 2— *M. proximus*.

I D 12-13, II D 16-20, III D 21-23, I A 18-21, II A 18-20, gill-rakers 16-21, vertebrae 54**. Parapophyses directed to the sides almost horizontally, broadened and elongate, the length of the largest somewhat exceeding the length of two vertebrae (Figure 31, A). The lateral edges of the frontals are parallel. The hornlike processes of the anterior part of the swim bladder are but slightly curved towards the midline of the bladder. Second anal fin shortened, its base constituting 12.0-12.5 % of body length. The unpaired fins are somewhat lower than in *M. proximus*: the height of the first dorsal constitutes 11.0-12.3 %, the first anal 10.5-11.6 % of body length. In per cent

* Cited by Jordan and Evermann.

** According to Schults and Welander, I D 11-14 (12.9), II D 15-19 (16.7), III D 16-18 (17.0), I A 18-23 (20.7), II A 16-19 (17.5).

FIGURE 31. Structure of the parapophyses in the species of the genus *Microgadus*

A— *M. tomcod*; B— *M. proximus*. View of vertebral columns from below; above, over each of them is the tenth vertebra.

FIGURE 32. Structure of the horn-like processes at the anterior end of the swim bladder in the species of the genus *Microgadus*

A— *M. tomcod*; B— *M. proximus*.

of body length: anteanal distance 39.8–43.5, antedorsal distance 28.0–30.6, length of pectoral fin 13.6–14.3, length of pelvic fin 10.7–12.6, depth of caudal peduncle 4.7–5.1, its length 12.1–13.0, head length 20.3–21.6. In per cent of head length: snout length 31.6–33.8, lateral diameter of eye 15.6–19.5, length of upper jaw 37.4–40.7, length of lower jaw 45.3–48.0, width of forehead 26.0–28.4. Coloration of body from above brown, greenish, or yellowish-brown with black spots and dots which spill over the pectoral, pelvic and anal fins. Belly light without spots. Length to 38 cm (5 specimens).

DISTRIBUTION. Atlantic coast of North America from Virginia to Labrador. Very common at the shores of the state of Massachusetts.

BIOLOGY. Marine fish, remaining at the shore. Does not undertake large migrations, but remains locally; like navaga, enters brackish estuaries and rivers. During the winter it is found in great quantities under the ice in Belle-Isle Strait and in the mouths of rivers in the vicinity of Boston. Spawning occurs in shallow places, in salt or brackish waters. Spawning continues from November to February, its height in January. Fecundity from 25 to 44 thousand eggs. There are indications that the eggs adhere to submerged rocks, vegetation, etc.*. Development of the eggs occurs at a temperature of 6° C for 24 days, at 4.5° C for 30 days.

COMMERCIAL VALUE very small but highly prized for their taste quality. The catch is usually conducted with nets, hook and line, drop line and long line. The annual catch exceeds 800 metric centner (1919).

* Ryder's report [Rept. U. S. Fish. Comm., XIII, (1885), 1887:523, pl. XIII] that the eggs of *M. tomcod* have an oil droplet and were hatched in fresh water needs verification. According to kind information of T.S. Rass, larvae hatched from these eggs as described from the drawing of Ryder greatly differ from the larvae of cods and in no case could they be referred to them. Apparently the error occurred in identification by Ryder.

Gadus proximus Girard, Proc. Acad. Nat. Sci. Phila., 1854:141 (San Francisco). — *Morrhua californica* Ayres, Proc. Calif. Acad. Nat. Sci., (1854-1857), 1857:8 (San Francisco). — *Morrhua proxima*, Girard, U. S. Pac. R. R. Surv., X, Fishes, 1858:142. — *Gadus californicus* Günther, Cat. fish., IV, 1862:332 (San Francisco). — *Microgadus proximus* Gill, Proc. Acad. Nat. Sci. Phila., 1865:69 (description of the skull); Evermann a. Goldsborough, Fish Alaska, 1907:348, f. 129 (from Seattle to Unalaska). — *Eleginus navaga* (non Pall.) Evermann a. Goldsborough, l. c.:347 (ex parte: stations 4218, 4219, 4220 and Port Townsend, at the Admiralty Islands in Alaska).

DISTRIBUTION, BIOLOGY. Jordan a. Gilbert, Proc. U. S. Nat. Mus., IV, (1881), 1882:65 (from Monterey to Puget Sound, very numerous north of San Francisco); Jordan and Jouy, *ibid.*:3 (San Francisco, Puget Sound); Jordan and Starks, Proc. Calif. Acad. Nat. Sci., (2), V, 1895:849 (Puget Sound); Jordan and Evermann, Fish. N. a. M. Amer., III, 1898:2539, f. 88 (from Monterey Bay to Alaska); Schultz a. Welander, Copeia, 1935, 3:135 (from Port Townsend, from the Admiralty Islands in Alaska); Schulta and DaLacy, Mid.-Pacific Mag., Jan.-March, 1936:63 (from Alaska to Monterey Bay, Bibliography).

I D 12-15, II D 16-18, III D 21-22, I A 23-25, II A 22-23, gill-rakers 26-28*, vertebrae 58. Parapophyses are directed ventrally, narrow and not very long; the longest does not exceed the length of two vertebrae (Figure 31, B). The lateral edges of the frontals are placed at a slight angle to each other. The horns at the forward end of the swim bladder are directed at a straight angle toward the mid-line (Figure 32, B). The second anal fin is elongate, its base constituting 16.1-16.7 % of body length. The height of the first dorsal fin is 12.9-13.2 % of body length, height of first anal 13.0-14.1 %. In per cent of body length: anteanal distance 39.1-39.9, antedorsal distance 28.2-31.9, length of pectoral fin 13.9-14.3, length of pelvic fin 9.2-9.9, depth of caudal peduncle 4.5-4.9, its length 12.3-12.8, head length 22.4-22.6. In per cent of head length: snout length 27.8-34.8, horizontal diameter of eye 16.2-22.6, length of upper jaw 38.7-41.0, length of lower jaw 48.0-48.6, width of forehead 23.2-28.4. Coloration of upper half of body grayish brown, belly silvery white. Fins are of the same color as the body; dorsal caudal and second anal fins with small black dots. Usual size about 20 cm, but reaches 30 cm and more (2 specimens).

DISTRIBUTION. Pacific coast of North America from Alaska (Unalaska**, if the identification of Evermann and Goldsborough is correct) to Monterey Bay. Very common along the coast of Washington (Puget Sound), Oregon, near San Francisco (Monterey Bay).

BIOLOGY. Marine fish. It apparently does not undertake large migrations. As in *M. tomcod*, it is found in greatly freshened waters †.

COMMERCIAL VALUE. In places it is caught in considerable quantities and very highly prized for its appealing taste.

* According to the data of Schultz and Welander, I D 11-14 (12.2), II D 17-20 (18.5), III D 18-20 (18.8), I A 20-25 (22.5), II A 18-21 (19.7).

** According to Tanner [Rept. U. S. Comm. Fish a. Fisher., XVIII, (1892), 1894:5], if his identification is correct, it is found at the Pribilof Islands and in Bering Sea.

† According to information kindly furnished by L. M. Shapovalov, it is caught together with fresh-water and brackish water fishes in San Francisco Bay during winter and spring, when the water here is greatly freshened.

Eleginus G. Fischer, Mém. Soc. Nat. Moscow, IV, 1812-1813:252, 257 (Type: *Gadus navaga* Pallas). — *Tilesia* Swainson, Nat. Hist. Classif. monocard. anim., II, 1839:300 (Type *G. gracilis* Tilesius, nomen praeoccupatum). — *Pleurogadus* Bean, in: Jordan, Cat. fish. N. Amer., 1885, (1887):130 (Type: *G. gracilis* Tilesius).

The dorsal and anal fins are separated by broad spaces. The first anal fin begins slightly before or directly beneath the origin of the second dorsal fin. The caudal fin is truncate or has a slightly noticeable notch. The barbel on the chin is developed very weakly and is equal to the pupil in length. Lower jaw slightly shorter than the upper. Teeth present on only the premaxillary, dentary and head of the vomer, palatines without teeth. The lateral line continues without interruption only to the beginning of the second dorsal fin, descending sharply beyond toward the mid-line of the body and continuing backward interrupted. Only pit organs on the head. Mucous cavity on the frontals not closed in front. A slight notch on the prootic in front. The parapophyses are long, with inflated tips into which enter the processes of the swim bladder.

SKELTON. The skull is not high (A), the height contained more than 3 1/2 times in the length of the base. Parasphenoid with a slight curve beneath the forward end of the prootic; before and behind this curve the bones at the base of the skull are in a straight line. A slight rounding of the rear portion of the base of the skull is caused by a downward projection of the opisthotic and prootic. The upper profile of the skull is almost straight, gradually descending forward. The crest on the supraoccipital and frontals is not high, terminating in front in the approximate middle of the skull, in the back extending to almost the rear end of the basioccipital, its upper surface straight with a slight curve in front anterior to the mucous cavity. The anterior end of the mesethmoid descends abruptly, almost straight down, with a hardly noticeable notch on top, placed at almost right angles to its upper edge. The orbital space is not high; its base exceeds its height more than 3 times. The facial nerve exits from the skull by a notch, the lower edge of which is straight and the upper with a small shelf at the junction of the prootic and alisphenoid. The glossopharyngeal foramen on the opisthotic is always well developed. The skull, when viewed from above (B), is quite broad in the rear, gradually narrowing toward the front, its greatest width contained a little less than 2 times in the length of its base. The lateral edges of the skull present almost straight lines which converge somewhat in front. Frontals without noticeable notches in the interorbital space. The lateral ethmoids project slightly to the sides and in front from under the frontals and are lengthened more longitudinally than latitudinally. The forward edge of the vomer projects slightly from beneath the anterior end of the mesethmoid. The crests above the lateral line canals on the pterotic and frontals touch each other; they are broad, and on the pterotic they are not so long. Mucous cavity with small notches in the lateral crests of the frontals; the edges of the lateral and central crests of the frontals usually do not fuse and do not close it [the cavity] from the front, and do not form a bone formation over the sensory canals in front of it. If at times the edges of the middle and lateral crests do coalesce, this fusion is very narrow and most often on just one side. On the parietals there are no crests

192 or weakly developed crests above the foramine of the recurrent dorsal branches of the facial nerves. A crest and two rows of small teeth run along the forward edge of the head of the vomer on the skull when viewed from below (C). The lower surface of the parasphenoid is rounded in front, and farther back it is quite concave with the edges of the prootic and opisthotic projecting on either side. The basioccipital and parasphenoid are narrow. When the skull is viewed from behind (D), the sides of the cranial box are convex, bulging to the sides and extending slightly downward. The upper surfaces of the supraoccipital and epiotic present a straight line, above which rises the supraoccipital crest, but not high. The first two suborbital bones are longer than they are wide. The opercular process of the hyomandibular is long and narrow, considerably longer than any other; the preopercular process does not reach the end of the lower process; their edges and angles are parallel. The lower edge of the opercle has a deep notch and sharply elongate ends. Both forks of the posttemporal are long, the lower somewhat shorter than the upper. The postcleithrum is curved at its upper end, broadened above and below the curve. The parapophyses are long, all with inflated tips with the exception of the shortened first three to five (in *E. gracilis*) or one (in *E. navaga*); the first 5 to 6 haemal arches have similar inflations on the sides. The first of them are broad.

FIGURE 33. Distribution of the genus *Eleginus*

1— *E. navaga*; 2— *E. gracilis*.

Description given from 40 skeletons of *E. navaga* and from 16 *E. gracilis*.

DISTRIBUTION. Two species — one at the northern shores of Europe and western Siberia, the other from the far eastern seas (Figure 33).

COMPARATIVE NOTES. In the basic characteristic distinction between the general *Microgadus* and *Eleginus* — the structure of the vertebral

column — we observe great similarity between both Atlantic (*M. tomcod* and *E. navaga*) and Pacific species (*M. proximus* and *E. gracilis*). In the first the parapophyses are longer and project less ventrally (Figures 31, 34) than in the latter. Externally, with the exception of the structure of the lateral line, the genera are almost indistinguishable.

Diagnostic Key to the Species

- 1 (2). Inflations at the tips of the parapophyses begin with the sixth vertebra, only the first pair of parapophyses are shortened and without inflated tips. Gill-rakers 24–28 1. *E. navaga* (Pall.)
- 193 2 (1). Inflations at the tips of the parapophyses commence on the ninth vertebra, the first four pairs of parapophyses are shortened and without inflated tips. Gill-rakers 20–23 . . . 2. *E. gracilis* (Til.)

*1. *Eleginus navaga* (Pallas) — *Navaga* (Tables XV, LX, LXXI)

Piscis e gadorum genere, russis navaga Koelreuter, Nov. Comment. Acad. Petrop., XIV, (1769), 1770:484, tabl. XII. — *Gadus navaga* Pallas, Zoogr. rosso-asiat., III, 1811:196 (Arctic Ocean, east to the Ob). — *Eleginus navaga* G. Fischer, Mém. Soc. Nat. Moscow, IV, 1812–1813:252, 257; Lanshin, Russk. zool. zhurn., VIII, 4, 1928:17 (Mezen' Bay, biometry); Kuz'min-Karavaev, Tr. inst. rybn. khoz., V, 4, 1930:57 (White Sea, systematic characteristics, age, growth); Berg, Ryby presnykh vod, II, 1933:741. — *Eleginus navaga navaga* Esipov, Tr. nauchno-issled. inst. polyarn. zemled., zhivotnov. i promysl. khoz., ser. promysl. khoz., 15, 1941:44 (White Sea and its bays). — *Eleginus navaga karaensis* Esipov, ibid.:145 (Kara Sea; Brydaratz Bay, Ob Bay, Malygin Strait).

