

MEDDELELSER

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KOMMISSIONEN FOR HAVUNDERSØGELSER

SERIE: FISKERI · BIND III

Nr. 7. JOHS. SCHMIDT: ON THE DISTRIBUTION OF THE FRESH-WATER EELS
(*ANGUILLA*) THROUGHOUT THE WORLD.

I. ATLANTIC OCEAN AND ADJACENT REGIONS. A BIO-GEOGRAPHICAL
INVESTIGATION. WITH ONE CHART

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BY

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OF THE FRESH-WATER EELS (ANGUILLA)
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¹ This paper is a translation of "Ferskvandsaalenes Udbredning i Verden" etc. published in "Mémoires de l'Académie Royale des Sciences et des Lettres de Danemark, Copenhague", 7^{me} série, Section des Sciences, tome VIII, no. 3, 1909.

KÖNIGLICH DANISCHES
VITENSKABSAKADEMIENS
SAMLINGE
1909

I. INTRODUCTION.

FROM the investigations which I carried out in the years 1904—1905 with the Danish investigation- steamer "Thor" in the Atlantic waters off the coasts of N. and W. Europe, in order to determine the distribution of the larvae and the spawning regions of the common fresh-water eel, I came to the conclusion that, in order to be able to propagate, this species demands certain external conditions (chiefly great depths with high temperature and salinity of the water, see SCHMIDT, 1906, p. 266).

As I have shown in the above-quoted work, this conclusion proved wholly correct for the regions investigated, namely, the N. E. portion of the Atlantic and Norwegian Sea. This distribution constitutes only a small portion of the territory in which fresh-water eels (genus *Anguilla*) occur and the thought immediately struck me that it might be of great interest to test the validity of the above conclusion for other seas of the world, and thus eventually to gain further corroboration for it. But, even at the very beginning of the preparatory investigations, it was obvious to me that the work to be done would require years for its execution, in the first place, because the systematic classification of the *Anguilla*-genus is in the most complete disorder and confusion, and in the second place, because our knowledge of the facts of distribution is also defective, as also applies to the hydrographical conditions, which are of importance in this connection. As the publication of the above-mentioned work could not be postponed, since it constituted a portion of the work of the international investigations of the sea, I had at that time to exclude an investigation into the wider distribution of the fresh-water eels. But four years ago I already began to collect material in this direction and have carried this on to as great an extent as time has permitted.

During this work it has been my idea partly to try and bring order into the systematic classification of the genus *Anguilla* and partly to come to an understanding of the distribution of this genus throughout the world and the external conditions on which this distribution depends. Even now, this large task is far from being completed, but still, the working up of some of the points is so far advanced that I consider it most correct to publish that part of it which is already completed. From purely practical considerations I will defer the publication of the systematic examination to a subsequent occasion and as regards the separation of species I content myself here with making a separation between (1) uniformly-coloured *Anguilla*-species such as the European and N. African *Anguilla vulgaris* TURT. and the American *Anguilla chrysypa* RAF. (see SCHMIDT 1906, p. 239) and (2) the brindled or marbled *Anguilla*-species such as the Indian *Anguilla bengalensis* HAM. BUCH. This separation is quite sufficiently accurate for this preliminary part of the work, which is only occupied with the conditions of distribution, especially as in the region principally dealt with here, viz. the Atlantic Ocean, there only occur the two uniformly coloured *Anguilla vulgaris* and *Anguilla chrysypa*, the mutual relations of which I have already discussed (l. c. p. 239).

In the Indian and Pacific region there occur, in contrast to the Atlantic, both uniformly-coloured and mottled eels, and I have examined hundreds of specimens from Japan, Java and New Zealand; but

about this I shall here only remark that the result tends in high degree to reduce the number of species set up, a great many of which are obviously based on the examination of single specimens; and their description has thus been made quite uncritically and necessarily so, since nothing was known about the systematic value of the characters used.

So long as the relation of these eels to the relatively well investigated Atlantic eels (*A. vulgaris* & *chrysypa*) remains obscure, even in systematic regards, it will naturally be quite useless to discuss their biology on the basis of our knowledge of the biology of the above forms. To this must be added, that those hydrographic conditions in the Pacific Ocean which are of interest to us are also rather imperfectly known over great distances. It is for these reasons that I only take up preliminarily the Atlantic Ocean and adjacent waters.

