II.—GEOGRAPHICAL DISTRIBUTION OF THE GADIDÆ OR THE COD FAMILY, IN ITS RELATION TO FISHERIES AND COMMERCE.

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A.—CHARACTERISTICS OF THE GADIDÆ.

Next to the herring, the cod is perhaps the best known and most important family of fishes, on account of its extended and very productive fisheries and commerce. The study of its characteristics and general distribution, however, is not only interesting to the fisher and business man, but also to the naturalist, on account of their bearing upon the relations existing between currents, temperature, saltness, and depth of the ocean; the modes of distribution of animal and vegetable life, and many other unsolved problems. According to the careful and reliable investigations of Dr. Albert Günther, of the British Museum, the family comprises 22 genera, 60 species, and numerous varieties. Of these, 9 genera, with 41 species and several varieties, are especially important, viz: *Gadus*, with 19 species; *Merlucius*, with 3; *Phycis*, with 5; *Molva*, with 3; *Motella*, with 5; *Brosmius*, with 2; *Couchia*, with 3, and *Raniceps* and *Lota*, with 1 species each, while the other 13 genera, with their 19 species, are simply connecting and transitional forms in this large series of widely-distributed fish, and are far less numerous in individuals as well as in species. The fertility appears to decrease in the individual in proportion to this multiplicity of genera and species. We may, for instance, find with the ling and the cod three to nine

* Gaea, 1877, III, pp. 158, 224, 345, 422.—Revised by Tarleton H. Bean.—Dambeck's paper is compiled from various sources, some of them antiquated, and, consequently, containing no reference to recent discoveries. Many statements offered as facts are untrue, and others doubtful. Some generalizations are made from insufficient data, some are entirely founded on error. After making due allowance for misstatements and conclusions of uncertain value, there still remains much that is interesting. The nomenclature which he accepts differs from that adopted by many American authors, hence a brief synonomy is given:

Lota vulgaris (*maculosa*) = *Lota maculosa*, (Le S.) Rich.
Lota vulgaris = *Lota maculosa* var. *vulgaris*, Jenyns.
Gadus morrhua-callarias = *Gadus morrhua*, L.
Gadus æglefinus = *Melanogrammus æglefinus*, (L.) Gill.
Gadus virens = *Pollachius carbonarius*, (L.) Bon.
Gadus tomcodus = *Microgadus tomcodus*, (Walb.) Gill.
Couchia argentata = *Ciliata argentata*, (Reinh.) Gill.
Phycis regalis = *Urophycis regius*, (Walb.) Gill.
Phycis americanus = *Phycis chuss*, (Walb.) Gill.
Gadus californicus = *Microgadus proximus*, (Grd.) Gill.
Brosmius vulgaris = *Brosmius brosme*, (Fabr.) White.

millions of fully-developed eggs, while *Lotella* and *Halargyreus* have only a few thousand.

The cod family has a remarkable tendency to variation, as is most strikingly apparent in the difficulty of defining genera and species; the species show many varieties (*Gadus morrhua*, near Great Britain, has two, a light-colored one in the north and a dark one in the south), the genera, numerous species, &c., throughout the whole family. The caudal or tail fin is never placed at the end of the terminal vertebra, but has its lower portion slightly in front of it, and even unites sometimes with the anal fin; the scales are frequently ctenoidal,* and thus also similar to those of the fishes of former ages. Sometimes the eyes are very large, which is usually considered as peculiar to the more recent forms of fishes, as the number of barbels also is most probably an indication of the stage of development, increasing or diminishing with the antiquity of the fish. The head is often comparatively small, as with *Brosmius vulgaris;* often large, as with *Gadus macrocephalus*, and sometimes the lower jaw is elongated and hook-shaped—a mark of antiquity, according to the analogy of the salmon. I therefore conclude that the family is still in the process of development, namely, from fresh-water into salt-water fish. I do not assert, however, that the saltness of the ocean is greater at present than in former ages, but I wish to state the fact that the codfish, *Gadidæ*, also at previous periods lived in regions of the sea where the water was but slightly salt; for in the present time, too, they live more particularly in fresh and brackish water, or in sea-water of not more than 2 to 3 per cent. of salt.†

The *Lota vulgaris* is a true fresh-water fish in the lakes and rivers of Central, Northern, and Eastern Europe, Northern Asia, and northern North America, and yet, according to Pallas, it also occurs in the Arctic Ocean, on the coast of Siberia, as far as Indigirka, and according to Rathké in the Black Sea, and according to Yarrell in the Frith of Forth. Others live in the open ocean, but their old habit drives them into the rivers again. Thus the cod migrates up the Tweed. The *Gadus macrocephalus*, according to Pallas, frequents the ocean around Kamtschatka and America, but ascends the rivers in May and returns to the ocean in August and September, after remaining about four months in fresh water.

They all live in regions of the sea where the water contains but little salt, especially at the mouths of rivers, fresh-water basins, ports, &c. They require a temperature of the water of from 39° to 44°; the *Lota vulgaris* can endure a somewhat lower temperature, and the southern forms, *Physiculus* and *Uraleptus*, will bear a somewhat higher; thus the family belongs to the temperate zone, and its occurrence indicates unmistakably a medium temperature, even where such might not be

* The gadoids, as now limited, all have cycloid scales.—T. H. B.

† *Microgadus tomcodus* has been transferred suddenly from salt water to a fresh-water aquarium and kept alive for months.—T. H. B.

expected, whether it be in the arctic or tropical regions.* At spawning time, when the northern forms develop greater vital activity and possess a higher temperature of the blood, they seek for water of from 35° to 37°, as it may be found in February and March upon the southern coast of Spitzbergen, at the Loffoden Islands, in the fiords of Finmark, and at the Faroes, in May and June on the Banks of Newfoundland, Gulf of St. Lawrence, and Labrador; the southern forms, however, are smaller and less lively, and live in uniform temperature; they, therefore, only migrate at spawning time to the near coast, but usually from water of considerable depth. The former migrate in a horizontal direction; the latter in a vertical one. The *Gadidæ*, then, are fresh-water and migratory fish. They are voracious, and subsist upon marine vegetation as well as upon animals; they are omnivorous, and consequently readily adapt themselves to their surroundings.

Professor Mœbius found in the stomach of *Gadus morrhua*, L., large pieces of *Ulva lactaca* and *Zostera marina*, two marine plants, besides shells, snails, crabs, and fishes. The above-mentioned variations in color generally indicate differences in depths at which they live, and comprise white, yellowish, brown, speckled, green, and black.† Every species, it is true, lives at different depths at different seasons, but all are capable of living at considerable depth, even the fresh-water species, some of which inhabit fresh water at considerable elevations, especially in Europe. This fact seems also to prove their fresh-water origin, as does the size of their gill openings, which enables them to absorb the requisite amount of oxygen from the deep fresh water, always less rich in that element than salt or surface water. Therefore, in seeking after fresh water and deep water they are perfectly in accordance with their habits.

The following tables will show the depths and elevations at which the *Gadidæ* live, as well as the temperature of the water, and the proportions of salt contained in it:

Names of species.	Locality.	Elevation and depth.	Temperature.	Proportion of salt.
		Feet.		*Per cent.*
Lota vulgaris	The Alps, Lake of St. Maritz (These lakes are 180 to 240 ft. in depth.)	5,580 Elevation.		
Do	Switzerland, Lake of Seelisberg (These lakes are 180 to 240 ft. in depth.)	2,240 Elevation.		
Do	Lake Garda (These lakes are 180 to 240 ft. in depth.)	213 Elevation.		
Gadus morrhua	Baltic Sea, Stollesgrund	42 Depth.	4-5° C.	1.44
Do	Baltic Sea, Benchanon	300 Depth.		0.80
Do	Baltic Sea, Dalaroe	240 Depth.		0.75
Do	Newfoundland	360 Depth.		
Phycis blennioides	North Sea	300 Depth.		
Gadus merlangus	Skagerak, Arendal	360 Depth.		3.60
Molva vulgaris	European coasts	600 Depth.		3.64
Gadus minutus	Mediterranean	1,000 Depth.		
Phycis mediterraneus	Mediterranean, Sicily	1,200 Depth.		
Halargyreus Johnsonii	Atlantic, Madeira	1,800 Depth.		
Chiasmodus niger	Atlantic, Madeira	1,872 Depth.		

* *Gadus morrhua* has been taken by the United States Fish Commission in from 34° to 46° F. *Lota maculosa* endures a much higher temperature in the Connecticut River, the Ohio, and the Missouri.—B.

† Variations in color coincide with changes in the colors of surrounding objects upon the feeding-grounds.—B.

B.—GENERAL DISTRIBUTION.