DISTRIBUTION, BIOLOGY. Smitt, Scand. fish., I, 1893:481, f. 119 (White Sea); Knipowitsch, Ezhegodn. Zool. muz. Akad. Nauk, II, 1897:150 (shores of the eastern part of the Murman, White Seas, Kanin Peninsula, Kolguev Island, Yugorsk Shar, Novaya Zemlya); Varpakahovskii, Ryby bass. Obi, 1902:162, f. 11 (northern part of Ob Inlet); Mikhailovskii, Ezhegodn. Zool. muz. Akad. Nauk, VIII, 1903:57 (mouths of rivers of Kolguev Island); Smitt, Ryby vostochnikh morey, 1904:221 (Suma Settlement, Solovet Island), Indiga River, Jugorsky Shar); Deryugin, Fauna Kol'skogozaliva, 1916:589 (Kola Bay, occasionally); Soldatov, Tr. plov. morsk. nauchn. inst., III, 1923:63 (mouth of the White Sea, Barents Sea, Baidaratsk Bay and Kara Sea); Lanshin, Russk. zool. zhurn., IX, 3, 1929:103 (growth, fecundity); Kuz'min-Karavaev, Tr. Inst. rybn. khoz., V, 4, 1930:83 (Ivanovskaya Bay on the Murman, young); Probatov, Mat. po nauchno-prom. obsled. Karskoi guby i r. Kary, 1934:78 (Kara Inlet, lower waters of Kara and Sibireha Rivers); Khaldinov, Zool. zhurn., XV, 2, 1936:321 (Onega Bay, biology, places and time of spawning, artificial insemination, literature on spawning); Probatov, Uchen. zap. Permsk. univ., II, 3, 1936:155 (biology); Sakhno, Za rybn. industr. Severa, 1936, 1:21, ibid., 2:40 (biology, commercial importance); Agapov and Toporkov. Probl. Arktiki, 2, 1937:107 (on the coast of Novaya Zemlya); Burmakin, Tr. nauchno-issled. inst. polyarn. zemled., zhivotnov. i promysl. khoz., ser. promysl. khoz., 10, 1940:44 (northern part of Ob Inlet southward to mouths of Tembei River, bibliography); Manteifel, Navaga Belogo morya i ee promysel, izd. Polyarn. nauchno-issled. inst. morsk. rybn. khoz. i okeanogr., 1945 (biology).

- I D 12–16, II D 14–21, III D 20–22, I A 19–23, II A 19–26, gill-rakers 24–28, vertebrae 57–60*. There is only one short pair of parapophyses without inflated tips, on the fifth vertebra; all other pairs of parapophyses
- 194 are greatly elongated, with large inflated tips (Figure 34, A). There are large inflations on either side of the first four or five haemal arches. Processes of the swim bladder which enter into the inflated tips of the parapophyses are long; the horn-like processes at the forward end of the swim

* The number of fin rays, gill-rakers and vertebrae in *navaga* from Mezen Bay (according to data of Lanshin) and from Dvina and Onega Bays and from the summer shores (according to data of Kuzmin-Karavaev) are as follows [see Table on p. 203.]

bladder are greatly curved (Figure 35, A). The antedorsal distance is 25.8–28.7 % of body length, depth of caudal peduncle 3.4–4.1 %, length of head 19.9–21.8 % of its length. In per cent of body length: anteanal distance 42.0–46.2, length of pectoral fin 12.1–14.6, length of pelvic fin 7.1–9.2, height of body 14.3–17.3, length of caudal peduncle 11.9–13.9. In per cent of head length: length of snout 32.6–37.1, horizontal diameter of eye 12.6–17.4, length of upper jaw 35.0–39.1, length of lower jaw 42.8–46.7, width of forehead 20.3–26.0. Coloration of the back and sides gray, with brownish or dark spots on the back; belly silvery-white. Usual sizes in the White Sea 15–23 cm, but reaching 35 cm and more; In Mezen Bay at the western shores of Kanin Peninsula — to 40–42 cm. Not always identical over the entire stretch of the region, for example: navaga of Dvina Bay are smaller than navaga from other White Sea bays. Apparently, in the other bays local races or schools are formed.

DISTRIBUTION. All along the northern coasts of Europe and western Siberia from Kola Bay in the west to Ob Inlet in the east, White Sea, around Kanin Peninsula and Kolguev Island, Cheshskaya Inlet, at the western shores of Novaya Zemlya* north to Belus'ya, at Baidaratskaya, Kara Inlet and in the very northern portion of Ob Inlet. Found in greatest quantities in the Bays of the White Sea and in Cheshskaya Inlet. It is rare in Kola Bay and in the northern part of the Ob Inlet.

	Mezen Bay			Dvina Bay		
	Limits	Average	Number of specimens	Limits	Average	Number of specimens
I D	12–14	12.9	170	11–16	13.1	104
II D	16–21	18.2	169	12–24	18.7	105
III D	18–21	18.8	166	18–26	21.2	101
I A	17–23	19.8	169	18–28	23.0	104
II A	17–23	19.3	167	19–26	22.3	102
Vertebrae	56–60	57.5	153	56–59	57.7	105
Gill-rakers	23–28	25.6	165	-	-	-
Pyloric caeca	31–55	39.7	138	-	-	-
	Onega Bay			Summer Shores		
	Limits	Average	Number of specimens	Limits	Average	Number of specimens
I D	11–17	13.3	157	11–16	13.5	158
II D	14–23	18.4	158	15–23	18.4	158
III D	18–24	21.2	158	20–26	21.9	157
I A	19–26	22.2	157	20–27	22.9	157
II A	18–26	22.4	157	20–25	22.9	158
Vertebrae	55–60	57.8	159	55–60	57.8	157
Gill-rakers	-	-	-	-	-	-
Pyloric caeca	-	-	-	-	-	-

The vertebrae were counted with the exception of the last, to which the rays are directly connected.

* According to information kindly furnished by I.P. Savvatimskii, during his work on the eastern shores of the southern island in August–September 1935 they did not find any navaga.

FIGURE 34. Structure of the parapophyses in the species of the genus *Eleginus*

A— *E. navaga*; B— *E. gracilis*. View of the vertebral columns from beneath; above, over each of them is a view of the 10th vertebra.

FIGURE 35. Structure of the horn-like processes at the anterior end of the swim bladder in the species of the genus *Eleginus*

A— *E. navaga*; B— *E. gracilis*.

BIOLOGY. A cold-water fish, although not to such a great extent as is *Boreogadus saida*. Apparently it does not undertake extensive migrations. Generally found at shallow depths along shores with soft muddy bottom. Not found in the open sea and at depths. In winter it is found in great quantities under the ice. It is often caught in greatly freshened and at times completely fresh water, entering the mouths and tidal zones of rivers and traveling upstream. In winter before spawning it gathers in great numbers close to shore, at that time entering the mouths and upper parts of rivers into sections which are still under tidal influence. For spawning navaga goes away from the shores and mouths of rivers to greater depths (8–10 meters) with hard sandy or rocky bottom. Spawning sites of the navaga are distributed in channels between islands or in depressions between the shore and shallow banks where strong tidal currents play a great role. In the White Sea navaga spawns in the bays of Onega (near Shuy Island, Myag Island, at Glubokii Cape) and in the Dvina (Unskaya Inlet, Dvina Delta, Vagri Island, in the area of Dry Sea)* Besides these spawning places, they are known at the shores of Kanin Peninsula, Murman (Ivanovskaya Inlet, 60° 22' north latitude, 38° 40' east longitude) and undoubtedly during winter gatherings of navaga are observed under the ice everywhere. Spawning occurs from the beginning or middle, and sometimes even from the end of January, and terminates mainly about 15 days later, although individual adults are found even later. Fecundity of the navaga is from 6 to 90 thousand eggs. Navaga's eggs are not sticky** and do not appear to be pelagic, but sink to the bottom. Development of the eggs

* [Sukhoe more in Russian.]

** Indications of their adhesiveness (Vebel, Za rybn. indust. Severa, 1935, 5:24) is disputed (Sahno, l.c.).

occurs only in salt water; in fresh water they perish. Indications of the spawning of navaga in rivers (Probatov, l. c.) are erroneous. The emergence of larvae from the eggs at an average temperature of $+2^{\circ}\text{C}$ was observed on the 39th day. Under normal conditions with temperatures of about -1°C , the incubation period apparently continues about 4 months. Navaga reaches sexual maturity in the third or fourth year. The main mass of spawning navaga consists of two to four-year-olds whose dimensions, according to data of Kuz'min-Karavaev, at this time (January) are as follows (in cm):

Age (years)	2	3	4
Oneza Bay (Rebald Island)	18.5	22.5	-
Unskaya Inlet (summer shores)	18.3	21.1	31.4

Navaga from Northern Dvina estuary have slower growth and the smallest size the fifth year reaching 16–17 cm, as compared with 20–25 cm in other regions. The greatest size and greatest age is attained by navaga of Mezen Bay and the west coast of Kanin Peninsula where the main mass caught is 6–7 years old and 16–28 cm long. Basic foods are amphipods, Mesodonta and worms; feeds partially on small fish (stickleback, capelin, sand lance, saika, small cod, flounder, navaga) which play the greatest role in the sustenance of larger navaga. In summer, with the rise of water temperature to 10°C and higher, they eat very poorly.

COMMERCIAL VALUE extensive. Main fishing grounds are Dvina, Oneza and Mezen Bays of the White Sea and Cheshskaya Inlet. The industrial catch takes place at the mass gathering for spawning beneath the ice near shore. Fishing in commercial quantities begins in November, the greatest catches coinciding with the height of spawning — in January, after which hungry post-spawning navaga are caught and the catch figure drops rapidly. Unfortunately, we do not have full and exact statistical data on the navaga catch. Fishing takes place mainly along the shores of Karelo-Finnish SSR in Oneza, Dvina and Mezen Bays, at Cheshskaya Inlet and in the Pechora region.

196 The total catch from 1898 to 1944 varied from 1.6 (1920) to 24.0 (1930) thousand metric centner (Manteyfel, l. c.). According to some information (Skvortsov, Biol. rybn. khoz., 1926, 1:16) it had reached in the past years over 40 thousand metric centners. The lowest catches were 1920–1923, but in succeeding years they grew and reached their former level. The increase in catch occurred mainly due to the development of the industry in the Cheshskaya Inlet and Pechora region. In past years the greatest quantity of navaga was caught in Mezen Bay and along the western coast of Kanin Peninsula, but in recent years its numbers have greatly diminished. The main methods of catch were with ryuzh* and partially with hook and line.

COMPARATIVE NOTES. *E. navaga karaensis*, described by V. K. Esipov from specimens from Ob Inlet and separated by him into a subspecies based on a comparison with specimens from the White Sea examined and studied by G. A. Kuz'min-Karavaev, differs from the latter by having fewer rays in the second and third dorsal and both anal fins. In all other compared characteristics (number of vertebrae and rays in the first dorsal fin) there are no material differences. Judging by the lesser number of rays in the indicated fins in specimens examined by V. K. Esipov, it may be presumed that their distinction from the White Sea specimens is

* [This is a local name for a type of net used in Northwestern Russia.]

conditioned by the fact that the fleshy covers at the ends were not cut when counting the rays and the rays concealed within them were left uncounted*. As was indicated above, (page 64), without cutting the skin covers, the correct number of rays can be established only in the first dorsal fin. According to the number of rays in the first dorsal fin in the specimens of V. K. Esipov, there is no difference from the specimens of G. A. Kuz'min-Karavaev. All subspecies of gadoids (for example *Lota lota*, *Molva dipterygia*, *Trisopterus minutus*, *Gadus morhua* and others) differ greatly craniologically, particularly in the width of the skull. V. K. Esipov did not indicate such differences. Judging from all information furnished, *navaga* apparently do not possess these. Undoubtedly *navaga*, as was indicated above, falls into a group of taxonomically smaller forms, below the subspecies. To segregate these forms we must observe uniformity in methods of counting and measuring as used by one person in order to utilize for comparison data obtained by other workers.