The first thing which had to be done for this work was to secure the information where fresh-water eels were to be found in the world, and what is of no less importance here, where they were not to be found. For this purpose, numerous works treating of the fish-fauna of the different regions had to be consulted, and this task has taken up much of my time, as I was not familiar with the ichthyological literature in distant lands, which is naturally found scattered in small pamphlets and lists in the most diverse journals. Further, there is also the difficulty in being obliged to utilise works which are often only based on a short visit of an expedition or a collector in the region concerned, viz. that one does not get the least information as to whether the eel was there one of the most common fish or whether on the contrary perhaps a single specimen had only been taken once, or whether its scarcity in numbers in the collections is due to the fact that it is a rare fish there or merely that suitable instruments for its capture have been lacking. In short, the ordinary collector's list very often gives absolutely no conception of the numbers of eels occurring at a place or the part they play in the fish fauna of the region, and what is worse, one cannot always be sure from the apparent lack of eels in the lists that this is true in reality. It is therefore only in such instances where we find the same results in many different reports that we can safely place reliance on the absence of eels at a place, or where the reports dealing with a neighbouring region show the same condition (cf. p. 22). I have therefore tried to overcome these difficulties as far as it has been possible at the present time by communicating with institutions and persons in the different regions of the world from which better information than the literature could give was desirable, and as will likewise be seen, I have often received very instructive and valuable answers. There is special reason for giving prominence to the valuable assistance rendered by the Danish Consuls throughout the world, as will be seen most clearly on reading the following section. A report stating that eels are fished for here or there is, of course, of the greatest value in this connection, to a much greater extent in fact that a record of the occurrence of one or other newly established *Anguilla*-species more or less distinguishable from the description in a list of fish species collected, may be by chance, in that region. That such information as the first mentioned gives a much more solid basis in judging of the quantities in which the eel occurs, is plain enough, but even negative information that eels are not fished for in the locality or that the natives do not know it or have no name for it can also be of great value and information on this point has always been asked for in my enquiries. It is from a combination of the available scientific fauna-lists and from the information obtained from institutions and persons belonging to the regions in question that I have reached the following general view concerning the distribution of the fresh-water eel; in every case however the source of my information is shown.

After the raw material for a description of the distribution had been collected the problem was to try and understand it, i. e. by studying the external conditions to show why the eel is found just at one place but not at another. This side of the problem, undeniably the most interesting, will be discussed in the third section.

Before describing the distribution of the eel in the different regions with which we are here concerned, I may remark that on this occasion essentially only the distribution in the regions close to the coast are to be considered, that is, those places where the eel has direct communication with the sea. We have certainly a very interesting and instructive problem if we investigate how far the eel penetrates at the different places up into the land through the large fresh-water systems debouching into the sea; but I have preferred not to make the present explanation too long, and to defer the discussion of this part of the question to a later opportunity. I shall therefore confine myself merely to the remark here, that nothing is better suited to at once illustrate the fact that the fresh-water eels breed in and come from the ocean than a representation on a chart of the world of how far up they occur in the fresh-water; we see immediately how they decrease in numbers the further we go from the ocean, until at last they entirely disappear. North America offers a good example of this, for the density of the eels in the different provinces varies greatly, a fact which I have tried to represent on p. 8 of the present work.

II. DISTRIBUTION OF THE FRESH-WATER EELS.

A. Western Part of the Regions considered.

Greenland.

According to FABRICIUS (1780, p. 137) the eel is met with, though rarely, in the southern rivers and lakes of Greenland. This has recently been confirmed as the Zoological Museum, Copenhagen, has acquired a silvery female specimen of the Greenland eel. Concerning this Cand. mag. AD. JENSEN, Zoological Museum, Copenhagen, has kindly communicated the following:

"The eel was sent down in the autumn of 1903 by the Colonial officer Brummerstedt. It was caught in the same year by means of a spear by the Esquimau Elisa, in an estuary on the estate of Igdlukasik, about four Danish miles S. of Nanortalik on the most southerly portion of the west coast of Greenland. It measured 603 mm.; the distance from the point of the snout to the dorsal fin 195 mm.; the distance between the beginning of the anal fin and that of the dorsal 61 mm.; the length of the head 69 mm. The first portion consequently makes up 32.5% of the total length, the next 10.1% and from this we must conclude that it does not belong to the European *Anguilla vulgaris* Turr. but to the American *A. chrysypha* Raf. (cf. JORDAN and EVERMANN, 1896 a, p. 349) as one was also entitled to expect from the distribution".

This interesting find thus confirms FABRICIUS' long unconfirmed statement that some eels live in the southern portion of West Greenland, but that it is only a question of very few specimens is also certain. On the northern portion of the west coast and on the east coast they are not found (AD. JENSEN, 1904), what one as a matter of course could not expect considering the extremely unfavourable conditions which prevail there, both for the conveyance of the young and for its thriving in these arctic, ice-bound regions.