As to their general distribution, they occupy a portion of the frigid zone, but preferably the temperate zone of the northern hemisphere, especially the Arctic, Northern Atlantic, and Northern Pacific Oceans, as well as the fresh waters of northern North America, Europe, and Asia. They occur, however, sporadically in the torrid zone, and southern hemisphere. Individuals are most numerous on the coasts of Newfoundland, Nova Scotia, and Labrador, and in the neighborhood of the Loffoden Islands, Norway, Finmark, Iceland, the Faroe, and British Islands, that is, on the coasts of both continents, and on the line where the Arctic and North Atlantic Oceans meet. This region may therefore be named the domain of the *Gadidæ*, and to it belong particularly the 9 genera of the above tables, with 41 species; the other 13 genera, with 19 species, belong to the southern temperate and torrid zone, and to the Pacific and Indian Oceans, viz, the extreme limits of the domain. Whether these latter are the remnant of a southern *Gadidæ* fauna, or are simply straying members from the northern one is difficult to decide, but most probably the latter is the case. The northernmost limit is in general 77° north latitude, and the southernmost, in the Atlantic, 30° north latitude. The middle region, therefore, between 45° and 62° north latitude, stretches from Newfoundland to Great Britain and Scandinavia. In the Pacific Ocean the boundary runs from Northern China, at Chusan, northward along the west coast of Japan and the Kurile Islands to the southern extremity of Kamtschatka, and across to the Aleutian Islands by Kodiak, Sitka, and the islands of the west coast of North America to San Francisco. In the tropics these fish are found on the east coast of the Phillippines, and at the mouth of the Ganges in one genus and species, *Bregmaceros Macclellandi*. Only one genus and species is found in the Atlantic of the southern hemisphere, namely, the *Phycis brasiliensis* at Montevideo, likewise but one genus and species in the Pacific on the coast of Chili, *Merlucius Gayi*, and 2 genera with 3 species at New Zealand, *Lotella* and *Pseudophycis*. This is not surprising, since the coasts of Chili and New Zealand are under the influence of the cold antarctic currents, and Montevideo of the cold Cape Horn current, so that the antarctic drift ice even reaches at times up to that latitude. The fresh, cool water of the Hoang Ho, Yangtsekiang, Brahmapootra, and La Plata is favorable to the existence of *Gadidæ*.

Statistics show that the fisheries of the cod, which seem to be the most developed of the family *Gadidæ*, are most productive at Newfoundland and the Loffoden Islands, points 870 geographical miles apart. About midway lie Iceland and the Faroe Islands, which seem to form an inclosed region bounded on the north by Spitzbergen, Bear Islands, and Loffoden Islands. The center of this wide, oval, oceanic trough is most probably the northern home of the *Gadidæ*. Between Cape Charles, Cape Farewell, Southwestern Iceland, and the Gulf

Stream there is an Atlantic region of great depth, which is under the influence of the cold arctic current from the Davis' Strait and the Greenland Sea. This cold current deflects the Gulf Stream toward the European coast, and a second southern region of the *Gadidæ* is the result, which extends to the southeast of the above region, from Nova Scotia by the Azores to the Canaries and the Mediterranean and Black Seas. Both of the extreme points, Newfoundland and Loffoden (distant 25° of latitude one from the other), are poor in genera and species but very rich in individuals.* In the middle region, extending from southern Spitzbergen, Iceland, and the Faroe Islands past the British Islands and along the coast of France and Portugal to the Canaries, and especially Madeira, the number of species and genera increases from the north toward the south; but the number and size of the individuals diminish as the depth in which they live increases, a clear indication that the existence of these fish is dependent upon a particular temperature, for there are none to be found in localities under the influence of the prevailing arctic current or of the warm Gulf Stream. The northern region borders upon Spitzbergen, New Siberia, Parry Islands, and Greenland in the north, and upon Iceland, the Faroes, Southern Scandinavia, Russia, Siberia, the regions about Hudson's Bay, Canada, and Newfoundland on the south, comprising thus the whole Arctic Ocean and extending in a west-east direction 1,800 miles. It contains the following genera and species: *Gadus morrhua-callarias, æglefinus, virens, merlangus, luscus, nanus, saida, navaga, minutus, Fabricii; Merlucius communis, argentatus; Molva vulgaris; Motella tricirrata; Brosmius vulgaris, flavescens, Couchia argentata; Lota vulgaris;* that is, 7 genera with 18 species, in the average 3 species for every genus.

The Southern region is bounded by Nova Scotia, the Eastern coast of North America to Cape Hatteras, the Bermudas, the Azores, Canaries, the Mediterranean and the Black Seas, the coast of Portugal and France, the North and Baltic Seas, Southern Scandinavia, the Faroes and Southern Iceland back to the northern coast of Nova Scotia; thus it comprises the North Atlantic Ocean. The extent from the east coast of North America to the Black Sea is 1,245 miles. It contains the following genera and species: *Gadus morrhua-callarias, æglefinus, virens, Esmarkii, merlangus, luscus, nanus, minutus, pollachius, poutassou, euxinus, tomcodus; Gadiculus blennioides, argenteus; Hypsiptera argentea; Merlucius communis, argentatus; Molva vulgaris, abyssorum, elongata; Motella tricirrata, quinquecirrata, maculata, cimbria; Brosmius vulgaris; Raniceps trifurcatus; Couchia Edwardii, glauca, argentata; Lota vulgaris; Mora mediterranea; Chiasmodus niger; Halargyreus Johnsonii; Strinsia tinca; Physiculus Dalwigkii; Uraleptus Maraldi; Læmonema Yarellii, robustum; Haloporphyrus lepidion; Phycis blennioides, mediterranea, regalis, ameri-*

* Newfoundland has many genera and species of gadoids.

canus, brasiliensis; that is, 19 genera, with 44 species, in the average two species for every genus.*

In the Pacific Ocean the *Gadidæ* are distributed: on the west coast of North America to San Francisco, and of South America to Chili, and on the east coast of Asia from Behring Strait to Northern China, Chusan and by way of the Philippines to the mouth of the Ganges, and farther southward to New Zealand, not, however, as a connected series. The following are the genera and species: *Gadus morrhua, minutus, californicus, productus, macrocephalus, chalcogrammus; Merlucius Gayi; Motella pacifica; Lotella phycis, rhacinus, bacchus; Pseudophycis breviusculus; Bregmaceros Maclellandii;* that, is 6 genera with 13 species. The number of genera and species in the same ratio as in the Atlantic Ocean.

We shall now discuss more in detail the natural relations and the distribution of the genera and species in those three oceanic basins.

C.—THE ARCTIC REGION OF THE GADIDÆ.

Between the two large continental masses of the Old and the New World and almost entirely surrounded by them a great body of water is situated, which forms an immense inland sea of 1,826,000 square miles. This enormous sea is the basin of the Arctic and Atlantic Oceans. That these two oceans naturally form but one, is shown by the three connecting straits, whose breadth averages from, respectively 40 to 120 miles, while the Pacific Ocean has but one connection with the Arctic, the narrow Behring Strait. This great sea is naturally subdivided into three smaller basins, the Arctic, the North and the South Atlantic Oceans. The North Atlantic Ocean is connected with the Arctic and with the South Atlantic Ocean. The North Atlantic is, therefore, more particularly subject to the influence of the Arctic Ocean, while the latter, too, is influenced by the former, and this in return by the South Atlantic. The line of division of these three basins cannot be defined, as their natural characteristics are frequently blending with each other. The Arctic and North Atlantic Oceans are extraordinarily rich in large and small islands, between which straits and channels run, and they have numberless creeks, fiords, bays, and many inland seas of different size. Many and large rivers carry quantities of fresh water, sand, and detritus into these seas, and so form lagoons.

In consequence of this exceedingly rich development of the coast region the formation of fresh-water ice is favored, which, however, melts rapidly on account of the warm current from the South Atlantic Ocean, thus supplying, in conjunction with the rivers, the sea largely with wide and deep strata of fresh water.

The temperature, saltness, amount of food, currents, and depth of the sea are essential conditions for the distribution. The Arctic Ocean has, even in midsummer, according to Martius, a somewhat higher temperature at its surface than the air, in consequence of the Gulf Stream,

* Add *Phycis tinuis*, (Mitch.) DeKay. Two new species, *Haloporphyrus viola* and *Phycis Chesteri*, have recently been discovered in the southern region by the United States Fish Commission.

which not only reaches as far as the southern extremity of Spitzbergen, but up to Novaja Semlja, with a temperature as high as + 12.5 C. = 54.5° F., as has been ascertained by the imperial Russian expedition under Middendorf, in the summer of 1870.

It may be that this current runs along the northern coast of Siberia, cooling more and more by the influence of the ice and the cold water of the large Siberian rivers, and returns as cold arctic under current out of Behring Strait, as cold arctic surface-current through Davis Strait and the Greenland Sea. The channel between Iceland and Norway, 120 miles wide, serves the warm Atlantic current as entrance into the Arctic Ocean. Near Spitzbergen, even in 80° north latitude, the temperature of the water in the open sea was found by Gaimard to be never below + 0.7° C.= 33.26 F. near the surface, but nearly always + 1° C.= 33.8 F. According to the records of the Swedish expedition the water had in winter a temperature of —2° C.= 28.4° F. The temperature of the sea-water was found to be everywhere above 32° as far as 77° north latitude and as far west as the meridian of Greenwich, and none of the reports speak of ice. To the east of meridian 0 the temperature of the water at the surface is + 1, 2, 3, and over 4° C.= 33.3, 35.6, 37.4, 39.2° F.; in 75° 45′ north latitude, 4° east longitude from Greenwich, the surface of the sea showed 4.7° C.= 40.46° F. This is distant 230 sea miles W. N. W. from Bear's Island, where the monthly mean temperature in November, 1865, was observed — 5.4° C.= 22.28° F. and — 8.50° C.= 16.7° F. in December. The mean temperature of the water between Norway and Spitzbergen, 74° and 77 north latitude, was found to be + 3.94° C. = 39.1° F., and in 75° to 76° north latitude even + 5. C.= 41° F. perceptibly higher than that of the air, giving a mean of — 2.92° C.= 26.7° F.