*2. *Eleginus gracilis* (Tilesius) — Far-eastern *navaga*, *vakhnya* (Tables XV, LXI, LXXII)

- 197 *Gadus gracilis* Tilesius, Mem. Acad. Sci. Petersb., II, 1810:354, tabl. XVIII (Kamchatka). — *Gadus wachna* Pallas, Zoogr. rosso-asiat., III, 1811:182, 190 (coasts of Kamchatka, Avachin Inlet, Petropavlovsk, mouth of the Bol'shaya River). — *Tilesia gracilis* Bean, Proc. U.S. Nat. Mus., IV (1881), 1882:245 (Cook Bay, Kodiak Island, Norton Sound, Port Clarence). — *Pleurogadus gracilis* Bean in: Jordan, Cat. fish N. Amer., 1885:130. — *Gadus gracilis* Grebnitskii, Vestn. Ryboprom., XII, 6-7, 1897:324 (Avachin Inlet, Petropavlovsk, Bering Island, in freshwater lake on Bering Island). — *Eleginus navaga* Evermann a. Goldsborough, Fish. Alaska, 1907:347, f. 128 (ex parte: Letnik Bay in Alaska and, possibly, Petropavlovsk and Tar'inskaya Inlet on Kamchatka). — *Eleginus navaga* var. *gracilis* Smitt, Ryby vostochn. morei, 1904:221 (mouth of the Anadyr River, coasts of Kamchatka, Sea of Okhotsk, Sakhalin, Hokkaido, at Vladivostok, Chemulpo). — *Eleginus gracilis* Chranilov, Morph. Jahrb., 64, 1930:343 (anatomy). — *Gadus navaga* f. *vegae* Rendahl, Ark. Zoologi, XXIIA, 10, 1931:9 (Chukchi Peninsula: Pitelkai and Naitschkai). — *Gadus navaga* typ. Rendahl, l.c.:9 (Port Clarence and Bering Strait). — *Eleginus navaga gracilis* Berg, Ryby presn. vod., II, 1933:742. — *Eleginus gracilis* Schultz a. Welander, Copeia, 1935, 3:134 (structure of the swim bladder, distinction from *Microgadus proximus*).
DISTRIBUTION, BIOLOGY. Jordan and Metz, Mem. Carnegie Mus., VI, 1, 1913-14:64 (Chinnampo); Pravdin, Izv. Tikhookeansk. st. I, 1928:189 (western shores of Kamchatka, Bol'shaya River 10 km from the mouth); Lindberg and Dulkeit, Izv. Tikhookeansk. st., III, 1, 1929:63 (Shantar Islands, Bol'shoe Lake on the island Bolshoi Shantar); Soldatov and Lindberg, Obzor ryb dal'nevost. morei, 1930:514, fig. 75 (Japan, Okhotsk and Bering Seas, Anadyr Gulf) Milovidova-Dubrovskaya, Dal'nevost. navaga izd. tikhookeansk. inst. rybn. khoz., 1933: 2-9 (biology); Mori and Uchida, Journ. Chosen Nat. Hist. Soc., 19, 1934:22 (Gensan Tumen-Ula) Sato, Fac. Sci. Hokkaido Univ., (VI), (Zool.), VI, 1, 1937:32 (Akkeshi-Bay); Andriashev, Issled. morei SSSR, 25, 1937:350 (distribution); Milovidova-Dubrovskaya, Vestn. Dal'nevost. fil. AN, 28, (1), 1938:140 (young their mode of life and feeding); Agapov, Tr. nauchno-issled. inst. polyarn. zemled., zhivotnov. i promysl. khoz., ser. promysl. khoz., 16, 1941:100 (Anadyr Bay, egg studies).

I D 11-15, II D 15-23, III D 18-21, I A 20-24, II A 19-22, gill-rakers 20-23, vertebrae 60-64**. The skull is almost indistinguishable from the

* Whether this necessary precaution was observed, V. K. Esipov does not indicate. G. A. Kuzmin-Karavaev did remove this skin cover.

** According to data of Milovidova-Dubrovskaya, from 100 specimens from the Bay of Peter the Great, I D (11) 12-15 (16), II D (15) 16-23, III D 17-22 (23), I A 20-26 (27), II A (18) 19-23, P 18-20 (21), gill-rakers 14-24, vertebrae 57-64 (including the last). According to Schultz and Welander, I D 12-16 (13.7), II D 17-20 (18.4).

skull of the preceding species, being of slightly different shape and narrower in its rear portion. The first four pairs of shortened parapophyses are without inflated tips; all other parapophyses are shorter with considerably less developed inflations at their tips than in the preceding species (Figure 34, B). The inflations on the first haemal arches are small. The processes of the swim bladder opposite the inflated tips of the parapophyses are insignificant; the processes at the forward edge of the swim bladder are just slightly curved (Figure 35, B). Antedorsal distance 27.1–30.8% of body length, depth of caudal peduncle 4.3–4.9%, head length 21.4–22.6% of body length. In per cent of body length: anteanal distance 41.0–45.6, length of pectoral fin 12.0–15.1, length of pelvic fin 7.3–10.0, height of body 15.5–18.9, length of caudal peduncle 11.6–13.5. In per cent of head length: length of snout 31.2–35.9, horizontal diameter of eye 15.2–19.9, length of upper jaw 33.7–39.0, length of lower jaw 42.6–46.3, width of forehead 21.9–27.0. Coloration a dirty greenish-gray, dorsum brownish- or olive-brown with marbled outlines formed by dark spots, belly silvery-white, fins yellowish or reddish with blackish-gray dots. Much larger than the navaga, at Kamchatka usual measurement run to 35 cm, reaching 40 and even 50 cm; at Shantar Islands smaller, not exceeding 30 cm. Like navaga, apparently divides into a group of races or schools.

198 DISTRIBUTION. Northern portion of the Pacific. At the northern shores of eastern Siberia it is known from Pitlyakei (on Chukchi Peninsula north-west of Bering Strait); at the shores of North America definitely known from Port Clarence (on Bering Strait) and Letnik Bay. At present it is indicated from Norton Sound, Kodiak Island, Cook Bay; southward it is found to Sitka*. Very common at Kamchatka. In the Sea of Okhotsk south to Nemoro Strait on the eastern shore of Hokkaido. In the Pacific Ocean to Akkesi Bay on the southeastern shore of Hokkaido. In the Sea of Japan southward, apparently to the southern tip of Sakhalin and to Vladivostok; individual specimens were found farther south: at the mouth of the Tumen'-Ula River at Gensan (Korea) and even in the Yellow Sea (at Chemulpo **). Like navaga, they come to the mouths of rivers and sometimes enter into rivers — Anadyr, Bol'shaya (on Kamchatka), Amur, Suifun, Tumen'-Ula. In the Bol'shaya River, it was found within 10 km of the mouth; in the Suifun River at Razdol'naya Village and even at Voroshilov-Ussuriiskii; on Bering Island in a fresh water lake †.

BIOLOGY. Studied less than navaga; judging by its more southward distribution, less cold loving. Like navaga, it enters brackish and even fresh waters, occurring quite far up rivers and streams, but remaining within regions of tidal influence. In summer it remains at depths of 30–50 meters, in fall it comes closer to shore. In the Anadyr it is caught in the delta in October. In the Bay of Korf it occurs in commercial quantities with running sexual products at the end of January. At Avachinskaya Inlet it is caught during winter on hook and line. At the western shores of Kamchatka it is caught in trawls at 40–60 meters in June. Found everywhere in Penzhinskaya Inlet; caught during June–July. In Tauiskaya Inlet it is numerous in October–November and in early spring. It occurs in very large schools at Shantar Islands.

* No. 1882 in the collections of the Zoological Institute of the Academy of Sciences of the U.S.S.R., delivered in 1847 by Mr. Voznesenskii.

** No. 8589 of the collections of the Zoological Institute of the Academy of Sciences of the U.S.S.R.

† Records of V. Franz (Abh. math.-phys. Cl. K. Bayer, Akad. Wiss., Suppl. Bd., IV, 1, 1920:30) of finding it in Sagami Bay (Fukuura) are doubtful.)

It is found in commercial quantities in the Amur Delta and around the western and eastern shores of Sakhalin. It is caught all through the Maritime Provinces, especially in the Gulf of Peter the Great, where two-year-olds predominate in the catch. In places with a less intensive industry (western shores of Sakhalin, Kamchatka) 3 and even 4 year olds predominate in the catch. The age composition in different places can be seen from the following (data furnished by Milovidova-Dubrovskaya):

Age (years)	1	2	3	4	5	6	7
Amur Bay	8.0	60.4	25.5	5.5	0.5	0.3	0.1
Posiet Bay	5.4	24.4	32.2	28.4	8.5	1.1	0.3
Decastris Bay	3.1	48.1	35.5	11.1	1.5	0.7	-
Sakhalin, western shore	1.4	29.3	60.7	8.6	-	-	-
Kikchik-Vorovskaya (western Kamchatka)	-	1.0	26.0	42.0	24.0	5.0	2.0

Sexual maturity usually occurs in the second, less frequently in the third year. Growth in different parts of the range progresses unevenly (according to the observations of Milovidova-Dubrovskaya and Agapov, in cm):

Age (years)	1	2	3	4	5	6	7
Amur Bay	17.3	25.5	30.2	34.0	37.4	41.2	-
Posiet Bay	17.1	27.6	31.1	35.5	38.5	43.4	45.9
Ussuris Bay	16.0	25.3	29.7	34.0	37.6	41.5	40.7
Decastris Bay	14.5	23.5	29.0	32.7	36.7	38.0	-
Sakhalin, western shore	14.8	25.8	31.1	36.5	-	-	-
Kikchik- Vorovskaya	16.9	28.4	35.4	39.9	42.8	46.9	52.0
Anadyr Gulf	16.8	21.8	24.9	28.1	32.3	35.6	-

Spawning occurs at some depth and at shore at temperatures from -1.6 to -1.8° C. There are indications that the eggs are adhesive. Fecundity varies from 25 to 210 thousand eggs.

COMMERCIAL VALUE. If it were possible to catch when it comes in the winter, it could have almost over-all commercial value, but this is not possible everywhere. In the Bay of Peter the Great in the period from 1910 to 1930 the annual catch was from 127 (1910-1911) to 16,300 metric centner (1929-1930).

19. Genus **BOREOGADUS** Günther

Boreogadus Günther, Cat. fish., IV, 1862:336 (subgenus, type: *Gadus fabricii* Richardson-*Boreogadus saida*); Berg, Fresh Water Fishes, II, 1933:739.

Dorsal and anal fins separated by large spaces. The first anal fin begins beneath the origin of the second dorsal or a little farther forward. The caudal fin is strongly notched. Mental barbel short, not longer than pupil.
199 Lower jaw projecting. Palatines without teeth, one row of minute, widely spaced teeth on head of vomer and on dentaries, two rows of teeth on premaxillaries anteriorly and one row posteriorly. Lateral line interrupted for its entire length, descending abruptly toward the longitudinal axis of the body beneath the origin of the second dorsal fin, with a strong wavy curve

beneath the posterior portion of the second dorsal fin. On the head there are only pit organs. Mucous cavity open in front, with two characteristic transverse crests behind it. A deep notch at the anterior edge of the prootic. Parapophyses short, without inflated tips.

SKELETON. Skull low (A), its height contained three times or more in the length of its base. Bones at the base of the skull arranged upward along a straight line, parasphenoid without curvature. Posterior part of the skull base somewhat rounded at the bottom as a result of the convexity of opisthotic. Upper profile of skull almost straight, descending anteriorly. Crest on supraoccipital and frontals low, with imperceptible termination in middle of skull, extending in the rear to the posterior edge of basioccipital or beyond it, its upper edge straight throughout. Anterior edge of mesethmoid almost straight, without visible indentation and gradually descending, placed at an obtuse angle to its upper edge; upper edge of mesethmoid short. Orbital space low, its height contained about three times in its base, lower in *B. saida* than in *B. agilis*. Facial nerve exits from skull through a deep notch at the anterior edge of the prootics, the edges of which bear small protuberances at the junction of the prootic with the alisphenoid dorsally and with the ascending process of the parasphenoid ventrally. The foramen of the glossopharyngeal nerve on the opisthotic is small but always clearly noticeable. The skull from above (B) is quite broad, its maximum width contained less than two times in the length of its base. Lateral edges of frontals slightly convergent anteriorly. Lateral edges of pterotic rounded toward the ends, somewhat indented in the middle, almost parallel. Frontals narrower in *B. saida* than in *B. agilis*. Lateral ethmoids expanded somewhat more in the transverse than in the longitudinal direction, projecting considerably forward from beneath the frontals, projecting laterally the farthest at the anterior end of the frontals. The anterior edge of the vomer projects considerably from beneath the anterior end of the mesethmoid. Crest above the canals of the lateral line on the pterotic short, moderately broad, considerably broader on frontals, with raised edges. Mucous cavity not closed in front by coalesced edges of lateral and median crests, which thus do not form canals in front of it. Due to indentions on the sides of the mucous cavity, there is broad contact between it and the canals under the lateral crests of the frontals. A small elongate, lengthwise crest is found on each side of the skull above the foramen of the recurrent dorsal branch of the facial nerve on the parietal. Behind the mucous cavity perpendicular to the longitudinal axis of the skull, there is a small crest on each side. Along the anterior edge of the head of the vomer on the lower surface of the skull (C) there is a small crest, behind which there is one row of small teeth, moderately curved at the tips; those at the sides are somewhat larger than those near the apex. The convex opisthotic and prootic rise on the
200 side of the flattened posterior part of the parasphenoid; this bears a small longitudinal concavity; anteriorly, the lower edge of the parasphenoid is oblique. When the skull is viewed from behind (D), the opisthotic and prootic are convex, the auditory region of the skull bulges laterally and even slightly downward. The supraoccipital crest projects slightly upward, somewhat higher in *B. agilis* than in *B. saida*. The lengths of the first two sub-orbitals are greater than their widths. Opercular process of hyomandibular shorter than the lower process, and narrow. Preopercular process quite broad. Lower edge of operculum with a deep notch and long pointed ends.