This same conclusion undoubtedly holds also for the most northerly portion of the American Continent (W. coasts of Davis Straits), where the natural conditions are if possible even more unfavourable for the occurrence of the eels; but I have no certain knowledge until we come as far south as Labrador and Newfoundland.

Labrador; Newfoundland.

On inquiry, Mr. JOHN BROWNING, the Danish Consul in St. Johns', Newfoundland, communicates in a letter of 30th April 1908 the following information, for which we are indebted to Mr. W. B. PAYN, the Deputy Minister of the Department of Marine and Fisheries:

"Fresh water eels are found in mostly all our lakes and rivers, but not in great numbers. They are also found on Labrador. There is no eel fishery of any importance in this country. They are only caught now and again by trouters except on the West Coast where they are caught with traps".

To this Mr. BROWNING adds the following remarks:

"I have made several inquiries but cannot obtain further information than is contained in the reply of the Marine and Fisheries Department excepting that the eels are not of a large run; an occasional large one is caught".

Concerning the number of eels caught in Newfoundland no information can be given. According to the "Annual Report of the Department of Marine and Fisheries, Newfoundland" for the year 1906, St. Johns', 1907, p. 33, there were exported in the year 1906 from the Colony 53 barrels of eels to a total value of 465 dollars.

From this the conclusion can be drawn that the eel occurs in Labrador and that in Newfoundland it must be a commonly occurring fish, since on the W. coast it is the object of a fishery with traps and since there is an export, though modest, from that place.

Canada.

Through Captain A. SØLLING, the Danish Fisheries Agent in London, I have received the following information from Professor E. E. PRINCE, Commissioner of Fisheries for Canada (in a letter of 20th Feb. 1906):

"Only one species is recognized in this country; it is called *Anguilla chrysypa*, Raf., sometimes *Anguilla rostrata*. It occurs in most rivers from Prince Edward Island, Cape Breton and Nova Scotia on the east to Lake Ontario and adjacent lakes on the west, an area of over 300000 square miles. Some of the places where eels are obtained in very considerable quantities are: the rivers of Prince Edward Island especially Cardigan, Morell and Durk Rivers, also Cape Breton especially the Grand River and Mira River. In New Brunswick the chief eel rivers are the St. John and the Nepisiguit, in Quebec the Three Rivers and the Richelieu River. From all these nine rivers and twenty or thirty more frozen eels are shipped to New York and London.

The elvers ascend from the sea in July and August. Unfortunately there is no literature on the eels in Canada. They are not eaten generally here as we have such quantities of salmon, trout, Coregonus or whitefish and the finer qualities of seafood; hence eels are despised by our people generally".

Through the Danish Consul General in Montreal, Mr. H. H. WOLFF, I have obtained the following interesting information communicated by the Office of the Minister of Marine and Fisheries of Canada and signed L. P. BRODEUR:

"I may say that eels are more or less plentiful from the Maritime Provinces, even as far west as Lake Ontario. The following is a statement of the quantities and value of eels caught in the different Provinces in which they are taken, during 1904:

	Lbs.	Dollars
Prince Edward Island	270,000	13,500
Nova Scotia	554,000	27,720
New Brunswick	649,200	32,460
Quebec	897,800	53,534
Ontario	45,500	2,730

In the Province of Quebec, eels are caught all along the St. Lawrence River from Lake St. Francis to the Gulf, as well as in all the main tributaries, and notably in the Richelieu River, from which eighty to ninety thousand pounds are annually taken.

In the southwestern portion of Quebec eels are caught towards the end of June, after the high water has receded, when they start to descend to the Gulf, and their capture continues throughout the summer and even late into the fall in the eastern portion of the Province".

The above report completely establishes the fact that a very large number of eels occur in the Atlantic Provinces of Canada. From the numbers of the eels captured in the different Provinces one gets a clear impression that the eels decrease in numbers as one travels from places near the sea such as

Nova Scotia, Prince Edward Island and New Brunswick, in a westerly direction towards Quebec and Ontario. (Thus compare the ca. 650,000 lbs. caught in New Brunswick with the ca. 900,000 lbs. caught in Quebec, a Province ever so many times greater but lying more westerly or more remote from the sea; or what is still more obvious Prince Edward Island (270,000 lbs.) with the larger Province Ontario (45,000 lbs), the Province of the Dominion of Canada where the eels are at all taken which is situated farthest from the Atlantic Ocean.)