In the inclosed parks of the sea and in the bays the enormous accumulation of ice, which the summer can never entirely melt, naturally exercises a chilling influence. Yet numerous fishes—cod, salmon, and herrings—inhabit the waters on the western coast of Spitzbergen 77° north latitude at Belsunde, surrounded by glaciers, and feeding upon the vast quantities of crustaceans.

While the temperature in the fiords and between the islands near the Norwegian coast is comparatively low, 3 to 4° C.= 37.4° to 39.2° F., at a distance from the coast it increases to a certain limit which for 69° and 70° latitude is 7° C.= 44.6° F., being about 15 geographical miles from the coast; the limits of the 6° C.= 42.8° F. and 5° C.= 41° F. are at a distance of 10 and 5 to 8 geographical miles respectively. Almost parallel with the 12° and 14° east longitude from Greenwich, the maximum temperature amounts to 4° and 5° C.= 39.4° and 41° F.; but while the isothermal of 5° keeps in the vicinity of the 72° latitude, the vertex of the isothermal of 4° lies in the latitude of the south cape of Spitzbergen, that is, 4° or 60 (German) geographical miles further north; in other words, a warm current runs along the 14th degree of longitude toward the north, while a similar arm branches off to the eastward along the coast of Finmark. In its further course the warm Atlantic current

divides into two arms at the west coast of Norway, one of which turns to the Murmanian coast, the other, west of Bear's Island, to the west coast of Spitzbergen. Concerning this second arm in winter-time, the Albert expedition has collected new information based upon positive observations. These show that the temperature diminishes to the eastward toward Bear's Island and East Spitzbergen. To the westward we find as limits of the warm water the isothermal of 0° (32° F.), which runs in a nearly north-south direction along the 10° and 11° longitude from the 73° to the 76° latitude; farther south it seems to turn to the west toward Jan Mayen. To the east of this curve for 0° (32° F.) the isothermal of 1°, 2°, and 3° (33.8°, 35.6°, 37.4° F.) are in pretty close proximity, indicating that the warm water has cooled off in a higher degree toward the limits of the icy water of the polar current. The observations of deep-sea temperatures made by the French expedition to Spitzbergen have shown that the warm water, without ever cooling below 0° (32° F.), occupies the whole depth of the sea between Norway, Bear's Island, and Spitzbergen; and, according to the assertion of Captain Otto, the experienced Norwegian seamen are well acquainted with the above-named current in spring and summer. From Captain Otto's observations it is positively ascertained that a warm current also at the beginning of winter is running west of Bear's Island to the western coast of Spitzbergen.

Ross, on the contrary, found that in Baffin's Bay, between 63° 49′ and 75° 44′ north latitude, the temperature of the water was above freezing only during thirty-one days in the months of June, July, August, and September; the rest of the time it was always below. The maximum was + 1.11° C. = 34° F.; the minimum − 1.11° C. = 30° F. In deep water, however, the temperature during July and August was constantly above 0, even at the greatest depth sounded, that of 3045 feet. As the temperature of the Arctic Ocean remains constant in great depths all the year round, it is easy to see how it can be the abode of many marine forms occurring there in deep water which in the North Atlantic Ocean are found near the surface or in its shallower parts. No fishes have been found up to the present time on the west coast of Greenland, near Hall's Land, in 81° 38′ north latitude, although nets and hooks have been used for the purpose; but the sea abounds in marine invertebrates, such as mollusca and crustacea, so that food for fishes is not wanting. The water at the Arctic region probably contains not more than 3 to 4 per cent. of salt; the general amount is about 3.3 per cent. The average depth of the Arctic Sea is very likely not more than 2,000 feet, and though near Spitzbergen a depth of 6,000 to 7,000 feet has been found, yet the water is very shallow along the Asiatic coast, the greatest depth north of the Behring Strait being only 220 fathoms = 1,320 feet. In 77° 2′ north latitude and 107° 40′ east longitude from Greenwich the depth is 245 feet English. The shallowest part in the Charles Foreland Sound, 79° 53′ north latitude, 16° 15′ 5″ east longitude from Greenwich, has a

depth of 12 feet, with sandy bottom. Spawn, young fry, and partly-developed fishes were found in water of a temperature of — 2° C.; unfortunately without stating genus and species. The depth of the water between Iceland and Greenland is 7,560 feet; that of the Juliushaab fiord, in Eastern Greenland, at least 900 feet.

In the Arctic Ocean the abundance of animal life contrasts strongly with the desolation of the land, the productions of the former often being of collossal dimensions; we only mention as an instance, the *Umbellularia* of 1.5 feet in size, which has lately been found. There are especially some families of fishes, small crustaceans, *ascidians*, *pteropods*, which are found in inexhaustible quantities, and serve as food of gigantic water-mammals and fishes.

The fishes of the Arctic Ocean are represented by extremely prolific families, as the *Salmonidæ* and *Gadidæ*. The *Gadidæ*, in particular, are found there in 6 different genera, with 13 or 14 species, namely, *Gadus*, with 8 or 9 species; *Molva vulgaris; Motella tricirrata*, *Brosmius vulgaris; Couchia argentata*, and *Lota vulgaris*. Their maximum, of course, is only found at the limits of the Arctic and in the North Atlantic Oceans. Two of the six above-named genera, including three species, are found near the southern coast of Spitzbergen, *Gadus morrhua*, *virens*, and *Molva vulgaris*. On the coast of Siberia, to the eastward of the mouth of the Indigirka, they disappear entirely, for only one genus is found there, according to Pallas, including one species, *Lota vulgaris*, this being the fresh-water type. It occurs at the mouth of a river, which falls into the Arctic Ocean, and at its extreme limits, and also at considerable elevations. Near the mouth of the Obi River 1 genus with 2 species is found, *Gadus luscus* and *navaga*. In the White Sea we find 1 genus with 3 species, *Gadus luscus*, *navaga*, and *saida*. The amount of salt in the water here is 3.2 per cent. Toward the west the number of genera and species increases rapidly with the higher temperature of the water. From Finmark to the Loffoden Islands the number of genera increases to 4, with 9 to 10 species: *Gadus*, with 6 or 7 species; *morrhua-callarias*, *æglefinus*, *virens*, *nanus*, *saida*, *navaga; Molva vulgaris; Brosmius vulgaris*, and *Lota vulgaris*, which lives in Lake Belemis, in Russian Lapland, and other lakes and rivers. From this the conclusion may be drawn that the limits of the *Gadidæ* for the eastern portion of the Arctic Ocean are the mouth of the Indigirka in the east, Spitzbergen and New Siberia in the north.

Iceland and the Faroe Islands are situated where the Arctic and North Atlantic Oceans join. Iceland has a perfectly isolated situation, for its distance from Norway is 120, from the Faroe Islands, 50, and from East Greenland, 40 miles. According to Fred. Faber, 1829, the *Gadidæ* are represented around Iceland by 1 genus with 11 species; but according to recent determination, 4 genera with 11 species, viz: *Gadus*, with 6 or 7 species, *morrhua callarias*, *æglefinus*, *virens*, *merlangus*, *nanus*, *Fabricii; Merlucius*, with two species, *communis*, *argentatus; Molva*

vulgaris, and *Brosmius vulgaris*. Iceland and Finmark have nearly the same genera of *Gadidæ* in common, viz: *Gadus*, *Molva*, and *Brosmius*. The genus *Merlucius*, with two species, and *Gadus Fabricii* are found in Iceland, but not in Finmark. The Faroe Islands have also four genera, but only 7 or 8 species: *Gadus*, with 4 or 5 species; *morrhua-callarias*, *æglefinus*, *virens*, *merlangus*; *Merlucius communis*; *Molva vulgaris*, and *Brosmius vulgaris*. Although these islands are situated about 2° farther south than Iceland, yet they produce less of the *Gadidæ*. This is probably caused by the violent cold current, the great depth, and extreme saltness of the water around these islands. The genera and species of *Gadidæ*, common to Iceland and the Faroe Islands, are *Gadus morrhua-callarias*, *æglefinus*, *virens*; *Molva vulgaris*, *Brosmius vulgaris*, and *Merlucius communis*; thus the purely northern types, *Gadus nanus*, *Fabricii*, and *Merlucius argentatus*, do not occur. The diminution of species and individuals, as also the disappearance of the northern types, indicate that Iceland and the Faroe Islands are situated at the southern limits of the northern region of the *Gadidæ*.