The posttemporal branches are quite long. Upper end of postcleithrum bent and broadened at the upper end. Parapophyses short, broad.

The description has been compiled on the basis of 14 skeletons of *B. saida* and one of *B. agilis*.

DISTRIBUTION. Two species in the Arctic seas.

COMPARATIVE NOTES. In well-preserved specimens of *B. saida* from the collections of the Floating Maritime Scientific Institute and the Arctic Institute, the lateral line has the same wavy curvature under the second dorsal fin as *B. agilis*, a feature that could not be noticed in less well-preserved specimens from the old collections at the Zoological Institute of the Academy of Sciences. Thus, as far as the main characteristic is concerned, there are no differences between these species, the only distinction being that the body of *B. saida* is lower and considerably tapering caudad, the caudal fin is more deeply notched and less rounded at the tips of its lobes, the barbel is much smaller and, most important, the base of the third dorsal fin is larger than that of the second, while in *B. agilis* the base of the third dorsal fin is shorter than or equal to that of the second. Moreover, the lateral line in *B. saida* shows another curvature beneath the third dorsal fin, a feature absent in the specimens of *B. agilis* examined. Craniological differences between them are insignificant. The vertebrae in *B. agilis* are slightly larger. It is possible that *B. agilis* is only a subspecies and that specimens of *B. saida* will be found in which the base of the third dorsal fin is equal to the second or shorter, while specimens of *B. agilis* may be discovered in which the third dorsal fin is longer and the lateral line beneath it shows a curvature. Once it is proved that *B. agilis* is only a subspecies of *B. saida* and the latter is not discovered at the shores of Greenland and North America, the appellation *B. agilis* will have to be changed to *B. saida polaris* (Sabine, 1824).

Key to the Species

- 1 (2). Base of third dorsal fin longer than that of second. Body considerably tapered caudad. Caudal fin with deep notch 1. *B. saida* (Lepech.)
- 2 (1). Base of third dorsal fin shorter than or equal to that of second. Body gradually tapered caudad. Caudal fin with somewhat shallower notch. 2. *B. agilis* (Reinh.)

*1. *Boreogadus saida* (Lepechin) — Polarcod cod, Saika (Tables XVI, LXII, LXXII)

Gadus saida Lepechin, Nov. Comment. Acad. Petrop., XVIII, (1773), 1774:512, tab. V (White Sea). — *Merlangus polaris* Sabine, Suppl. Parry's voy., 1824: CXCII (Baffin Bay). — *Gadus fabricii* Richardson, Fauna Bor. Amer., III, 1836:245 (North Greenland). — *Pollachius polaris* Gill, Proc. Acad. Nat. Sci. Phila., (1861), 1862:218. — *Boreogadus polaris* Gill, Proc. Acad. Nat. Sci. Phila. 1863:233. — *Boreogadus saida* Bean, Proc. U.S. Nat. Mus., IV, 1882:243 (Providence Bay, Cape Lisburn, Norton Sound).

DISTRIBUTION, BIOLOGY. Smitt, Scand. fish, I, 1893:484, f. 20 (Iceland, Spitzbergen, White Sea, Taimyr, Chukchi Peninsula, Pitlekai, Alaska, in a fossil state in glacial clays of Sweden); Camerano, Os-

servaz, scientif. Spediz. Polare Savoia 1899–1900, 1903:609 (Teplits Bay on Franz Josef Land); Knipowitsch, Memoirs of the Academy of Sciences, (8), Physics and Mathematics Division XVIII, 5, 1907:52 (ex parte*: p. 10d, Yenise Bay, p. 35, Zari Bay, p. 47, facing the mouth of Khatanga River, p. 49, facing the mouth of the Lena River, p. 54, Nerpch'ya Bay); Isachenko, the Fishes of the Turukhansk Region, 1912:100 (Yenisei Bay, north of Cape Krestov); Deryugin, the Fauna of the Kola Bay, 1915:589 (occasionally enters Kola Bay); Thielemann Wiss. Meeresunters., Abt. Heig., XIII, 2, 1922:215 (Barent Sea, at a depth of 19–320 June to July, at a temperature of -1.7 – -4.0°C , feeding); Soldatov, Works of the Floating Maritime Scientific Institute, 3, 1923:65 (Kara Sea, White Sea, mouth of North Dvina); Jensen, Rapp. Proces-Verb., XXXIX, 1925:94 (western Greenland, spawning); Knipovich, Classification Fishes of the Barents, White and Kara Seas, 1926:157, fig. 120 (during the cold season of theyear at the western shores of Murman); Suvorov, Works of the Research Institute for the North, 34, 1927:48 (Pesha River emptying into Chesk Bay); Rendahl, Ark. Zoologi, XXIIA, 10, 1931:15 (Taimyr Peninsula, east of Khatanga Bay, Pitlekai on Chukchi Peninsula); Eispov, Works of the Research Institute for the North, 49, 1931:162 (northern part of Barents Sea); Berg, Fresh Water Fishes, II, 1933:739; Taranets, Journal of the Far East Branch of the Academy of Sciences, 1–3, 1933:77 (shores of Chukotka, Anadyr Bay, one specimen in Olyutorsk Bay); Popov, Arctica. I, 1933:162 (Laptev Sea, East Siberian Sea and Chukchi Sea, St. Lawrence Bay); Vladyskov, Contrib. Canad. biol. fisher., (n. s.) VIII, 1–8, 1933:26 (Hudson Bay and Strait); Probatov, Materials of a Scientific and Industrial Expedition to the Kara Bay, 1934:90 (Kara Bay); Rass, The Karelo-Murmansk Region, 1934, 3–4:58 (spawning); Rass, Int. Rev. ges. Hydrob. Hydrogr., 33, 1936:255 (spawning); Klumov, Reports of the Academy of Sciences, Mathematics and Natural Sciences Division, 1937:135 (biology, importance to economy); Andriashev, An Investigation of the Seas of the U. S. S. R., 25, 1937:346 (Distribution, fecundity); Kiseleva, Works of the Scientific Research Institute for Polar Agriculture, Animal Husbandry and Industry, Industrial economic series, 10, 1940:103 (Ob Bay, biometry); Rass, Problems of the Arctic, 1945, 6:72 (Chukchi Sea near Cape Schmidt, East Siberian Sea in the estuaries of the Kolyma River and in the Indigirka River, larvae).

I D 11–15 (12.8), II D 12–17 (14.7), III D 17–23 (20.1), I A 14–20 (17.0), II A 18–24 (20.9), gill-rakers 37–46 (41.4), vertebrae 53–58 (55.2), pyloric caeca 20–37**. Caudal fin with deep notch, with slightly rounded, almost pointed tips of the two lobes. Barbel small, sometimes scarcely noticeable, thin, villiform. Body low, considerably tapered caudad. Base of third dorsal fin longer than that of second dorsal fin. In per cent of body length: anteanal distance 41.5–49.5 (45.6), antedorsal distance 26.5–31.5 (28.6), distance between the base of pectoral and origin of first anal fin 16.5–23.5 (19.9), distance between base of pelvic and origin of first anal fin 16.5–24.5 (20.9), base of first dorsal fin 7.5–12.5 (10.6), base of second dorsal 11.5–16.5 (13.6), base of third dorsal 13.5–17.5 (15.8), base of first anal 12.5–18.5 (15.4), base of second anal 13.5–18.5 (15.7), height of body 11.5–17.5 (15.0), depth of caudal peduncle 2.5–3.5 (2.9), length of head 22.5–26.5 (24.7). In per cent of head length: diameter of eye 25.5–32.5 (28.8), width of forehead 20.5–29.5 (24.4). Minute black dots and small hard protuberances scattered on sides of body, head and fins. Coloring quite varied: dorsal surface usually brownish, sides of body above lateral line slightly lighter, with a violet or yellowish hue; sides of body below lateral line and ventral surface silvery.

Soldatov pointed out some differences existing between specimens of Polar cod from the Kara Sea and those from the White Sea. A comparison of the number of rays in the fins and the number of gill-rakers in specimens of Polar cod from the White Sea and the Kara Sea with those in Polar cod from the eastern part of the Barents Sea did not reveal any differences.

* It was found that the remaining specimens belong to *Arctogadus borisovi*.

** The systematic characterization has been given on the basis of 70 adult specimens (90–170 mm in length) from the eastern part of the Barents Sea. E. V. Kiseleva (l. c.), who for comparison with her materials used the average number of rays in the fins of these fishes, incorrectly indicated the place where these fish were caught (Kara Bay).

It is possible that differences might appear if a greater number of specimens were to be compared. Usual dimensions 12 to 16 cm, individual specimens larger, one specimen reaching 32.1 cm.

FIGURE 36. Distribution of *Boregadus saida*

DISTRIBUTION. Circumpolar (Figure 36). Iceland, Spitzbergen, Kola Bay (seldom in winter), Barents Sea (small quantities in its southwestern part, common in the eastern), White Sea, Cheshskaya Bay, around Novaya Zemlya, Kara Bay, along the entire northern coast of Siberia, only in the northern part of the Bering Sea (Anadyr Bay and, partly, Olyutorskii Bay at the shores of North America). Does not occur in the Sea of Okhotsk*, at the Arctic shores and islands of North America, in Hudson Bay or at

* The indication by Popov, *Issledovanie morei SSSR* (An investigation of the seas of the U. S. S. R., 14, 1931: 147) that *B. saida* occurs in the Sea of Okhotsk is erroneous; Andriashev (An investigation of the seas of the U. S. S. R., 22, 1935:137) proved that it was a young specimen of *Th. chalcogramma*.

203 Greenland*. The southern boundary in the distribution of Polar cod depends upon the seasonal distribution of ice and the cold water zone. While in summer, only individual specimens are found in the southwestern part of the Barents Sea (State Institute of Oceanography, "Perseus," page 1125, 71° 30' north latitude, 38° 00' east longitude, June 21, 1923, page 1126, 71° 45' north latitude, 36° 32.5' east longitude, June 21, 1929; page 1127, 72° 00' north latitude, 35° 00' east longitude, June 22, 1929), in winter this species appears here in greater numbers. During the low temperature period caused by glaciers, it was spread farther south, down to the southern end of the Scandinavian Peninsula (it was found in the glacial clays near Lund). The belief in discontinuous distribution of Polar cod is erroneous (Klumov, l. c.), since it is found, as has been pointed out, in the southwestern part of the Barents Sea, as well as along the entire northern shore of Siberia (collections of the Russian Polar Expedition of 1900-1903 and of the Hydro-Geographical Expedition to the Northern Arctic Ocean, Starokadomskii, 1914, kept in the Zoological Institute of the Academy of Sciences of the USSR).

BIOLOGY. Fish of the cold regions that prefer staying under compact ice or at its edge. Larger schools, like those of *Eleginus navaga*, usually stay near the shores; it is found in great numbers far from the shores among floating ice, where these fish are quite mobile and swim fast between blocks of ice and hide in cracks. Occasionally these fish are found in warmer water zones having a temperature of 6.2° C (Soldatov, l. c.). They withstand well admixtures of fresh water and feel at ease in completely fresh water, often moving far upstream in the rivers. This happens when Polar cod are massed near the shores, namely in the fall and especially in the winter during the spawning period. It is not quite clear under what conditions these fish spawn, but it seems that, like *Eleginus navaga*, they move at that time farther off shore; although these fish are known to spawn occasionally in fresh water as well**. The eggs are pelagic. Spawning takes place from October to March (near Cape Zhelaniya, according to G. A. Kluge, it starts in October, in Cheshskaya Bay in February, in the Barents Sea apparently in January and February, in Alaska and Eastern Siberia in February). Fecundity, as compared with other species of the family, is low - several thousand eggs. Sexual maturity is reached at 3-4 years, when the specimens attain a length of 190-200 mm; at the age of 1½ years they measure 75-100 mm in length, at 2½ years 144-158 mm and at 3½ 190-200 mm. These fish feed mostly on crustaceans, especially Euphasiidae and Calanidae (*C. finnarcticus*), less frequently on amphipods and Crangonidae, and only exceptionally do they hunt for small fish (Thielemann, l. c.).

ECONOMIC IMPORTANCE. In spite of the fact that saika is always caught together with *Eleginus navaga* and sometimes is landed in mass during a storm, its economic importance has been nil. It has been used as a food only in recent years. The resources of this species are apparently large and almost untouched. It plays an important part in the feeding regime of belukha [beluga(syn)] (*Delphinopterus leucas*) and, to a lesser

Kendal (Proc. Portl. Soc. Nat. Hist., II, 1909:207) mentions *B. saida* at the shores of Labrador; Vladikov (l. c.) believes that this is not *B. saida* but *G. morhua* (as indicated by the number of gill-rakers).

** In the Kia and Torna Rivers emptying into Cheshsk Bay (Zenkevich, Journal of Zoology, III, 4, 1933:20). The eggs were probably squeezed out under the pressure of the mass of fish when the net was landed.

204 extent, in that of a number of other aquatic mammals, such as *Phoca hispida*, *Hystriophoca groenlandica*, *Erignathus barbatus* and some other Arctic animals (Klumov, Rybn. khoz. SSSR, 1935, 5:18).