With respect to the species of the eels occurring in Canada I am able to refer to my earlier work (SCHMIDT 1906, p. 240), in which 100 large eels from the St. Lawrence River have been examined and found to differ from the European fresh-water eel by distinct anatomical and morphological characters, e. g. number of vertebrae, which in the specimens investigated was generally considerably lower than in the European species.

United States.

JORDAN and EVERMANN (U. S. Commission of Fish and Fisheries, 1896, p. 269) record the occurrence of the eel (*Anguilla chrysypa* Raf.):

"Atlantic Coast of the U. S.; very abundant from Maine to Mexico, ascending all rivers S. of Canada and E. of the Rocky Mountains and resident throughout the Mississippi Valley".

In addition to this summary given by JORDAN and EVERMANN regarding the distribution of the eel, we find its occurrence mentioned in various of the local fish-fauna, in which the North American literature is so rich. Some impression of the varying density with which it occurs in the different parts of this large territory, cannot however be obtained from these. As it was nevertheless of great interest in this connection to know something of the matter, I have endeavoured by means of the fisheries statistics to obtain some trustworthy and usable information. I have received the material through the Danish Consul General in New York, Mr. J. CLAN, from the Commissioner of Fisheries in Washington, Mr. GEO. M. BOWERS, in the form of a statement of the "yield of eels (*Anguilla chrysypa*) in the United States", in which the yield for the separate States is given. The contents of this statement are shown in the Table p. 8.

For the biological study which concerns us here, we may divide the United States into three regions, namely:

- 1) Eastern Region or the States in which the rivers flow out into the Atlantic north of Florida¹, thus in the main the region east of the Alleghanies.
- 2) Central or Gulf Region, i. e. the region (lying west of Florida) where the rivers open out into the Gulf of Mexico and which to the west is bounded by Montana—Wyoming—Colorado—New Mexico².
- 3) Western Region, i. e. the region which is drained into the Pacific Ocean and which is situated to the west of Montana—Wyoming—Colorado—New Mexico², thus in the main the region lying west of the Rocky Mountains etc.

From this division it follows, that the eels found in the Eastern Region must run up the rivers which flow out into the Atlantic east of Florida, whilst the stock of eels in the Central Region must come from the Gulf of Mexico (west of Florida).

¹ In choosing Florida as the boundary between the first two Regions, so that it is not included in either of them, the reason is partly, that this State by its form acts as a natural division between the two seas (Atlantic and Gulf of Mexico), from which the eel fry can penetrate into the fresh water and live there, partly because the statistics do not mention any eel fishery in Florida, though there can be no doubt that eels occur there, since there is a fishery for this species in the neighbouring States.

² The boundary States Montana—Wyoming—Colorado—New Mexico between the Central and Western Regions are not included in either of these.

Before giving the results of the comparison I may expressly state, that this method naturally cannot give an exact picture of the density of the eels in the various States. There is no doubt that the existing stock of eels in the various States is not everywhere sought after with the same energy or with equally developed methods, and it is also possible that the statements of the yield, which form the basis of the statistics, are not everywhere made in the same manner¹.

Considerable shortcomings thus exist on this method. In believing nevertheless in spite of these, that important conclusions can be drawn from the comparison, the reason is that the results are so extremely distinct and striking, that there can be no doubt they give us on the whole a correct picture of the actual conditions.

Table showing the Yield of eels (*Anguilla chrysypa*) in the United States, in lbs.².

I. Eastern Region		II. Central Region		III. Western Region	
	lbs.		lbs.		lbs.
Maine	255,150	Alabama	1,045	Washington	0
N. Hampshire	800	Mississippi	3,930	Idaho	0
Vermont	4,100	Louisiana	1,670	Oregon	0
Massachusetts	541,945	Texas	484	California	0
Rhode Island	290,195	W. Virginia	100	Nevada	0
Connecticut	178,197	Tennessee	8,787	Utah	0
New York	807,157	Arkansas	5,240	Arizona	0
Pennsylvania	60,650	Kentucky	150		
N. Jersey	407,609	Indian Territory ..	?		
Delaware	268,255	Oklahoma	?		
Maryland	326,465	Kansas	600		
Virginia	86,350	Missouri	6,555		
N. Carolina	507,111	Illinois	20,813		
S. Carolina	?	Indiana	1,550		
Georgia	5,300	Ohio	618		
Michigan ³	1,211	Wisconsin	2,487		
		Iowa	21,978		
		Minnesota	5,632		
		Nebraska	300		
		S. Dakota }	insignificant		
		N. Dakota }			
Total ...	3,740,395	Total ...	81,939	Total ...	0
or 97.90 %		or 2.10 %		or 0 %	

Of the total product of the eel fisheries of the States, namely 3,822,434 lbs., 3,740,395 lbs. were taken in the Eastern Region, 81,939 lbs. in the Central Region and nothing at all in the Western Region. In percentages 97.90 % fall in the Eastern Region and only 2.10 % in the Central Region, although the latter has an area which is between 3 and 4 times as large as the Eastern Region and although it consists for a great part of low lands with many rivers which are well-suited to the eel.