A powerful, cold Arctic current, proceeding from the Greenland Sea, between Greenland and Iceland to the south, joins a similar one from Davis and Hudson Straits. This current in its course southward crosses about 10° of latitude, a distance of 150 (German) geographical miles. It is deflected to the east by the rotation of the earth and the direction of the meeting currents, and combines, in 48° north latitude, and 40° east longitude, Greenwich, with the very warm Gulf Stream (16° C. = 60.8 F.) coming from the South Atlantic Ocean, and also deflected east. They cross each other; the lighter and warmer Gulf Stream continues its course near the surface, while the Arctic current, passing underneath the Gulf Stream, appears as surface-current near the Azores, onward to the Mediterranean, Madeira, and the Canary Islands. The Arctic current removes the *Gadidæ* region on the American coast 25 degrees or 375 geographical miles farther south than on the European, and the limit of the inhabitable region for them on the African coast 5° farther south than on the American.

The southern limits of the Arctic *Gadidæ* region run from the south of Iceland east and south around the Bank of Newfoundland to the Bay of St. Lawrence. No *Gadidæ* are found in the entire region of the cold Arctic current in the North Atlantic Ocean; its depth is too great by far, amounting to 17,700 feet between Iceland and Newfoundland. This cold current divides the Arctic *Gadidæ* region into an eastern and western part. The latter includes Greenland, Newfoundland and its bank, the Bay of St. Lawrence, Labrador, the countries bordering on the Hudson Bay, as also Arctic North America with its islands as far as Behring Strait.

In Greenland occur, according to Reinhardt, 4 genera and 10 or 11 species of *Gadidæ*, some of them rare, and the classification of others uncertain; but it has undoubtedly few species, only as many as Ice-

land, although it extends farther north and south. According to a more recent determination, 4 genera with only 9 or 10 species, and two rare genera and species are found: *Gadus*, with 6 or 7 species, *morrhua-callarias*, *æglefinus*, *virens*, *luscus*, *merlangus*, *nanus*; *Molva vulgaris*; *Motella tricirrata*; *Couchia argentata*; *Brosmius vulgaris* rarely occurs, and *Merlucius communis* still more so, which leads to the conclusion that the temperature of the water is very low.

Newfoundland.—The banks around Newfoundland are not, as is often supposed, sand masses accumulated there by the St. Lawrence River and the Gulf Stream, but a rocky submarine plateau, whose eastern and southern borders steeply descend to a great depth. Farthest to the eastward lies the Outer or false Bank 47° north 45° west, upon which the sea has a depth of 600 feet to 900 feet; the Great Bank extends over fully nine degrees of latitude from north to south; from west to east it covers in some places five degrees. The depth of the water varies from 50 to 360 feet; from the coast to the western border it is from 120 to 360 feet. The bottom around the southern part of the island consists of an uninterrupted series of shallows as far as Cape Breton and Sable Island. To the west there are several smaller banks, for instance, Porgoise Bank, Banquereau and Mizen Bank. The current of the sea strikes with great impetuosity against the borders of the bank and is thrown back from them with equal violence, while upon the bank itself the water is as smooth as in a harbor, if not agitated by heavy storms from a distance.

Remarkable results were obtained by the soundings and thermometrical observations of Commander Chimno of the English ship Gannet. He found a depth of 9,000 feet at the west end of the Great Bank. The sediment had a temperature of 13.3° C.,about 55.9° F., but the sea-water was only 4.6° C. = 40.3° F. at a depth of 6,000 feet, and even only 4.1° C. = 39.4° F. at 3,000 feet; the surface temperature was 15.5° C. = 59.9° F. In 43° 20′ north latitude and 60° west longitude from Greenwich, thirty miles to the south of the Sand Island, the depth was 15,600 feet. In 44° 3′ north latitude and 48° 7′ west longitude from Greenwich the sea was 9,900 feet deep.

Temperature at the sea's surface, 16.1° C. = 60.9° F.
at a depth of 300 feet, 6° = 42.8° F.
at a depth of 6,000 feet, 4.1° = 39.2° F.

The depth around the bank is from 10,000 to 15,000 feet. Upon the bank the water is not warmer than the surrounding is at a depth of 300 feet to 6,000 feet, namely, 4 to 6° C. = 39.2 to 42.8° F.

The "fishing-grounds," "cod-meadows," have an extent of about 200 geographical miles in length and 67 miles in breadth, and the yield of the cod fishery has not decreased since nearly 400 years. The codfish represents, then, the principal item of the national wealth around Newfoundland, upon the Bank, on the Bay of St. Lawrence, and the coast of Labrador, and the capture of this fish furnishes not only employment for entire fleets of the North Americans, but English, French, and Dutch-

men participate largely in it. In the Arctic *Gadidæ* region we find the greatest abundance of individuals, particularly in the eastern part near the Loffoden Islands and Finmark, and in the western part in the vicinity of Newfoundland and Labrador. The Bank of Newfoundland and the Bay of St. Lawrence form an extensive sea of fresh water, which receives continually new supplies from the Canadian lakes through the mighty St. Lawrence River.

Upon the Bank only three genera, with six or seven species of the *Gadidæ*, are found; not many more genera occur near the Loffoden Islands and Finmark, and few more species. Upon closer examination a few more species may be found there yet, but certainly not more than two or three; for the abundance of individuals reduces the number of genera and species; and a variety of food is wanting, too. The following genera and species are represented here: *Gadus*, with four or five species, *morrhua-callarias*, *æglefinus*, *virens*, *minutus; Molva vulgaris; Brosmius flavescens*, the latter being peculiar to the Bank.

Toward the northwest, the arctic *Gadidæ* region may be continued along the northern coast of North America. It extends from the coasts of Labrador to the 74° latitude, and to Behring Strait. The Hudson Bay and the Polar Sea, north of North America, are only slightly salt, on account of the influx from the American lakes and rivers; but the temperature of the water is low, and consequently the arctic *Gadidæ* are not numerous.

From Labrador to the peninsula of Boothia and 74° latitude, only two genera are found, including five or six species, *Gadus morrhua-callarias*, *virens*, *Fabricii*, and *merlangus*, which are captured in Baffin's Bay, in 74° latitude.

In the numerous rivers and lakes *Lota vulgaris* is found, the roe of which is used by fur-dealers for baking bread and tea-cakes. To the west of Boothia, as far as the mouth of the Mackenzie River, Beechey Island, and Behring Strait, the genus *Gadus* is represented by only two to three species, *morrhua callarius*, *Fabricii*. The range of the latter extends to Beechey Island. Capt. James Ross says: "We found four species of this fish on the northern coast of America and along the western coast of the peninsula of Boothia. They are common also in Davis Strait and Baffin's Bay, and two of them inhabit the sea east of Boothia likewise. The arctic *Gadidæ* are migrating fishes. In the eastern part they probably inhabit a submarine plateau, situated between Iceland, Jan Mayen, Spitzbergen, Bear's Island, Norway, and the Faroe Islands. From there they visit Spitzbergen, Iceland, Norway, traveling from 60 to 70 or 80 miles; certainly a considerable distance. In the western part, the abode of the *Gadidæ* must not be sought for to the north of Greenland and Iceland. It is either upon the Banks of Newfoundland themselves, or farther east, on the Northern Fucus Bank; for this yields an inexhaustible quantity of food, and the bank, with its calm, fresh water, offers desirable spawning-grounds. To reach these

the *Gadidæ* need not traverse the icy Arctic current; they have but to seek for the cool and fresh water of the bank. Adding to this that the distance from Greenland and Iceland is about 200 or 300 geographical miles, while from the Northern Fucus Bank to the Bank of Newfoundland it is but 100 miles, it is therefore more natural that the fishes migrate from the Fucus Bank than from Greenland and Iceland. If the Fucus Bank were scientifically examined, we should obtain certainty in regard to this question.

The two parts of the Arctic *Gadidæ* region are separated, from the mouth of the Indigirka to Behring Strait on the one side, and from the mouth of the Mackenzie and Beechey Island on the other. Probably these two parts diffuse through the depth and unite at the Behring Strait, and through it spread into the Pacific Ocean, along the American and Asiatic coast; for some *Gadidæ* of the Arctic type are met with in the northern parts of the Pacific. The abundance of individuals is very great on the two opposite coasts.

D.—THE ATLANTIC REGION OF THE GADIDÆ.

The Atlantic region of the *Gadidæ* comprises the sea extending along the eastern shores of North America from Nova Scotia to the 35th parallel; Cape Hatteras; from there in an easterly direction to the Azores by way of the Fucus Bank, extending as far north as Great Britain; the German Ocean and the Baltic, and south through the Mediterranean Sea as far as the Black Sea, and by way of Madeira to the South Canary Islands. We are unfortunately not acquainted with the fish-fauna of the Bermuda Islands and the Azores, but it is probable that here, too, some Atlantic forms of this widely-spread family will be found, as they occur very frequently near Madeira.

The Fucus Bank divides the region into two uneven parts, the Atlantic region of the *Gadidæ*, extending east and west of this bank. The western part, along the coast of North America, is the smaller of the two. South of Nova Scotia, as far as Philadelphia and Cape Hatteras, we find only 4 genera with 9–10 species, northern and southern fish living together within a small space.

East of the Fucus Bank the *Gadidæ* fauna changes very suddenly, exhibiting greater variety of form, size, and mode of life. In the north, we begin with the Scandinavian *Gadidæ*. Near the Scandinavian and the Cimbric peninsulas, the Danish Islands, and in the seas surrounded by these countries, there is a very rich *Gadidæ* fauna, rich not so much in individuals as in genera and species. According to Nilsson's account, of 1855, we find here 4 genera, with 17 species, but, according to more recent accounts, 8 genera, with 18–19 species. Southern Scandinavia and Denmark have, besides many northern varieties, genera and species of the *Gadidæ*, which never occur as far north as Finmarken, Iceland, and the Faroe Islands.