2. *Boreogadus agilis* (Reinhardt) (Tables XVI, LXIII, LXXII)

Gadus agilis Reinhardt, Kngl. Danske Vidensk. Selsk., Nat. Aft., VII, 1838:115, 126 (at the shores of Greenland). — *Boreogadus agilis* Svetovidov, Doklady Akademii Nauk, I, 6, 1935:427 (northern gulfs of Greenland). — Schultz a. Welander, Copeia, 1935, 3:138 (Godhavn Harbor, Greenland).

I D 13-14, II D 16, III D 19-20, I A 18-19, II A 19-22, gill-rakers 40-42, vertebrae 52. Caudal fin with a notch rounded at the tips of the two lobes. Barbel small, well perceptible. Body higher, becoming tapered posteriorly but not as suddenly as in the previous species. Base of third dorsal fin shorter than or equal to base of second dorsal fin. In per cent of body length: anteanal distance 42.7-47.1, antedorsal distance 25.8-28.5, distance between base of pectoral and origin of first anal fin 21.8-26.2, distance between base of pelvic fin and first anal fin 23.6-29.1, base of first dorsal fin 12.3-13.6, base of second dorsal 16.9-17.6, base of third dorsal 15.2-16.9, base of first anal 18.0-18.1, base of second anal 15.3-17.2, height of body 18.7-19.6, depth of caudal peduncle 3.2-3.7, length of head 20.7-21.8. In per cent of head length: length of snout 27.3-30.6, diameter of eye 22.9-27.3, length of upper jaw 43.5-45.0, length of lower jaw 54.5-57.4, width of forehead 22.2-23.4. There are minute black dots and small hard tubercles on the sides of the body, the head and fins. Length of longest specimen known 37 cm (3 specimens).

DISTRIBUTION. This species is known from a small number of specimens in the gulfs of the western part of Greenland (Godhavn Harbor).

BIOLOGY. Like the preceding species, these fish live in ice area and are extremely active.

20. Genus **ARCTOGADUS** Drjagin

Arctogadus Drjagin, Zool. Anz., 98, 1932:151 (Type: *A. borisovi* Drjagin); Berg, Ryby presnykh vod S. S. S. R., II, 1933:746.

The dorsal and anal fins are separated by wide spaces. The first anal begins beneath the origin of the second dorsal fin. Caudal fin has a shallow notch. Barbel on chin quite long, not less than the pupil of the eye. Jaws of equal length or lower projecting; large teeth on vomer, premaxillary and dentary; teeth on the palatines. The lateral line is interrupted for its entire length, in the shape of a shallow arch in the forward portion of the body, descending sharply to the midline of the body beneath the origin of the second dorsal. On the head only pit organs. Mucous cavity on the frontals not closed in front; in its rear portion two short transverse crest-like processes. A quite deep notch on the forward edge of the prootic. Parapophyses of normal structure.

SKELETON. Skull quite high (A), its height contained about $2\frac{1}{2}$ times in the length of its base, the upper profile gradually descending toward the front. The lower edge of the vomer, parasphenoid and basioccipital present

an almost straight line with a slight curve on the parasphenoid beneath the forward end of the prootic; a slight rounded appearance at the rear of the
205 base of the skull is caused by the convexity of the prootic and opisthotic. The crest on the supraoccipital and frontals is not extremely high, its rear end extending somewhat beyond the rear of the basioccipital, terminating imperceptibly in the front; in the middle of the skull the upper edge of the crest is slightly rounded. The forward edge of the mesethmoid is straight, without notches, descending shallowly, placed at an obtuse angle to the upper edge. Orbital space high, contained about $1\frac{1}{2}$ times in the length of its base. Quite a deep notch for the facial nerve in the forward edge of the prootic; the edges of the notch have rounded ridges at the junction with the alisphenoid from above and with the parasphenoid from below. The foramen on the opisthotic for the glossopharyngeal nerve is small, but quite evident. The skull from above (B) is quite broad; the distance between the rear edge of the pterotic is more than half the length of the base of the skull. The lateral edges of the pterotic are placed at a slight angle to each other. The lateral edges of the frontals narrow sharply toward the posterior third and are almost parallel with each other in the interorbital space. The lateral ethmoids are greatly lengthened longitudinally, extending considerably on the sides from beneath the frontals and reaching a quite considerable distance back from the front end of the frontals and extending an even greater distance forward. The forward end of the mesethmoid is located somewhat behind the forward end of the vomer. The sensory canal crests are not extremely broad; they are along the pterotic for its entire length. The edges of the lateral and medial crests of the frontals are not fused, the mucous cavity is not closed in front, and there is no bony canal which is closed over in front of it nor are there any notches in the crests bordering the frontals from the sides. There is a small crest over the foramen of the recurrent dorsal branch of the facial nerve and somewhat behind it along the parietals from each side of the skull. The shaft and head of the vomer on the skull from beneath (C) are rounded; two rows of strong and long teeth run from the forward end of the head in a continuous line; in the second row the teeth are somewhat larger than in the first. The parasphenoid in the forward portion from beneath is rounded, in the center it is flattened, and in the rear it has a small longitudinal concavity. From each side of the rear portion of the parasphenoid the inflated prootic and opisthotic extend downward. The lateral walls of the skull when viewed from the rear (D) in the otic region are greatly inflated from the sides and somewhat projected downward. In the rear above the skull the supraoccipital crest projects somewhat. The first two suborbitals are large, the width of the second is somewhat more than its length. The opercular process of the hyomandibular is narrow and short, shorter than the lower process. The opercular is narrow, its lower edge has a deep notch and elongate tips. The upper end of the postcleithrum is slightly curved and broadened. The parapophyses are quite long and narrow, the first haemal arches are not too broad.

Description based on one skeleton of *A. borisovi*.

DISTRIBUTION. Two Arctic species.

Diagnostic Key to the Species

- 1 (2). Pelvic and pectoral fins short, do not reach the beginning of the first anal fin by far, are contained 1.5–1.8 times in the length of the head. Eyes large, about 3.9–5.3 times in the length of the head*.
- 2 (1). Pelvic and pectoral fins considerably longer, almost reaching the origin of the first anal fin and contained in the head length only 1.3 times. Eyes still larger, 3.2 times in head length**.
1. *A. borisovi* Drjag.
2. *A. pearyi* (Nichols and Maxwell)

*1. *Arctogadus borisovi* Drjagin — Eastern Siberian cod, devyati-perstka [Translator's note: common name means 9-fingered cod] (Tables XVII, LXIV, LXXII)

Gadus saida (non Lep.) Knipowitsch, Zap. Akad. Nauk, (8), fiz.-mat. otd., XVIII, 5, 1907:52 (ex parte: st. 14 opposite Cape Sterlegov, st. 44 Taimyr Bay, st. 46 northeast of Taimyr Peninsula, st. 50 north of Novosibirian Islands, st. 58 Nerpich'ya Inlet. — Nava ga Borisov, Mat. Yakutsk, kom. Akad. Nauk, 27, 1928:7 (delta of the Lena River opposite Sagastyr' Island). — *Arctogadus borisovi* Drjagin, Zool. Anz., 98, 1932:151, abb. 1 (Kolyma Delta at Sukharnoe, Laptev lighthouse at the mouth of the Kolyma, Lyakhov Island, Delta of the Lena); Berg, ryby presn. vod, II, 1933:747, 868, fig. 762 (Kolyma Delta, Lyakhov Island, Lena Delta); Popov, Arctica, I, 1933, fig. (Foka Bay west of the shores of Taimyr).

FIGURE 37. Distribution of *Arctogadus borisovi*

I D 11–12, II D 18–21, III D 21–24, I A 20–24, II A 20–23, gill-rakers 32–34, vertebrae 59. Lower jaw equal to the upper or slightly projecting

* In fishes with lengths exceeding 45 cm, 4.7–5.3 times, in fishes 14–17 cm, 3.9–4.3 times.
** In specimen 22 cm in length.

forward. On the dentary one row of large teeth, on the premaxillary two rows of considerably smaller and much more closely placed teeth; teeth in the outer row of the premaxillaries somewhat larger than the inner row. Large fish usually have, in addition to these, still smaller teeth between the rows of the premaxillary and an outer (rarely inner) row of teeth in the lower jaw. On the vomer and palatines one row of large teeth, from the external, less frequently from the internal, side of which on large fish there are smaller teeth. All large teeth are hooked backward at the end. Pectoral and pelvic fins short, do not reach the origin of the first anal fin by far. Body not high, depth contained about 5 times in its length to the base of the caudal fin. The eyes are large, contained 5 times in the head length. In 207 per cent of body length; anteanal distance 48.0-53.1, antedorsal distance 30.5-34.7, base of first dorsal fin 9.8-11.1, base of second dorsal fin 15.2-17.2, base of third dorsal fin 12.3-15.3, base of first anal 15.9-17.9, base of second anal 12.3-13.6, depth of caudal peduncle 3.1-3.5, its length 8.8-10.5, head 24.7-27.1. In per cent of head length; diameter of eye 18.9-21.2, snout length 33.7-36.2, length of upper jaw 46.3-51.2, length of lower jaw 53.7-59.6, width of forehead 17.5-20.7. Head, back and upper portion of the sides of the body dark olive in color, brownish or yellowish in spots; lower portions of the sides of the body gray, breast and belly light gray with numerous black dots. Fins dark gray, anal somewhat lighter. Reaches 55 cm and more in length.

DISTRIBUTION. (Figure 37). Indicated in the description from the deltas of the Kolyma; Lena and Lyakhov Island, this species was later found in the Gulf of Foka (southwest of Cape Cheliuskin). Presently it may be considered that the eastern Siberian cod is also found in the Kara Sea at Cape Sterlegov (75° 49' north latitude, 89° 35' east longitude), at Cape Svyatoi Nos (northeast of the mouth of the Yana River), at the northern tip of the New Siberian Islands (Nerpich'ya Inlet), northward from there (77° 26' 30" north latitude, 138° 47' east longitude)* and at Cape Billings**.

BIOLOGY. Studied very little. Like navaga and saika, it is found in salt as well as fresh water at the mouths of rivers. Judging by its distribution, along with *A. pearyi* this is the most Arctic of all cod species. Conditions of propagation are unknown but apparently, as in navaga and saika, spawning occurs in salt water.

COMMERCIAL VALUE none at present, but apparently, along with saika, could be an object of a small industry.

COMPARATIVE NOTES. The location of the lateral line beneath the second dorsal fin is quite variable. Sometimes it is located in almost the center of the body, but more often considerably lower.

2. *Arctogadus pearyi* (Nichols and Maxwell)

Boreogadus pearyi Nichols and Maxwell, Copeia, 1933, 1: 26 (Lincoln Bay and the north coast of Greenland).

I D 12, II D 20, III D 21, I A 23, II A 22. Scales small, about 155 transverse rows. Lower jaw projecting slightly. Teeth sharp, slightly hooked,

* All of these specimens are kept in the collection of the Zoological Institute of the Academy of Sciences.

** R. Number 2687 of the collection of the Zoological Museum of Moscow State University.

not very closely spaced, in two rows on the upper and in front on the lower jaws; row of closer spaced, unequal sized teeth on the vomer and palatines. Pectoral and pelvic fins long, reaching almost to the origin of the first anal fin. The pectoral fin is contained 1.3 times in head length, the pelvic fins 1.1 times. Body very shallow, its depth contained about 7 times in its length to the base of the caudal fin. The eyes are very large, contained only 3.2 times in head length. The head is contained 3.6 times in body length to the base of the caudal fin. In head length the snout is contained 3.2 times, interorbital space 4.2 times, upper jaw 2.5 times, barbel 6.5 times, length of caudal peduncle 2.5 times, the longest ray of the first dorsal fin 1.6 times, first anal fin longest ray 2 times, the lobes of the caudal fin 2.5 times. The
208 length of the barbel is contained in the diameter of the eye 2 times, depth of caudal peduncle 2.3 times. The upper jaw extends to the forward edge of the pupil. Coloration pale, the fins somewhat darker than the body. Only two specimens are known.

Description based on a specimen 22.4 cm in length (according to Nichols, and Maxwell).

DISTRIBUTION. Lincoln Bay at the northern tip of Greenland.

BIOLOGY. Unknown, but apparently does not differ materially from the biology of *A. borisovi*.

COMPARATIVE NOTES. *A. pearyi* is the only species in the *Gadinae* absent from the collections of the Zoological Institute of the Academy of Sciences. This species is very close to *A. borisovi*, differing only by its longer pectoral fins and the greater size of the eye. *Gadus glacialis* Peters (Die Zweite Deutsche Nordpolarfahrt in den Jahren 1869-1870, II, 1874:172), known from one specimen 12.0 cm in length from the very close (Sabine Island at the eastern shores of Greenland) places, undoubtedly, belongs to the genus *Arctogadus* (there are teeth on the palatines) and apparently is identical to *A. pearyi*; its eyes are contained 3.3 times in head length.

21. Genus **THERAGRA** Lucas

Theragra Lucas in: Jordan a. Gilbert, Rept. Fur-seal invest., III, (1896-97), 1899:486 (Type: *Gadus chalcogrammus* Pallas); Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898:2535.