The geographical location, near a large mass of land, the size and physical character of the British Islands, is favorable to a large number of different fish, which find many excellent spawning and feeding places and plenty of food of every kind in the tepid sea, the shallow bottom, and the many bays and estuaries. Such a location is particularly favorable for the *Gadidæ*, which show a tendency to change genus and species at the expense of the number of individuals. We therefore find near the British Islands a great variety of genera, and the greatest variety of species of *Gadidæ* occurring anywhere in the world, viz, 40 per cent.

Although I am not prepared to give statistics of the cod fisheries near the British Islands, as the codfish are here mostly eaten fresh and do not get into the market in a preserved state, I know for certain that the different species never occur in such large schools as near the Loffoden Islands, near Finmarken, and near the Banks of Newfoundland. According to Yarrel, there are near the British Islands 9 genera and 22 species of *Gadidæ*; but, according to Dr. Günther's account, of 1868, there are 10 genera and 23–24 species, out of 60 species, found in the whole world. Among these there are many southern varieties of the *Gadidæ*, showing in a very marked manner the influence of the Gulf Stream; such as *Gadus poutassou*, *Motella maculata*, *Phycis blennioides;* and still the British Islands are only four degrees farther south than Denmark.

Toward the western coasts of France and Cantabria the *Gadidæ* almost disappear; only two northern varieties, *Gadus callarias* and *Gadus luscus*, occurring in these waters. This astonishing change can only be explained by the fact that the Aquitanian Sea, which is very deep, has very cold, briny water, which the *Gadidæ* do not like. It is possible that a submarine Arctic stream flows into this submarine cave, driving out all animal life. Such a stream must turn north of the Fucus Bank; for south of Cape Finisterre we find a great change in animal life, and the farther south we get the greater is the variety of species. Already between the Azores and the Portugese coast we meet with entirely new varieties; still more is this the case near Madeira and in the western part of the Mediterranean, while these varieties disappear near the South Canary Islands, in the eastern part of the Mediterranean, and in the Black Sea.

On the coast of Portugal northern and southern varieties are mixed in a very peculiar manner. The genus *Gadus* has left its genuine representatives behind, and from the southern region no distinct varieties are found; consequently, we find there only transition varieties from both regions. There are, nevertheless, in these waters, 3 genera with 6 species, viz: *Gadus* with 4 species, *luscus*, *pollachius*, *poutassou*, *Merlucius communis; Motella*, with 2 species, *quinquecirrata*, *maculata*. *Gadus luscus* and *Motella quinquecirrata* are northern, and *Gadus poutassou* and *Motella maculata* southern varieties.

Near the North Canary Islands, especially near Madeira, the south-

ern varieties of the *Gadidæ* very suddenly occur in great numbers, not so much as regards individuals and species, but as regards genera, and these partly live at a great depth, which the *Gadidæ* do not do otherwise. This shows that the water is not very briny, that its temperature is moderate, and that there is great abundance and variety of food. According to Lowe's account (1846), only *Macrurus atlanticus* occurs near Madeira; this fish does not even belong to the *Gadidæ*, while Dr. Günther, in 1868, found in the same waters no less than 10 genera and 12 species of *Gadidæ*.

The Mediterranean contains a considerable number of *Gadidæ* even in proportion to its fish fauna, which is peculiarly rich in genera and species. As regards the genera, they are about evenly divided between northern and southern varieties, while in the species there is a very striking preponderance of northern varieties. This is only another proof of the law of nature, that the torrid zone is rich in genera, the temperate zone in species, and the frigid zone in individuals. According to Risso, we find in the Mediterranean 6 genera with 11 species, and according to Dr. Günther (1868), 10 genera with 19 species. There is a remarkable difference between the western and eastern parts of the Mediterranean. The western part extends from the Strait of Gibraltar as far as the Strait of Messina; in the eastern part we include the Black Sea. *Strinsia tinca* is a variety of the *Gadidæ* peculiar to the Mediterranean. By the predominance of the genus *Gadus* the Mediterranean has a northern character, which, however, is strongly varied by a strong addition of South Madeira varieties. As there are near the North Canary Islands, and in the western part of the Mediterranean, 10 genera of *Gadidæ* out of a total number of 22—more than 45 per cent.—we find here the greatest number of genera.

In the Black Sea there are only 2 genera with 2 species, viz, *Gadus euxinus* and *Lota vulgaris*. Four genera with five species, among these two deep-water fish, are peculiar to the North Canary Islands and Madeira. Near the South Canary Islands, which are 40–50 geographical miles farther south, we find only *Mora mediterranea*. The Atlantic region is thus indicated by a distinct border-line. The temperature of the water is +6 to +8 degrees, Celsius.

As a scattered northern variety we find, strange to say, *Lota vulgaris* near Pine Island on the southwest point of Florida.* The occurrence of this genus in the lagoons of West Key can only be explained by supposing that *Lota vulgaris* belonged to the Mississippi, went into the sea to escape the great heat in the river, and was then driven by the hot Gulf Stream into the fresh-water stream near the coast. As a scattered southern variety, we find in the south temperate zone of the Atlantic Ocean, via the mouth of the La Plata River, near Montevideo, *Phycis brasiliensis*, which is, of course, peculiar to those waters.

* *Lota maculosa*, which is the species referred to, has not been recorded from farther south than Kansas City, Missouri. Pine Island Lake, in the Hudson's Bay region, is, perhaps, the locality intended.—B.

We thus find in the Arctic Atlantic Ocean four central regions of the *Gadidæ*, two in the north and two in the south. The first central region is about fifty to sixty geographical miles broad, about eight to ten geographical miles distant from the coast of Norway, running parallel with it between Bear Island and the Faroe Islands; therefore, within the limits of the above-mentioned warm stream. The second central region extending about two hundred and twelve geographical miles in length and 150 in breadth, is near Newfoundland and the Northern Fucus Bank. In both these regions the number of individuals is very large. In the South the first central region with 40 per cent. of species is near the British Islands, and the second with 45 per cent. of genera extends from the North Canary Islands as far as the western part of the Mediterranean. In the south the *Gadidæ* are stationary fish, which, near Great Britain, in the German Ocean, the Baltic, the Doggers Bank, the Fish Bank, Nymph Bank, Hollergrund, &c., are with more or less success caught all the year round.

E.—THE PACIFIC REGION OF THE GADIDÆ.

The North Pacific Ocean is not much influenced by the Arctic Ocean, as is shown by its fish-fauna. In the Behring Sea, the surrounding islands are on the American and Asiatic coasts. Arctic transition varieties and Pacific varieties are found together. Only one genus is found there with three, and according to Pallas five, species. On the eastern coast of Asia, in the Sea of Ochotsk, near Kamtschatka, the Kurile Islands and the island of Saghalien the same genus with the same species is found; but in the latitude of Newfoundland, near Saghalien, perhaps with the same wealth of individuals, so that the Japanese had numerous fisheries in the southern part of Saghalien which recently have passed into the hands of the Russians. We, therefore, likewise find here in the North few genera and species, but numerous individuals. On the west coast of Japan we find instead of these *Gadidæ* two new genera and species.

Farther south, on the north and east coast of China, west of the Philippine Islands, at the mouth of the Ganges and the Brahmapootra, we again find a peculiar genus and species of the *Gadidæ*. This is the only tropical variety, and its being found near the mouth of the Ganges and Brahmapootra can only be explained by the fact that the Brahmapootra brings a considerable quantity of cold, fresh water from the Himalaya Mountains, and that there is abundant food. Similar causes must exist near the Chinese coast and the Philippine Islands. A cold current certainly comes from the Sea of Ochotsk, goes through the Sea of Japan and the North China Sea and extends as far as Formosa and the west coast of the Philippine Islands. If we go in the direction of the Philippine Islands, passing the Central Australasian Islands, we do not meet with any *Gadidæ* till we have passed the equator and have reached the

south temperate zone near New Zealand. Here we find two genera with three species, viz, the genus *Lotella*, which we first found near Japan, but here with two new species, viz, *rhacinus* and *bacchus*, and a new genus and species *Pseudophycis breviusculus*. There is no other place on the whole southern hemisphere where the *Gadidæ* are so numerous, both as regards genera and species as here. The fact of so many *Gadidæ* being found on the west coast of New Zealand is explained by the peculiar condition of the sea, regarding which the voyage of the Gazelle has furnished us with more detailed information. According to the observations made by Baron von Schleinitz, on board the Gazelle, the temperature of the water on the northwest coast of New Zealand is the following: At a depth of 200 fathoms or 366 meters, 10 degrees C.; at a depth of 400 fathoms or 732 metres, 6 to 8 degrees C.; and at a depth of 600 fathoms or 1097 meters, only 4 degrees C. The quantity of brine is only 0.58 to 0.59 per cent.

On the west coast of North America, between Kodjak and Sitka, near Vancouver Island, and as far south as California, there is only one genus with five species. In the north, between Kodjak and Sitka, as far as Vancouver Island, the genus *Gadus* is represented by the species *morrhua*, *minutus*, and *macrocephalus*. *Gadus minutus* is found especially near Mount St. Elias. In the bay between Kodjak and Sitka there are large codfisheries. We therefore likewise find here northern varieties mixed with Pacific varieties; but the northern varieties preponderate by the number of individuals and species. Farther south, on the coast of California as far as San Francisco, we find two other species of *Gadidæ*. Even as far south as this, the cold Arctic currents may be traced, although of course they have lost a good deal of their original coldness. The *Gadidæ* now disappear for a long distance along the west coast of America, and we do not meet them till beyond the equator, in the south temperate zone, on the coast of Chili, which is under the influence of the cool Antarctic current. Here we find a northern genus, but with a peculiar species, viz, *Merlucius Gayi*.

In the Pacific Ocean we therefore find the largest number of individuals between Kodjak and Sitka and near Saghalien, the largest number of species on the coast of Asia, and the largest number of genera near Japan and New Zealand.

F.—DISTRIBUTION AND FISHING OF THE DIFFERENT SPECIES.

a. The following are specifically Arctic varieties of the *Gadidæ*: *Gadus saida* is found in the White Sea, having 3.2 per cent. brine. *Gadus navaga* is likewise found in the White Sea and on the coast of Northern Russia. *Merlucius argentatus*, *G.* is only found near Iceland. *Gadus Fabricii* is very common in the north frigid zone of the western hemisphere, from Iceland to Baffin's Bay and Beechey Island. Quantity of brine, 3.3 per cent.; temperature of water, 1–2 degrees C.

b. The following are the Arctic-Atlantic varieties of the *Gadidæ*: *Gadus morrhua L.* is found in all the seas of the northern hemisphere from 40–77 degrees northern latitude, and even enters the mouths of rivers, *e. g.*, the Tweed. In the Atlantic Ocean it is found from New York as far as Hudson's Bay, and from Finmarken and Iceland as far as the German Ocean. Between the 45th and 71st degrees northern latitude it is found in almost incredible quantities. Near Spitzbergen Martens did not find it, but according to others it is found there. It is found in moderate numbers on the west and east coast of Greenland; but from Finmarken to the Loffoden Islands, and from Iceland to Nova Scotia, it is found in enormous quantities. It has been caught near the Faroe Islands, the Shetland and Orkney Islands, the Hebrides, near Great Britain, the Irish Sea, the German Ocean, *e. g.*, east-northeast from Bamborough, at a depth of 204 feet, the Skagerak, the Kattegat, and the Baltic. It seems to prefer entering the Baltic through the Sound rather than through the Great Belt. On the German coast it is found near Kiel and the Stollergrund, at a depth of 7 fathoms, with a water-temperature of 4–5 degrees C., and 1.44 per cent. brine; on the coast of Sweden, near Bohuslän and Ronehamm, on the island of Gothland. Twenty-seven nautical miles from Ronehamm the percentage of brine at a depth of 65 fathoms is 0.82, and 41 nautical miles from Ronehamm, at a depth of 96 fathoms, it is 1.02. It is found as far as Dalarö, near Stockholm, where, at a depth of 5½ fathoms, it is 0.59, and a depth of 40 fathoms, 0.75. East and north of North America it is found in every bay and in all shallow waters, in enormous numbers; near Newfoundland, Nova Scotia, and Labrador, as far as the Chaleur Bay in Canada, and as far south as Philadelphia. In the Pacific Ocean it is found in the Sea of Ochotsk, the Behring Sea, near the Fox and Shumaghin Islands, south of Alaska, and on the west coast of North America, in the bay between the island of Sitka and Kodjak; therefore between the 50th and 67½ degrees northern latitude.*

In three salt-water ponds in Scotland, in Gallaway, Fife, and Orkney, codfish are kept and flourish very well. Yarrell distinguishes two varieties: A darker one, south of Great Britain and near the Dogger's Bank; and a lighter one, north of Scotland and near the Scotch Islands.

Fishing.—Fifty years ago the codfisheries north and east of Iceland decreased very much. The Dutch fishers nevertheless caught a good many, proving that the fish were there in considerable numbers, but kept in deep water. Near the Faroe Islands an annual decrease in the number of fish was noticed, while it was caught in considerable quantities on the north coast of Funen and Zealand. At the present time it is frequently caught in nets on the Nymph Bank and Doggers Bank, near the Loffoden Islands and Finmarken, at a depth of 5–6 fathoms, and on the bank of Newfoundland it is caught with lines at a depth of 3–4 fathoms, and also in large quantities in the Pacific Ocean between Sitka and Kodjak.

* *Gadus morrhua* is not known to occur in the Pacific Ocean.

Gadus callarias L. is, according to Dr. Günther, the juvenile variety of the codfish. Both kinds are actually found together in most regions, but we must also state that there are regions where *Gadus morrhua* but no *Gadus callarias* is found, *e. g.*, near Spitzbergen and in the Pacific Ocean; and *Gadus callarias* occurs in places where *Gadus morrhua* has so far not been observed, *e. g.*, on the west coast of France. This certainly is no proof against *Gadus callarias* being the juvenile variety, and is not intended as such; it is only intended to prove that *Gadus callarias* is not found as far north as the codfish, but occurs more in the south, probably because, as a juvenile variety, it is more sensitive to temperature and very briny water. It is found just as frequently on the coast of Iceland as on the coast of Denmark, and occurs near the Faroe Islands, Great Britain, Norway, and Finmarken. It is common in the German Ocean, on the Doggers Bank, and near Heligoland. It is larger and more frequent in the Baltic, especially on the coasts of Germany, Courland, Esthonia, and Livonia, but is not found near St. Petersburg. On the coast of Courland, eighteen nautical miles southwest of Libau, the percentage of brine at a depth of 21 fathoms is only 0.77. The stream-cod, which lives in currents of the sea, is said not to be as good as that living in calm water. It is a remarkable fact that the common codfish lives and spawns in company with other fish in a fresh-water lake near the northern shore of Iceland, called Olafsvate, which is separated from the sea by a narrow sand-reef, and was probably in former times a bay of the sea, whose entrance has been closed up by sand, but which receives fresh water from some spring. Thus *Gadus morrhua*, in its juvenile variety, *callarias*, here shows the genuine characteristics of a fresh-water fish. It is also found near Greenland, and Capt. James Ross says: "On the north coast of America and along the coasts of the passage west of the Boothia Peninsula we found 4 species of these fish (*Gadidæ*), which are also common in Davis Strait and Baffin's Bay; two of these species inhabit the sea east of Boothia." This fish is therefore found all through the northern seas and on the coasts of the United States as far as New York.

Yarrell says that there are four varieties; these are occasioned by its different location. It keeps on clayey bottom or on rocky bottom where there are many sea-weeds, and has a more grayish or reddish color according to its location. *Gadus æglefinus L.* is found very frequently in the northern seas. It occurs quite often near the coasts of Greenland and the Faroe Islands, and is very common near the coasts of Norway, Scotland, and Iceland; not so frequent, however, on the northern coast of the last-mentioned island, and is everywhere exceeded in numbers by the *Gadus morrhua*. It is numerous on the American coasts of the North Atlantic Ocean, especially in the Gulf of St. Lawrence. According to Schonevelde it is found in the Schlei, near Eckernförde and near Kiel. Near Eckernförde the depth is 6 fathoms, and the percentage of brine 1.51.

Fishing.—The largest fish are caught in the Bay of Dublin and on the Nymph Bank. It is frequently caught in the German Ocean, near Heligoland, on the west coast of Schleswig near Sylt, and on the Doggers Bank, in the Skagerak, the Kattegat, and on the Danish coasts, especially near Elsinore.

Gadus virens, L., lives in the North Atlantic Ocean and in the Polar Sea as far south as the 46th degree northern latitude, and is found from the British coasts as far as Finmarken and Spitzbergen, and from the Baltic to the coasts of North America. In Iceland it keeps chiefly near the south and west side of the island and does not seem to leave this coast; on the Swedish coast it is found near Bohuslän; near the British coasts it is found in the Frith of Forth and near Palperro. From there on it does not occur till the Mediterranean is reached.

Fishing.—On the coasts of the Faroe Islands and Norway these fish during certain years appear in such quantities in summer and autumn that nearly all the bays are filled with them; this is also the case near the Isle of Man and in the Mediterranean. On the north coast of Jutland they also occasionally appear in large numbers; but in the south of Denmark they are but seldom caught, and then chiefly in spring and autumn. Near Greenland they are seldom caught, more frequently in Davis Strait, on the bank and near Boston.

Gadus luscus, L., chiefly lives in the Polar Sea and the northern seas but goes farther south than the above-mentioned varieties. Near Great Britain, as far north as the coast of Sweden and Norway, east on the coast of Siberia as far as the Obi River, it is a most highly esteemed fish. It is found south on the coasts of Germany, the Netherlands, France, and Portugal (near Lisbon), and as far as the western part of the Mediterranean, the Bay of Naples, and Sicily; also near Greenland; it is found at a depth of 96 feet, 1½ miles east-southeast of Lowestoft.