The unpaired fins are separated by broad spaces. The first anal fin begins anterior to the origin of the second dorsal fin. Caudal fin has a slight notch. Barbel on chin small. Lower jaw projects forward somewhat. Teeth on the premaxillary, dentary and head of vomer. Lateral line with a sharp curve beneath the first portion of the second dorsal fin, without interruption in the forward portion and interrupted for its entire length behind the curve, straight in front of and behind the curve. Pores on the head along the canals of the sensory system; 12 pores in the preopercular-mandibular canal, 9 pores in the infraorbital canal, 2 pores in the supraorbital canal and 1 pore in the supraoccipital commissure. The mucous cavity on the skull in front is closed. The notch at the forward edge of the prootic is quite deep. The parapophyses are of normal structure. The suboperculum and postcleithrum are greatly thickened.

SKELETON. The skull is low (A), the length of its base almost 4 times greater than the height. The bones lying at the base of the skull are placed in almost a straight line, parasphenoid only slightly curved beneath the prootic. The upper profile of the skull from the rear is almost parallel to the base, in front it gradually descends to the mesethmoid. The crest on the supraoccipital and frontals is not high; its upper edge along the supraoccipital is straight, curved along the frontals, terminating forward in approximately the middle of the cranium box forward of the mucous cavity, in the rear extending not farther than the rear end of the basioccipital. The forward edge of the mesethmoid is without a notch, somewhat inflated, descending gradually, placed at an obtuse angle, somewhat rounded on top to the upper edge. The orbital space is not high, the length of the base being $2\frac{1}{2}$ times the height. The foramen of the facial nerve is quite a deep notch in the forward end of the prootic; the edges of this notch where the prootic joins the alisphenoid from the top and where it joins the ascending process of the parasphenoid below have angular or rounded ridges. The foramen of the glossopharyngeal nerve on the opisthotic is small, hardly noticeable. Skull viewed from above (B) is broad in the rear, its width contained about 2 times in the length of the base, quite narrow in the interorbital region. Lateral walls of the pterotic are rounded, placed almost parallel to each other. The lateral edges of the frontals are concave, sharply narrowing in the interorbital region. Lateral ethmoids stretched greatly lengthwise, extending on the sides from beneath the frontals, extending far forward and still farther back of the forward edge of the frontals. The forward end of the vomer extends forward from beneath the forward edge of the mesethmoid. The crests above the sensory canals on the pterotic and frontals are quite broad, with elevated edges. The mucous cavity is quite deep; there is a longitudinal partition dividing it in two sections; the partition is not too high and does not reach the edges of the cavity. Forward of each half of the mucous cavity there is a short canal formed by fusion of the lateral crests with the median crest. On the parietals from each side above the foramen of the recurrent dorsal branch of the facial nerve are small crests, lengthened more longitudinally than laterally, their edges not rising above the surface of the parietals. The quite flattened head of the vomer on the skull from beneath (C) is toothless at its very tip and lies in almost the same plane as the surface of its shaft. Teeth are located in several (3-5) rows along only the rear half of the forward edge of the head of the vomer. The parasphenoid is thin and narrow, rounded beneath in front, flat in the rear with a small longitudinal concavity. The lateral walls of the cranial box when the skull is viewed from behind (D) in the auditory region are somewhat inflated; the lower half of the rear portion of the skull is almost semicircular, being somewhat flattened only in the area of the parasphenoid. Above the upper edge of the supraoccipital and epiotic at the top of the skull the supraoccipital crest rises slightly. The first suborbital is small, much smaller than the second. The opercular and preopercular processes of the hyomandibular are equal in length to the rear portion of the lower process; the rear edges of the lower and subopercular processes are almost parallel. The operculum is slightly thickened, its lower edge has quite a deep cavity and a greatly lengthened and sharpened rear end. The suboperculum and the upper broadened tip of the postcleithrum are greatly thickened; the suboperculum is large, broad. The posttemporal is normally developed, not

DISTRIBUTION, BIOLOGY. Grebnitskii, Vestn. rybopr., XII, 6-7, 1897:324 (Copper Island); Jordan and Evermann, Fish N. a. M. Amer., III, 1898:2535, f. 887 (Bering Sea and neighboring waters); Evermann and Goldsborough, I. c.:346 (Bering Sea, southward from the Aleutian Islands and Alaska); Mori and Uchida, Journ. Chosen Nat. Hist. Soc., 19, 1934:22 (Seyishin, Gensan); Schultz and Welander, Copeia, 1935, 3:131 (Alaska, comparison with the southern form); Kamiya, Journ. Imp. Fish. Inst., XXI, 3, 1935:27 spawning, development and structure of the eggs; Andriashev, Issled. morei SSSR, 22, 1935:136 (Bering Sea); Uno, Bull. Jap. Soc. Sci. Fish., Tokyo, V, 1936:173 (age studies); Andriashev, Issled. morei SSSR, 25, 1937:340 (northward to between the Chukchi Peninsula and St. Lawrence Island, biology); Sato, Journ. Fac. Sci. Hokkaido Univ., (VI), Zool., VI, 1, 1937:32 (Akkeshi Bay, plentiful in winter); Uno, Bull. Jap. Soc. Sci. Fish. Tokyo, VI, 1938:296 (age studies); Suvorov, Mintai i ego promyslovoe znachenie (biology, commercial value).

I D 12-14, II D 12-18, III D 20-21, I A 19-23, II A 21-23, gill-rakers 34-40, vertebrae 50*. Pectoral and pelvic fins are long, the pectorals almost reaching or going beyond the origin of the first anal fin; the pelvics do not reach or just about reach the origin of the first anal. In per cent of body length: anteanal distance 40.4-44.1, antedorsal distance 27.3-29.2, length of pectoral fin 17.5-21.4, length of pelvic fin 9.5-11.8, height of body 9.8-15.1, depth of caudal peduncle 3.0-3.5, its length 11.2-12.4, length of head 21.8-24.2. In per cent of head length: length of snout 33.1-36.4, horizontal diameter of eye 20.7-25.7, length of upper jaw 39.0-40.7, length of lower jaw 52.3-55.6, width of forehead 15.8-20.3. The dorsum is olive, the sides silvery with 2-3 stripes of dark spots, copper-olive along the edges. Dorsal fins olive, pectoral fins dark, pelvic and anal ashen colored, caudal light olive. Average sizes about 60 cm (from 572 specimens from Anadyr Bay, Andriashev, I. c.), reaches 75 cm.

DISTRIBUTION. Very common in Japan, Okhotsk and Bering Seas. The utmost limits of distribution to the south along the Asiatic coast appears to be Korea (Genzan) and Yamaguchi Province on the southwest coast of Hondo Island in the Sea of Japan**. The utmost northern location is in the Strait between Cape Chukhotsk and St. Lawrence Island; it was not found farther north. In the Sea of Okhotsk common at the western shores of Kamchatka, at the northern portion of the Island of Hokkaido and at the eastern shore of Sakhalin, found in lesser quantities at northern coast of the Shantar Islands. Widely distributed at the shores of Alaska and the Aleutian Islands. South of Alaska along the shores of North America it is represented by a closely related form *Th. chalcogramma chalcogramma n. fucensis*.

BIOLOGY. Keeps with cod, but usually at greater depths (from 180 to 200 and even 300 meters, in the Bering Sea from 30 to 150 meters). It is found in schools as a rule at temperatures above or close to zero, although there are cases known of finding it in small quantities at negative temperatures. Spawning at the shores of Kamchatka apparently occurs in the spring and beginning of summer; by the second half of July spawning is finished, though isolated specimens with undischarged sexual products are found until the middle of August. In the Sea of Japan at the shores of Japan spawning occurs during February-March-April. The incubation period during the development of the eggs at 9-11°C is equal to 7-8 days. Sexual maturity in mintay in the Sea of Japan occurs upon reaching three years, at the shores

* According to Schultz and Welander, the fin formulae of 30 specimens from the shores of Alaska are as follows: I D 11-13 (11.9), II D 14-18 (15.4), III D 15-20 (17.7), I A 17-22 (20.1), II A 16-21 (18.7); 1-2 first rays in III D, I A and II A concealed under the skin, apparently not counted.

** V. Franz's (Abh. math.-phys. Cl. K. Bayer, Akad. Wiss., Suppl. Bd. IV, 1, 1910:30) record of finding them at Yokohama is doubtful.

of Kamchatka, 4. For spawning it comes toward shore to lesser depths and after releasing the eggs departs for the depths, while males and smaller specimens remain at lesser depths a little longer than the females and older age groups. In July and August at depths of less than 55 meters at the shores of Kamchatka, males dominate, at depths of 80-235 meters, females. Young age groups (two and three year olds) 18-27 cm in length were found in July at depths of 180-200 meters; in August at lesser depths, 100-135 meters; in September in shallow water of about 60 meters. In September large mintay also comes close to the shores. The commercial period at the shores of Japan is from November to March-April. Usual food is *Mesidothia* and amphipods, *chionoecetes opilio* was also found in stomachs. In the southern regions it is greatly diseased by nematodes and poorly fed; in the northern regions it is less diseased and better fed.

COMMERCIAL IMPORTANCE. Comparatively small. With the poorly developed cod industry and still lesser navaga industry, the catch of mintay at the shores of Kamchatka (Kikchik-Kola region) does not exceed 7% of the total cod catch and about 2% of the total navaga catch. In statistics the catch of mintay is practically not considered. About 3.5 thousand metric centner was caught in 1928 in the Maritime Provinces. Mintay is considerably more utilized in Japan, where in 1931-1936 over 900 thousand metric centner were produced. Under-utilization of the reserves of mintay in our waters is explained by the presence of more valuable fish, by its poorer quality than the cod and by prejudice against it because of the heavy infestation with parasites, mainly nematodes.

COMPARATIVE NOTES. *Gadus minor* Döderlein, judging from all of its characteristics (I D 11, II D 12, III D 19, I A 19, lower jaw longer than upper, dorsal and anal fins divided by broad spaces, anal opening located between the verticals of the end of the first and the beginning of the second dorsal fins), is *Th. chalcogramma*. Within the limits of its range, *Th. chalcogramma* falls into the group of as yet unstudied local forms, forming morphologically well isolated forms in the Japan Sea and a fjord form in the harbors of the Chukchi Peninsula (Andriashev, l. c.). Jordan and Gilbert described one such form found at the shores of North America.

1b. *Theragra chalcogramma chalcogramma n. fucensis* (Jordan a. Gilbert)

Pollachius chalcogrammus Jordan a. Gilbert, Proc. U. S. Nat. Mus., III, (1880), 1881:454 (Puget Sound, Monterey Bay); Jordan a. Gilbert, ibid., IV, (1881), 1882:66 (occasionally in Seattle, rare at San Francisco). — *Pollachius chalcogrammus fucensis* Jordan a. Gilbert, ibid., XVI, (1893), 1894:315 (Puget Sound and Tacoma). — *Theragra fucensis* Jordan a. Evermann, Fish. N. a. M. Amer., III, 1898:2536 (from Vancouver to Monterey Bay). — *Eleginus navaga* (non Pallas) Evermann a. Goldsborough, Fish. Alaska, 1907:347 (ex parte: Puget Sound, Port Townsend).

DISTRIBUTION, BIOLOGY. Schultz and Welander, Copeia, 1935, 3:135 (Puget Sound, Port Townsend); Schultz and DeLacy, Mid.-Pacific Mag., Jan. -March, 1936:65 (Puget Sound and coast of the State of Washington, bibliography).

I D 11-13 (11.4), II D 12-15 (13.2), III D 14-19 (16.4), I A 15-19 (17.8)
II A 15-19 (17.3)*. Differs from specimens from Bering as well as Sea of

* From Schultz and Welander, 27 specimens from Puget Sound.

Okhotsk by fewer rays in the fins, and apparently some other characteristics. Measurements are the same as in the typical form.

DISTRIBUTION. Along the shores of North America from Monterey Bay to Vancouver and perhaps even farther north. The boundary of the range with basic form is not known. Usually very common and very numerous in Puget Sound, south to San Francisco and in Monterey Bay – rare.

BIOLOGY. As in the basic form, a marine fish; has not been studied more closely.

COMMERCIAL VALUE minor.

22. Genus **MICROMESISTIUS** Gill

Micromesistius Gill, Proc. Acad. Nat. Sci. Phila., (1863), 1864:231 (Type: *Gadus poutassou* Risso). — *Brachymesistius* Gill, *ibid.*:233 (Type: *Gadus poutassou* Risso).

The dorsal and anal fins are divided by spaces. The space between the first and second dorsal fins is greater than the diameter of the eye, space between the second and third dorsal fins is greater than the base of the second dorsal fin, beginning of the first anal fin is forward of the origin of the first dorsal. Caudal fin with a small notch. The lower jaw projects forward slightly. Barbel on the chin undeveloped. Teeth on premaxillary and dentary, 1–2 teeth on either side of the head of the vomer. Lateral line straight, running parallel with the dorsum above the midline of the body, uninterrupted for its entire length. On the head along the lateral line canal system there are pores: 12 in the preopercular-mandibular canal, 9 in the infraorbital canal, 3 in the supraorbital canal and 1 in the supraorbital commissure. The mucous cavity is closed in front. The facial nerve exits from the side of the skull through a foramen. Intestine without pyloric caeca.