Gadus merlangus, L., is found far north, but not in any great number. Its home is therefore south of the 60th degree northern latitude. It is not found near the east of Greenland and the north of Iceland, and it is rare near the south of Iceland and the Faroe Islands; it occurs frequently near the south coast of Norway, near Arendal, near Great Britain and the Orkney Islands. On the heights of Arendal the percentage of brine at a depth of 364 fathoms was 3.53. Near Iceland Faber found it all the year round only in the bay of Reikiavick. It is found at a depth of 204 feet east-northeast of Bamborough.

Fishing.—Near the Danish coasts, in the German Ocean and in the Baltic, it is common from May to September, especially on the Dogger's Bank, the Nymph Bank, and on the south coast of Iceland; it is also very frequent on the coasts of Southwestern Europe. It does not seem to occur on the western coast of the Cimbric peninsula, because it likes a sandy and moory bottom at a depth of about 360 feet, and therefore scarcely ever enters the shallow bays.

Gadus nanus Faber, the northern dwarf codfish, is found near the south

of Greenland, near Iceland only in the southwest, but very frequently in the Bay of Reickiavick; also from Finmarken, along the coast of Sweden and Norway, as far as Bohuslän, near Denmark and England.

Fishing.—In September this species, without being mixed with the *Gadus morrhua*, is caught near Iceland in vast numbers; it is distinguished by its small size and reddish color. Near Greenland and Denmark it is very common in winter.

Gadus minutus, L., the southern dwarf codfish, is very common in deep waters, and generally near the bottom at a depth of 1,000 feet. It is not found north of the 60th degree north latitude, but is found from the Baltic and German Ocean as far south as the Mediterranean, in the west on the eastern coast of North America, on the bank, near Boston and New York; but also on the western coast of North America, near Mount St. Elias. It is also called "Kagelin," and is used as bait in catching codfish. It is found at a depth of 96 feet, 1½ miles east-southeast of Lowestoft.*

Molva vulgaris, Flem., is found in the north between the 77th and 35th degrees northern latitude, from Spitzbergen to the Mediterranean, especially on the northern coasts of Europe as far as Iceland. The German Ocean, however, and the coasts of Norway seem to be his proper home, for here it is very common as far as Finmarken. On the coasts of Iceland it is found everywhere; it is rare in the north of Iceland, although it has been found as far as Grimsö; toward the west it gets more frequent, less so on the south coast. It is not very common, either, on the coasts of Greenland and the Faroe Islands, and it is not found in the Kattegat and the Baltic, while it occurs near the Bank of Newfoundland. It generally keeps near the bottom, and loves deep water more than common codfish; it is found on sandy and rocky bottom, at a depth of about 600 feet.

Fishing.—They are chiefly caught between Trondhjem and Bergen. The latter city alone furnishes about a million pounds every year. Next to the codfish and the herring it is the most common fish in the market. In Denmark it is caught by the fishermen on the west coast of Jutland as far as Heligoland. Large numbers are also caught near the western British Islands, the Orkney Islands, on the coast of Yorkshire, Cornwall, near the Scilly Islands, and nearly along the whole coast of Ireland. Near Iceland it is chiefly caught near Westjökul.

Brosmius vulgaris, Flem., or the small-headed cod, is chiefly found in the north, and on the European coasts it is not found much farther south than the 60th degree northern latitude, and not much farther north than the 70th degree. Large numbers are found on the coasts of Norway as far as Finmarken, on the west and south coasts of Iceland, and near the Faroe Islands, the Shetland and Orkney Islands, and the Frith of Forth; it is only found near the most northern point of Denmark, where it is occasionally caught near Skagen, in Jutland. It is not caught on the southern coasts of Denmark. It seldom occurs near the north and east

* The writer has confused several species under the name *Gadus minutus*.

coast of Iceland; it is said to be rare near Greenland, while it is frequent near Boston, thus being found 15 degrees farther south on the western shores of the North Atlantic Ocean than on its eastern shores. This fact certainly is a striking proof of the influence of the Arctic current. It lives in deep waters where sea-weeds grow, and is consequently but little known and rarely caught even in localities where it is frequent.*

We will, among the last of the Arctic-Atlantic varieties, mention the one which is mostly found in fresh water, viz, the *Lota vulgaris*. This fish is found throughout the greater portion of Central, Northern, and Eastern Europe as far as the western, northern and northeastern portion of Asia and the northern portion of North America (*Lota maculosa*). Its most westerly limit in Europe is in the Rhine, near Manheim; it is common in the Reuss, near Sissingen, and in the Lake of Constance, in the Weser, the Elbe, the Moldau, near Budweiss in Bohemia, near Teschen on the Oder, and in the Vistula. It is very common in the region of the Danube, in the Danube near Passau, in the Salzach, the Weitra, in the Traun Lake, the Atter Lake, Hallstädter Lake, Fuschler Lake, Mond Lake, and Zirknitzer Lake; in the river Drau, in the river Ramp near Zwettel, near Datschiz in Moravia, in Transylvania, in the river Stry in Galicia. The most southerly point where it is found in the region of the Po is the Garda Lake. It is found in the Swiss lakes, in the St. Maurice Lake at a height of 5,580 feet, and in the Lake of Seelisberg, near the Lake of the Four Cantons at a height of 2,240 feet. On the other side of the channel it is found in the west of England and in Scotland, in Norfolk, Lincolnshire, Yorkshire, Durham, in the rivers Cam, Trent, Thames, Ouse, Esk, Skern, Tees, Derwent, and also in the Firth of Forth; also in Central Scandinavia—Götaelf—and Northern Scandinavia, in Finmarken and Lapland. In Russia it is found nearly everywhere, in the Neva near St. Petersburg, in Lake Balamis in Russian Lapland, according to Rathke, in the Black Sea, and, according to Pallas, in the Obi River; it is very common in the river Lena and in the Northern Polar Sea as far as the Indigirka River, also in the Penshina River which flows into the Sea of Ochotsk. In North America it is common in Canada and in the neighboring portions of the United States, as well as in the lakes and rivers of the Hudson Bay region. It is found in Lake Madawaska in Canada, and in the sea near Pine Island in the Strait of Florida.† It likes the deep, cool, and clear bays of the sea or the deep basins of the ocean, but it is likewise found in large and small rivers and ponds both in flat and mountainous countries, in lakes frequently at a depth of 180 to 240 feet.

c. The following are Scandinavian varieties: *Gadus Esmarkii Nilss.* is only found on the south coast of Norway, in the Christiana fiord. *Molva abyssorum Nilss.* is perhaps the same as the *Gadus barbatus* in

* Sea-weeds do not grow in water deeper than 25 fathoms. *Brosmius vulgaris* (= *B. brosme*) is by no means rarely caught.—B.

† Rather Pine Island Lake, in the Hudson's Bay region.—B.

the Hamburg aquarium, and is only found on the coasts of Scandinavia. *Motella cimbria Nilss.* is common on the coasts of Northern Europe, in the Atlantic Ocean, on the west coast of Norway, in the Kattegat, on the south coast of Sweden near Bohuslän, but it is rare in the German Ocean, on the coast of Scotland, in the Frith of Forth, and on the coasts of England.

d. The following are British varieties: *Gadus pollachius L.* is found in large schools on the coasts of Europe, especially in the German Ocean, near the British coasts, near the Orkney Islands, and on every rocky coast as far as the Baltic, where it hides deep between the rocks; also on the coast of Portugal, from Lisbon to the Western Mediterranean. *Raniceps trifurcatus* is found on the coasts of Northern Europe, especially in Berwick Bay, on the east and west coasts of Scotland, in the Frith of Forth, near Ireland, especially the Bay of Donaghadee. It is rare on the coast of Cornwall and on the coast of Norway, as likewise on the Swedish coast near Bohuslän. The genera *Couchia Thomps.* and *Hypsiptera Gth.* are rare and very small sea-fish, which live in the open North Atlantic Ocean, and only visit the coasts occasionally. *C. Edwardii* was only discovered in the Moray Frith in 1866. *C. glauca* is found in the British and Scandinavian Seas near Polperro, Falmouth, and in different portions of the Channel. *C. argentata* is common from the west coast of England to the coasts of Greenland. *Hypsiptera argentea G.* is found in the open sea of the North Atlantic Ocean.*

e. The following are Mediterranean and Madeira varieties: *Gadus poutassou Riss.* is found on the coasts of Europe, in the Mediterranean, and nearGreat Britain. *Merlucius communis C.*, the common sea-pike, also called small codfish, is found not only in the North, but still more frequently in the Mediterranean. It is common from the southwest coasts of Europe to the German Ocean, especially near Scotland, in the Frith of Forth, England, and Ireland. The Bay of Galway is also called "Bay of Hakes," on account of the great number of these fish. In the Mediterranean it is very common (*M. esculentus Riss.*); also on the coast of Portugal near Lisbon, as far as Madeira; likewise on the east coast of North America. It is rare near Greenland, and is only found near the south coast; it is likewise rare near Iceland, where it is only found on the south and southwest coast. It is not found near the Faroe Islands and Finmarken, nor in the Baltic.

Fishing.—On the Nymph Bank they are so numerous that six men have caught 1,000 with lines in one night; great numbers are also caught in the Bay of Galway. It is frequently caught in the south of Norway and on the west coast of Jutland.

Motella quinquecirrata is not very common in northern latitudes. It is found on the coast of Portugal near Lisbon, near Ireland, near Portland, Brighton, on the coasts of Kent and Devonshire, in the Frith of Forth near the Orkney Islands, in the mouths of the Elbe and Eider,

*The U. S. Fish Commission has this species from off Cape May, New Jersey.—B.

near Heliogland (this is perhaps the *G. barbatus*); also on the coast of Schleswig-Holstein, in the mouth of the Schlei, the Bay of Kiel as far as Bergen, in Norway. It seems to like the deep sea where the bottom is rocky and overgrown with sea-weeds.

Motella tricirrata Nilss. is found in the Mediterranean and as far as Greenland. In the Mediterranean it is found in the Bay of Naples and near Trebizond. Near Ireland it is found in the Bay of Belfast. It is rare on the coasts of Great Britain, Devonshire, Cornwall, east coast of Scotland, Solway Frith.

Motella maculata G. is found on the coasts of Europe from the Mediterranean to Great Britain; in the Mediterranean near Sicily; in the Adriatic Sea near Dalmatia; also near Madeira, on the coast of Portugal near Lisbon; near Plymouth, Cannes, and on the coast of Devonshire.

Phycis blennioides Bl. is found on the coasts of Europe from the Mediterranean to Great Britain; in the Mediterranean near Sicily; very large near Madeira; numerous near Liverpool, Plymouth, Palperro; near Ireland, in the Axwich Bay; in the German Ocean; especially on the coast of Cornwall; Flintshire near Bowness; St. Andrews, in Scotland; in the Solway Frith. A young fish of this kind, measuring 3 inches in length, was caught at a depth of 300 feet.

Phycis mediterraneus Delar. is common in the Mediterranean near Sicily, where it is called *Mollera Figo* by the fishermen; also in the neighboring portions of the Atlantic Ocean near Madeira. It lives at a great depth, sometimes 1,200 feet, but is highly esteemed, and is frequently caught.

Gadiculus blennioides G., *Strinsia tinca Raf.*, *Molva elongata Nilss.*, are all found in the Mediterranean; *Gadiculus argenteus Guich.* is found on the coast of Algiers; *Uraleptus Maraldii Cost.* and *Haloporphyrus G.* are common to the Mediterranean and Madeira; *Mora mediterranea Riss.* from the Mediterranean to Madeira and the South Canary Islands. *Physiculus Dalwizkii* and *Læmonema Yarrellii et robustum* are found near Madeira; *Chiasmodus niger* and *Halargyreus Johnsonii G.* live near Madeira, at a depth of 1,800–1,900 feet. As with the *Saccopharynx*, the stomach of the last-mentioned fish had, in catching it, been driven into its mouth by the pressure of the air.

f. Gadus euxinus Nordm. is a Black Sea variety, which is common from the Black Sea to the Eastern Mediterranean and the Adriatic Sea on the coast of Dalmatia.

g. The following are North American Atlantic varieties: *Gadus tomcodus Mitch.* is common on the Atlantic coast of the Northern States of the Union near Boston and New York. *Brosmius flavescens Les.* is found on the Bank of Newfoundland. There are three species of *Phycis* on the east coast of America, two in North America, and one in South America. *Phycis regalis G.* is found on the Atlantic coast of the Union near New York. *Phycis americanus Stor.* is likewise found on the east coast of North America as far north as New York; and *Phycis brasili-*

ensis Kaup. is, strange to say, found near Montevideo, on the east coast of South America. The cool, fresh water of the La Plata River may be the cause.

h. The following are Pacific varieties: *Gadus chalcogrammus P.* is found near Kamtschatka, in the Behring Sea, and the Sea of Ochotsk. *G. macrocephalus Til.* is very common in the sea near Kamtschatka and America, and ascends rivers. In May and September it is common in the Bay of Avatscha. *Motella pacifica Schleg.* and *Lotella phycis G.* are common near Japan as far as the coast of North China, near Tschusa. As an intermediate variety between these two genera and the two following, we must mention a tropical genus found in the Pacific and Indian Oceans, viz: *Bregmaceros Macclellandii Thomps.* on the coast of the Philippine Islands, South China, and near the mouth of the Ganges. It is probable that the cool and fresh glacier water of the Brahmapootra and the rich vegetable food have enticed this genus so far east. *Lotella rhacinus G., bacchus G.*, and *Pseudophycis breviusculus G.* are found in the south temperate zone near New Zealand and in Queen Charlotte Sound. *Gadus californicus G.* and *Gadus productus G.* are found on the coast of California as far south as San Francisco. Then we find no more fish of this kind till we reach the south temperate zone, where *Merlucius Gayi Guich.* is found on the coast of Chili.

G.—FISHERIES AND TRADE.

a. Norway.—We will only give the results of the last 5 to 6 years. In 1871 the codfisheries in Söndmöre were very extensive. Up to March 19, 4,000,000 fish had been caught, valued at $336,000. The spring codfisheries near the Loffoden Islands produced in 1870, 18,000,000 fish; in 1871, 16,500,000; in 1872, 17,500,000, and in 1873, 19,500,000; 50,000 tons, or at least 25,000 tons oil; 18,000 tons roe, or 2,000,000 fish more than in the preceding year, and about 500,000 more than the average yield of the last 14 years. The total value of the products of these fisheries stands probably alone in the history of the spring fisheries, and was $1,904,000 against $1,411,200 in 1872, and the average of $1,400,000 during the years 1859–'72. Of this sum the fishermen of Marstrand received $24,640, and the fishermen of Bohuslän, $61,600. In 1873 the Marstrand fishermen only received $24,366.72. In 1874 the codfisheries near the Loffoden Islands were not successful—only 15,000,000 fish having been caught—while in 1875 the unusual number of 23,000,000 were caught. The codfisheries near Finmarken were also successful, yielding 20,000,000—the greater portion of which were caught on the coast of East Finmarken; prices were very low, however. Near Söndmöre, Romdalen, and Nordmöre, more codfish were caught than in an average year, viz, about 6,500,000. The Norwegian codfisheries have, therefore, in the year 1875, yielded a total of 50,000,000 fish, or seven to eight million more than an average year.

b. Sweden.—The statistics are fragmentary. In 1871, 318,075 pounds of dried cod were shipped from Gothenburg.

c. Denmark.—In 1871 a considerable number of codfish were caught on the west and east coast of Jutland, and 321,000 pounds, valued at $3,360, were exported, viz, 80,000 pounds from Aalborg, 80,000 from Hjärring, 161,000 from Frederikshavn. In 1871 a great number of codfish were caught near Greenland. In 1876 the codfisheries on the north and east coasts of Iceland were successful, while on the west, and especially on the south coast, they proved failures.

d. Germany.—In 1873 the fishermen caught a large number of codfish from the mouth of the Elbe to Jutland. The Heligoland fishermen brought 650,000 pounds of fresh and 8,000 pounds of dried cod to Geestemünde. In 1874, 300,000 kilograms (661,421 pounds) of cod were caught near Eckernförde. In March, 1876, 70,260 codfish, valued at $1,750, were caught near Travemünde.

Besides these incomplete data we will give the following statistics of the North European fisheries:

Year.	Country.	Million fish.	@ 30 pounds.	Pounds.
1870	Norway	41	@ 30 pounds	1,230,000,000
1871	do	40	do	1,200,000,000
1871	Sweden			318,075
1871	Denmark			321,000
1872	Norway	40½	@ 30 pounds	1,215,000,000
1873	do	41½	do	1,245,000,000
1873	Germany			658,000
1874	Norway	39	@ 30 pounds	1,170,000,000
1874	Germany			1,000,000
1875	Norway	50	@ 30 pounds	1,500,000,000
Total				7,561,897,075

7,561,897,075 pounds = 75,618,971 hundred-weights, at $2.25 = $170,142,932 in 6 years, or an average of $28,357,155 per year. Count about 50 per cent. loss, and there remain still about $14,128,577 annual income from the codfisheries on the coasts of Northern Europe. All these figures are only relatively correct, as they are based on very incomplete and imperfect data—oil, glue, manure, and other minor products of the fisheries not being counted at all. Not till we possess complete fishery-statistics from all the States of Europe, can we ascertain the productiveness of systematic fishing. We embrace this opportunity to ask all superintendents of fisheries to assist us by sending reports, so that by degrees we may be enabled to give more reliable statistics of our fisheries.

e. The codfisheries near Newfoundland yielded 400,000,000 fish. In the year 1790 the English brought about 656,000 hundred-weights into the market; in 1814, already, 1,245,808, valued at £2,831,528; in 1825, only 973,000 hundred-weights; in 1835, only 712,000, valued at £356,000; and in 1848 again about 1,000,000 hundred-weights. The French, likewise, caught about 1,000,000 hundred-weights in 1848. The Americans

caught about 1,773,000 hundred-weights in 1829. In 1842, St. John's exported codfish and oil valued at $4,476,315. In 1848, the Americans caught 1,500,000 hundred-weights. Nova Scotia exported codfish valued at $786,000. Counting the hundred-weight at $2.25, and counting 3,500,000 hundred-weights, an average annual yield, Newfoundland exports $7,875,000 worth of codfish, besides oil and other valuable products of the fisheries.

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