SKELETON. The skull is not high (A), the length of its base is more than $3\frac{1}{2}$ times its height. The parasphenoid has a small curve beneath the forward end of the prootic; the vomer in front and basioccipital in rear of this curve are placed in straight lines with the front and rear ends of the parasphenoid. The upper profile of the skull presents an almost straight line descending gradually forward. The crest on the supraoccipital and frontals is not high, almost straight along its upper edge, with a slight inflation at the junction of the supraoccipital and frontals, in front at about the middle of the skull [the crest] gradually transforms into a series of ridges which bound the rear end of the mucous cavity, terminating in the rear over the rear edges of the basioccipital or slightly in front of it. The forward edge of the mesethmoid descends gradually without a notch, placed at an obtuse angle to the upper edge. The orbital space is elongate and low, its height contained about $2\frac{1}{2}$ times in its length. The facial nerve leaves the skull through a foramen, limited in the front by the alisphenoid and ascending processes of the parasphenoid. The glossopharyngeal foramen on the opisthotic is hardly noticeable. The skull is quite narrow in the rear (B), its width contained a little over twice in the length of its base, and it is even narrower in the interorbital space. The lateral edges of the pterotic are slightly rounded, almost parallel to each other. The edges of the frontals narrow sharply in the interorbital region, widening somewhat at the forward

end. Lateral ethmoids extend scarcely from the forward ends of the frontals on the sides, and are basically located in front of it. The forward end of the mesethmoid lies quite far back of the forward end of the vomer. The crests above the sensory canals on the pterotic are short and narrow, long and wider on the frontals, their edges joined with the edges of the frontals through the aid of a bony bridge, one on each side, thus forming in this spot an almost closed bony canal. The mucous cavity is deep; the longitudinal partition dividing it into two parts does not reach the top in the rear portion. The lateral crests of the frontals in front of the mucous cavity fuse with the median crests and form short canal on each side of the forward section of the frontals which communicate with the mucous cavity. There is a crest on either side of the parietals covering the foramen of the recurrent dorsal branch of the facial nerve. The head of the vomer from beneath (C) is greatly flattened; its apex lies in the same plane as the shaft, only the edges of the head protrude slightly, with sparse hook-like teeth; the apex of the head of the vomer is toothless. The parasphenoid is narrow, greatly compressed from the sides forward of the prootic, the lower surface flattened, even somewhat longitudinally concave in the rear. The prootic and episthotic are convex, due to which the lower portion of the cranial box when viewed from the rear (D) is hemispheric. Above the skull in the rear only the supraoccipital crest rises, the parietal crests are not seen. The first two sub-orbitals are equally well developed, the second are almost equal in length as well as in width. The opercular and lower processes of the hyomandibular are of almost the same size. The lower edge of the opercular is almost without a notch, its rear end is slightly elongate, its forward end rounded. The upper end of the postcleithrum is curved and broadened. The parapophyses are short and narrow, the first haemal arch is small.

Description based on one skeleton of *M. poutassou* and one of *M. australis*.

DISTRIBUTION. Two bi-Polar species, one of the Atlantic and Mediterranean shores of Europe, the other at the utmost southern tip of South America (Figure 39).

Diagnostic Key to the Species

- 1 (2). 23-36 gill-rakers on the lower limb of the first gill arch, 27-33 on the entire gill arch. 1. *M. poutassou* (Risso)
- 2 (1). 33-39 gill-rakers on the lower limb of the first gill arch, 42-43 on the entire arch. 2. *M. australis* Norm.

*1. *Micromesistius poutassou* (Risso) — Putassu (Tables XVIII, LXVI, LXXII)

Gadus merlangus (non L.) Risso, Ichth. Nice, 1810:115 (Mediterranean Sea). — *Merlangus poutassou* Risso, Hist. nat. Europ. mérid., III, 1826:227 (Mediterranean Sea). — *Merlangus vernalis* Risso, l.c.:228. — *Merlangus pertusus* Cocco, Giorn. Sci. Lett. Sicilia, XXVI, 1829:140. — *Merlangus albus* Yarrell, Brit. fish., ed. II, II, 1841:247. — *Gadus potassoa* Düben, Vet. Akad. Handl., 1844: 88. — *Merlangus communis* Costa, Fauna Regni. Napoli, Pesc., 1850:7. — *Gadus merlanostomus* Nilsson, Scand. fauna, IV, 1853:556. — *Micromesistius poutassou* Gill, Proc. Acad. Nat. Sci. Phila., (1863), 1864:231. — *Boreogadus poutassou* Malm. Göteb. Bohusl. Fauna, 1877:486 Skagerrak,

Kattegat to Island of Vingo). — *Gadus poutassou* Vinciguerra, Ann. Mus. Civ. Stor. Nat. Genova, XVIII, 1883:465, t. II, f. 1-2.

DISTRIBUTION, BIOLOGY. Erhardt, Fauna Cycladen, 1859:91 (Cyclod Islands); Apostolides, Pêche Grece, Athen., 1883:29; Smitt, Scand. fish., I, 1893:511; Jensen, Med. Komm. Havunders., Fisk. I, 7, 1905:8, f. 4 (north to $69^{\circ}31'$ north latitude, $47^{\circ}06'$ west longitude); Hjurt, Rapp. Proces-Verb., X, 1909:60, f. 17 (spawning, biology); J. Schmidt, *ibid.*:82 (spawning, biology); Damas, *ibid.*:210 (biology); Johnsen, Bergens Mus. Arbok (1918-1919) 2, 1921:51 (one specimen length 200 mm, caught 27 June 1909 at the coast of Murman); Tortonese, Boll. pesca, piscicult., idrobiol., XI, 2, 1935:232; Boldovskii, Dokl. Akad. Nauk., XXIV, 3, 1939:305 (western part of the Barents Sea, eastward to 40° east longitude).

FIGURE 39. Distribution of the genus *Micromesistius*
1— *M. poutassou*; 2— *M. australis*.

I D 12-14, II D 12-14, III D 23-26, I A 33-39, II A 24-27, gill-rakers 27-33 (23-26 on the lower limb of the gill arch), vertebrae 57*. In per cent of body length: anteanal distance 30.5-33.3, antedorsal distance

* According to J. Schmidt, 56-60 vertebrae.

29.5-31.1, length of pectoral fin 12.4-14.6, length of pelvic fin 5.8-6.2, length of the base of the first dorsal fin 8.0-9.1, length of the base of the second dorsal fin 8.0-10.3, length of the base of the third dorsal fin 13.8-14.8, length of the base of the first anal fin 32.3-37.9, length of the base of the second anal fin 15.5-16.5, height of first dorsal fin 9.6-11.9, height of first anal fin 6.7-7.8, depth of caudal peduncle 3.7-4.9, its length 9.4-10.8, length of head 22.1-23.8. In per cent of head length: length of snout 31.3-35.0, diameter of eye 25.9-28.7, length of upper jaw 40.6-43.5, length of lower jaw 54.1-57.9, width of forehead 10.5-13.5. Coloration bluish-gray on back, lighter on the sides, silvery; belly milk-white. Small blackish-brown round spots on the body, more numerous in the area of the pectoral fin; small dark spot, sometimes absent, at the base of the pectoral fin. Length to 35 cm, seldom larger.

DISTRIBUTION. Atlantic Ocean at the European shores, north to the western section of the Barents Sea (south of Bear Island*, to the east to 40° east longitude) and the southern and southwestern shores of Iceland (judging by the currents and otoliths, almost to 69° 31' north latitude and 7° 6' west longitude, almost to the Island of Jan Mayen) along the Scandinavian Peninsula, to the east in Skagerrak and adjacent parts of Kattegat to Vingo Island. Around Great Britain and Ireland, south to the Straits of Gibraltar in western portion of the Mediterranean, occasionally at the shores of Italy, Greece and the Cyclad Islands.

BIOLOGY. Leads a pelagic mode of life, primarily over great depths (at 1,000 to 2,000 meters), at 100-200 and more meters from the surface, but also found in the very upper layers of water; the young are found near shore. Spawns in places located near the 1,000 meter isobath. In the Atlantic Ocean these places are distributed in a strip along a thousand meter isobath from the southern shores of Iceland, west from the Faroe Islands, Great Britain and Ireland, along the Bay of Biscay. Spawning also occurs in the Mediterranean. There is no spawning in the North Sea, Skagerrak and opposite the shores of Norway, although the adults are found there. Such a distribution of spawning grounds is defined not only by depths but also by the presence of corresponding temperatures and salinities. Spawning occurs at high temperatures — not lower than 8-9° C and a salinity not below 36.2 parts per thousand. These conditions are not satisfied, for example, at depths opposite the coast of Norway, due to which there is no spawning. Spawning is very prolonged, continuing from the end of winter to the end of spring — beginning of summer and, possibly, to a lesser degree almost throughout the year. The main spawning period in the Atlantic Ocean, apparently is February-April. Feeds primarily on pelagic crustaceans (Copepoda, Schizopoda). Often found in stomachs of cod at the shores of Ireland. At the end of the first year of life at the shores of Iceland reaches a length of about 18 cm, at the end of the second year — 24-25 cm, at the end of the third year — about 26 and at the end of the fourth — about 29 cm.

COMMERCIAL VALUE none. Not caught in great quantities.

COMPARATIVE NOTES. Some authors accept *Merlangus vernalis* Risso as a synonym of *O. merlangus merlangus*. If we accept the fin ray count of *M. vernalis* in I A according to Canestrini (36), then it would be wiser to refer it to *M. poutassou*. *Merlangus pertusus*

* No. 24310 of the collection of the Zoological Institute of the Academy of Sciences of the USSR (March 1931, "Persei").

Cocco, D'Ancona (Arch. Zool. Ital., XV, 1930:293) and other authors refers it to *M. poutassou*.

2. *Micromesistius australis* Norman (Table LXVII)

Micromesistius australis Norman, Discov. Rept., XVI, 1937:51, f. 22 (off Patagonia and the Falkland Islands).

I D 12-13, II D 13-14, III D 25-26, I A 35-36, II A 27-29, gill-rakers 42-43 (on lower limb of the first gill arch 33-34)*. The gill-rakers are much more numerous than in the preceding species. The teeth are somewhat weaker. In per cent of body length: anteanal distance 28.2-31.4, antedorsal distance 30.6-32.3, length of pectoral fin 14.7-15.7, length of pelvic fin 6.9-7.7, base of first dorsal fin 6.7-6.8, base of second dorsal 7.9-8.4, base of third dorsal 15.7-17.9, base of first anal 31.7-34.3, base of second anal 18.0-18.2, height of first dorsal 10.5-10.9, depth of caudal peduncle 3.7-3.9, its length 10.0-11.0, head length 21.0-21.8. In per cent of head length: snout length 33.4-33.6, diameter of eye 27.4-29.1, length of upper jaw 40.0-40.2, length of lower jaw 54.5-55.2, width of forehead 14.6-14.9. Length of known specimens from 7 to 51 cm (2 specimens).

DISTRIBUTION. Atlantic Ocean off the shores of South America (Patagonia) south to 45° south latitude and around the Falkland Islands. The range of distribution, apparently is broader than the indicated limits.

BIOLOGY. There are known only 33 specimens caught at depths of 133-485 meters.

COMPARATIVE NOTES. Craniologically the species does not differ. The structure of some bones, such as the operculum, the shape of which is usually quite variable, cannot be considered as material distinctions. Externally, *M. australis* differs by its slightly larger eyes, somewhat longer pectoral and pelvic fins, etc., but basically a sharp identifying characteristic appears to be the number of gill-rakers, the difference in quantity of which in both species is so great that it gives no room for doubt as to the individuality of the species.

* According to Norman, I D 11-13, II D 10-14, III D 22-26, I A 35-38, II A 21-25, gill-rakers 35-39 (on the lower half of the gill arch).

NOTE: The Arabic numerals refer to the page numbers of the Russian original, which appear in the left-hand margin of the translation.

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The lettering on tables showing skulls and their separate bones (Roman numerals XIX-LXVII) are as follows:

A—skull in lateral view	C—skull from ventral view
B—skull in dorsal view	D—skull from posterior view
als—alisphenoideum	p—parietale
boc—basioccipitale	pal—palatinum
cl—cleithrum	pcl—postcleithrum
eoc—exoccipitale(occipitale laterale)	plv—os pelvis
epo—epioticum	pro—prooticum
eth,l—ethmoidale laterale	prop—praeoperculum
f—frontale	ps—parasphenoideum
hy—hyomandibulare	pt—posttemporale
iop—interoperculum	pto—pteroticum
meth—mesethmoideum	spho—sphenoticum
op—operculum	soc—supraoccipitale
opo—opisthoticum	uhy—urohyale
	v—vomer

The length of vertebral columns (Roman numerals LXVIII-LXXII) are indicated in tables XXI-LXVII of the corresponding species.

TABLE I

1—*Brosme brosme* (Müll). Barents Sea, Teriberka. Length 33.3 cm. To the right the first gill arch, enlarged. 2—*Gaidropsarus mediterraneus* (L.). Black Sea at the coast of Penderakli. Length 21.8 cm. To the right the first gill arch, enlarged.

TABLE II

1-*Ciliata mustela* (L.). North Sea. Length 22 cm. To the right the first gill arch, enlarged. 2-*Enchelyopus cimbrius* (L.). Baltic Sea, Bay of Finland. Length 20 cm. To the right the first gill arch, enlarged.

TABLE III

1

2

1-*Raniceps raninus* (L.), North Sea. Length 29 cm. 2-*Phycis blennoides* (Brunn.). Mediterranean Sea, Nice. Length 29 cm.

TABLE IV

1-*Lota lota lota* (L.). Lower part of the Pechora River. Length 59.5 cm. 2-*Lota lota leptura* (Hubbs et Schultz).
Anadyr River from Ust' Belaya. Length 42.6 cm.

TABLE V

1-Molva molva (L.). Barents Sea. Length 111 cm. 2-Molva dipterygia dipterygia (Penn.). Atlantic Ocean at the Norwegian shores (Senjen Island).

TABLE VI

1-Merluccius merluccius (L.). Atlantic Ocean, Bay of Biscay. Length 28.4 cm. 2-Merluccius productus (Ayres). Pacific Ocean, 26°14'N., 113°13'E. Length 26 cm.

TABLE VII

1-*Trisopterus luscus* (L.). Atlantic Ocean, Bay of Biscay. Length 24 cm. 2-*Trisopterus esmarkii* (Nilss.). Atlantic Ocean at the coast of Norway (Senjen Island). Length 17.5 cm.

TABLE VIII

1-Odontogadus merlangus merlangus (L.). Barents Sea, Ekaterinskaya harbor. Length 25.2 cm. 2-Odontogadus merlangus euxinus(Nordm.). Black Sea, Batumi. Length 16.8 cm.

TABLE IX

1-*Pollachius virens* (L.). Barents Sea, Murman, Araguba. Length 75.5 cm. 2-*Pollachius pollachius* (L.). North Sea. Length 31.8 cm.

TABLE X

1-Melanogrammus aeglefinus (L.). Barents Sea, Murman, eastern Litza. Length 56.5 cm. 2-Gadus morhua L.
Barents Sea, Murman eastern Litza, Length 74.5 cm.

TABLE XI

1-*Gadus morhua callarias* L. Baltic Sea, Tallin. Length 56,8 cm. 2-*Gadus morhua kildinensis* Derjugin.
Lake Mogilnoe on Kildin Island. Length 59,3 cm.

TABLE XII

1-Gadus morhua maris-albi Derjugin. White Sea, Soroka. Length 46.6 cm. 2-Gadus morhua ogac Rich.
The western coast of Greenland. Length 29.8 cm.

1-Gadus morhua morhua n. hiemalis Taliev. White Sea, Kandalaksha. Length 31.2 cm. 2-Gadus morhua macrocephalus Til. Sea of Japan, America Bay. Length 69.3 cm.

TABLE XIV

- 1-*Gadiculus argenteus thori* (J. Schmidt). Atlantic Ocean off the shores of Norway (Senjen Island). Length 13.5 cm.
2-*Microgadus proximus* (Girard). Bering Sea, Alaska. Length 27.3cm.

1-*Elegendinus navaga* (Pall.). White Sea, mouth of the North Dvina River. Length 21.3 cm. 2-*Elegendinus gracilis* (Til.). Amur Liman, Sakhalin Bay, near Petrovskoe village. Length 35.8 cm.

1-Boreogadus saida (Lep.). Kara Sea, Kara Bay, Sibircha River, 5 kilometers from the mouth. Length 16.7 cm.
2-Boreogadus agilis (Reinh.). The western coast of Greenland. Length 37.0 cm.

1-*Arctogadus borisovi* Drjagin. Delta of the Kolyma River near Sukhamoe. Length 49.8 cm. 2-*Theragra chalcogramma* (Pall.). Sea of Okhotsk, Yavinsk Bank. Length 51.0 cm.

TABLE XVIII

1-*Micromesistius poutassou* (Risso). Barents Sea south of Bear Island. Length 25.1 cm.
 2-*Antimora microlepis* Bean. Pacific Ocean, coast of Japan, Misaki. Length 43.0 cm.

TABLE XIX

Uraleptus maraldi (Risso).
Mediterranean Sea, Messina. Length of
skull 35.5 mm.

Lotella phycis (Temm. et Schl.).
Pacific Ocean, Tokyo. Length of skull
32 mm.

T ABLE XX

Physiculus japonicus Hilgend.
Pacific Ocean, Kagoshima Bay. Length
of skull 38 mm.

Laemonema longipes P.Schmidt.
Sea of Okhotsk. Length of skull 74.5
mm.

TABLE XXI

Brosme brosme (Müll.). Barents Sea, Teriberka. Length of skull 49.5 mm., length of vertebral column 226 mm.

Gaidropsarus mediterraneus (L.). Black Sea, Gelendjik. Length of skull 29 mm, length of vertebral column 142 mm.

Ciliata mustela (L.). North Sea. Length of skull 31 mm, length of vertebral column 200 mm.

TABLE XXIV

Enchelyopus cimbricus (L.). Baltic Sea, Gulf of Finland. Length of skull 21.5 mm, length of vertebral column 140 mm.

Raniceps raninus (L.). North Sea. Length of skull 40 mm, length of vertebral column 152 mm.

Phycis phycis (L.). Atlantic Ocean, Madeira. Length of skull 39.5 mm, length of vertebral column 168 mm.

Phycis blennoides (Brunn). Mediterranean Sea, Nice. Length of skull 43 mm, length of vertebral column 174 mm.

TABLE XXVIII

Phycis chesteri Goode et Bean. Atlantic Ocean off the coast of North America (44°01'N, 59°02'30"E.). Length of skull 28 mm, length of vertebral column 124 mm.

Urophycis regius (Walb.). Atlantic Ocean, New York. Length of skull 35 mm, length of vertebral column 179 mm.

Urophycis chuss (Walb.). Atlantic Ocean off the coast of North America, Chesapeake Bay. Length of skull 24 mm, length of vertebral column 116 mm.

Urophycis floridanus (Bean et Dresel). Gulf of Mexico off the shores of Florida (Pensacola). Length of skull 17.6 mm, length of vertebral column 74 mm.

TABLE XXXII

Urophycis tenuis (Mitch.). Atlantic Ocean off the coast of North America. Length of skull 53 mm, length of vertebral column 222 mm.

TABLE XXXIII

Urophycis brasiliensis (Kaup). Atlantic Ocean off the coast of South America.
Length of skull 41 mm, length of vertebral column 185 mm.

Lota lota lota (L.). Shchelitoe Lake between the Pechora and Indiga Rivers.
Length of skull 68.5 mm, length of vertebral column 372 mm.

Lota lota maculosa (LeSueur). North America. New York.
Length of skull 98 mm, length of vertebral column 461 mm.

Molva molva (L.) Atlantic Ocean off the coast of Iceland. Length of skull 87 mm, length of vertebral column 403 mm.

Molva dipterygia dipterygia (Penn.). Atlantic Ocean off the coast of Norway (Senjen Island). Length of skull 78 mm, length of vertebral column 167 mm.

Molva dipterygia elongata (Otto). Atlantic Ocean near the coast of Spain, Vigo. Length of skull 78 mm, length of vertebral column 342 mm.

Merluccius merluccius (L.). Mediterranean Sea. Length of skull 36.5 mm, length of vertebral column 123 mm.

TABLE XL

Merluccius productus (Ayres). Pacific Ocean near the coast of California (Station 3103, Albatross). Length of skull 49.8 mm, length of vertebral column 172 mm.

TABLE XLI

Merluccius bilinearis (Mitch.). Atlantic Ocean near the coast of North America (Woods Hole, Massachusetts). Length of skull 45 mm, length of vertebral column 166 mm.

TABLE XLII

Trisopterus luscus (L.). Atlantic Ocean, Bay of Biscay. Length of skull 33 mm, length of vertebral column 127 mm.

Trisopterus minutus minutus (Müll.). North Sea. Length of skull 34.5 mm, length of vertebral column 135 mm.

TABLE XLIV

Trisopterus minutus capelanus (Risso). Mediterranean Sea, Palermo.
Length of skull 30 mm, length of vertebral column 107 mm.

TABLE XLV

Trisopterus esmarkii (Nilss.). North Sea, 11 miles from Aberdeen.
Length of skull 29.5 mm, length of vertebral column 111 mm.

TABLE XLVI

Odontogadus merlangus merlangus (L.). Atlantic Ocean, Iceland. Length of skull 31,5 mm, length of vertebral column 111 mm.

Odontogadus merlangus euxinus (Nordm.). Black Sea. Length of skull 34 mm, length of vertebral column 124 mm.

TABLE XLVIII

Pollachius pollachius (L.). North Sea. Length of skull 57 mm, length of vertebral column 185 mm.

TABLE XLIX

Pollachius virens (L.). Barents Sea off the Murman coast. Length of skull 80.5 mm, length of vertebral column 304 mm.

The figure consists of several detailed line drawings of insect skull parts, labeled with letters and anatomical abbreviations.
A: Lateral view of the skull. Labels include: *meth*, *z*, *eth l*, *ps*, *als*, *pro*, *opo*, *eth r*, *sphe*, *soc*, *epo*, *pto*, *eoc*, *roc*.
B: Dorsal view of the skull. Labels include: *meth*, *u*, *eth l*, *f*, *p*, *sphe*, *pto*, *epo*, *soc*, *eoc*.
C: Ventral view of the skull. Labels include: *eth l*, *f*, *ps*, *als*, *pro*, *sphe*, *pto*, *opo*, *eoc*, *roc*, *soc*.
D: Ventral view of the base of the skull. Labels include: *epo*, *soc*, *pto*, *opo*, *eoc*, *roc*.
E: Detail of a bone, labeled *hy*.
F: Detail of a bone, labeled *op*.
G: Detail of a bone, labeled *pt*.
H: Detail of a bone, labeled *cl*.
I: Detail of a long, slender bone, labeled *pcl*.
J: Detail of a bone, labeled *uhy*.

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TABLE II

Gadus morhua morhua L. Barents Sea, Murman coast, off Dal'nezelenetskaya Bay. Length of skull 134 mm, length of vertebral column 433 mm.

TABLE LII

Gadus morhua kildinensis Derjug. Mogilhoe Lake on Kildin Island. Length of skull 118 mm, length of vertebral column 387 mm.

TABLE LIII

Gadus morhua maris-albi Derjug. White Sea, Kandalaksha Gulf. Length of skull 68 mm, length of vertebral column 214 mm.

TABLE LIV

Gadus morhua ogac Rich. Greenland, Disco Bay. Length of skull 51.5 mm, length of vertebral column 171 mm.

TABLE LV

Gadus morhua macrocephalus Til. Sea of Japan, Sovetskaya Gavan', Length of skull 109 mm, length of vertebral column 354 mm.

Gadidulus argenteus argenteus Guich. Mediterranean Sea, Naples. Length of skull 25 mm, length of vertebral column 56 mm.

TABLE LVII

Gadidulus argenteus thori J. Schm. Atlantic Ocean off the coast of Norway (Senjen Island). Length of skull 25 mm, length of vertebral column 56 mm.

TABLE LVIII

Microgadus tomcod (Walb.). Atlantic Ocean off the coast of North America, New York. Length of skull 47 mm, length of vertebral column 218 mm.

Microgadus proximus (Gird.). Pacific Ocean off the coast of North America, Sitea. Length of skull 50 mm, length of vertebral column 189 mm.

TABLE LX

Eleginus navaga (Pall.). Kara Bay, mouth of the Sibircha River. Length of skull 42.5 mm, length of vertebral column 173 mm.

Eleginus gracilis (Til.). Sea of Japan, Bay of Peter the Great. Length of skull 51.5 mm, length of vertebral column 200 mm.

Boreogadus saida (Lep.). Cheshskaya Bay, mouth of the Indiga River.
Length of skull 35.5 mm, length of vertebral column 150 mm.

TABLE LXIII

Boreogadus agilis (Reinh.). Greenland. Length of skull 34 mm, length of vertebral column 126 mm.

Arctogadus borisovi Drjagin. Delta of the Kolyma River, Sukharnoe village. Length of skull 73.5 mm, length of vertebral column 300 mm.

Theragra chalcogramma chalcogramma (Pall.). Sea of Japan. Length of skull 84 mm, length of vertebral column 315 mm.

TABLE LXVI

Micromesistius poutassou (Risso). Barents Sea south of Bear Island. Length of skull 48 mm, length of vertebral column 177 mm.

Micromesistius australis Norman. Atlantic Ocean southeast of the Falkland Islands (52°31'15"S., 63°25'W.). Length of skull 68.2 mm, length of vertebral column 298 mm.

1-Brosme brosme, 2-Gaidropsarus mediterraneus, 3-Ciliata mustela,
 4-Enchelyopus cimbrius, 5-Raniceps raninus, 6-Phycis
 phycis, 7-Phycis blennoides, 8-Phycis chesteri.

1-Urophycis regius, 2-Urophycis chuss, 3-Urophycis tenuis,
 4-Urophycis brasiliensis, 5-Lota lota lota, 6-Molva
 molva, 7-Molva dipterygia elongata, 8-Merluccius
 merluccius.

1-*Trisopterus luscus*, 2-*Trisopterus minutus minutus*,
 3-*Trisopterus esmarkii*, 4-*Odontogadus merlangus*
merlangus, 5-*Pollachius pollachius*, 6--*Pollachius*
virens.

1-Melanogrammus aeglefinus, 2-Gadus morhua morhua,
 3-Gadiculus argenteus argenteus, 4-Microgadus tomcod,
 5-Microgadus proximus, 6-Eleginus navaga.

- 1-Eleginus gracilis, 2-Boreogadus saida, 3-Boreogadus agilis,
4-Arctogadus borisovi, 5-Theragra chalcogramma chalcogramma,
6-Micromesistius poutassou.

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