From this there can be no doubt that a much larger number of eels run up from the Atlantic Ocean than from the Gulf of Mexico, but on the other hand it is surprising to notice how high up the

¹ Thus, I am inclined to believe, that more eels must live in such States as e. g. Louisiana and Mississippi, than appears to be the case from the statistics.

² "The above figures are compiled from statistics of the New England States for 1905, Middle Atlantic States for 1904, South Atlantic States for 1902, Great Lakes and Mississippi and tributaries for 1903, Gulf States for 1899, and the interior waters of Texas for 1900, and those of New York and Vermont for 1902". (Note to the list excerpted from the Commissioner of Fisheries, Washington).

³ Michigan is here included under the Eastern Region, as the eels taken there come from the Great Lakes, which are connected with the Atlantic (see later Table p. 10).

eels venture to penetrate in such rivers as the Mississippi and tributaries. It is of interest in this connection to examine more closely into the yield of the eel fisheries in such States situated far from the ocean. I give here from the American statistics (U. S., 1902, p. 667) the product of the eel fisheries in 1899 in the Mississippi and its tributaries.

Table showing the yield of the Eel-fisheries of the Mississippi River and tributaries in 1899 (U. S., 1902, p. 667).

States	Eels, lbs.	States	Eels, lbs.
Alabama.....	8,040	Mississippi.....	3,930
Arkansas.....	3,702	Missouri.....	7,811
Illinois.....	29,263	Nebraska.....	300
Indiana.....	5,078	Ohio.....	618
Iowa.....	10,943	South Dakota.....	"
Kansas.....	1,070	Tennessee.....	14,180
Kentucky.....	3,900	West Virginia.....	755
Louisiana.....	1,670	Wisconsin.....	1,745
Minnesota.....	900	Total.....	93,905

We see from this that where eels are fished in a State, such as for example Wisconsin, in fresh water connected with the Mississippi, which flows into the Gulf of Mexico, these eels must necessarily have penetrated no less than over 1000 miles up into the land, reckoned from the mouth of the Mississippi. Thus the eels can travel enormous distances, even after they have entered the fresh water.

We have also the interesting condition that in several of the above-mentioned States which contribute to the eel fisheries in the Mississippi Region, there is also a fishing for eels, according to the American statistics, which must have a different origin from those fished in the same States within the Mississippi Region. This fishery occurs in the Great Lakes, where the eels must have entered through the River St. Lawrence from the Atlantic. It is of interest first of all to give a summary of the yield of the eel fisheries in the Great Lakes, which take place from the United States (U. S., 1902, p. 580).

Table showing the yield of the Eel-fisheries of the Great Lakes in 1899.

Lake	Eels, lbs.	Lake	Eels, lbs.
Ontario.....	123,840	Michigan.....	484
Erie.....	849	Superior.....	"
St. Clair.....	"	Total.....	125,590
Huron.....	861		

We see from this summary that the product of the eel fishery in Lake Ontario far exceeds that of the other lakes. A glance at the map however gives us the explanation of this condition. Lake Ontario lies nearest the sea from which the eels come, and in order to appear in the other lakes they must pass Niagara. The difficulty the eels have in advancing beyond this, must probably be the main reason for the striking difference between the yield in Lake Ontario and the other lakes, since we may believe that most of the eels come to a stop in the Ontario Lake without being able to penetrate into the other lakes.

Divided according to the States the eel fishery of the Great Lakes appears as follows (according to the U. S. statistics, 1902):

States	Lake Ontario	Lake Erie	Lake Michigan	Lake Huron
	lbs.	lbs.	lbs.	lbs.
New-York.....	123,840	200	"	"
Pennsylvania.....	"	"	"	"
Ohio.....	"	99	"	"
Michigan.....	"	550	100	861
Illinois.....	"	"	300	"
Indiana.....	"	"	84	"
Wisconsin.....	"	"	"	"
Total.....	123,840	849	484	861

From the official statistics (U. S., 1902) I may also give the product of the eel fisheries in the States surrounding the Great Lakes, a distinction being made in the case of each State between the part of the yield which comes from the Great Lakes and the part originating from the Mississippi Region. The quantities are given in lbs.

Table showing for the States bordering on the Great Lakes the yield of the eel fisheries, in respectively the Mississippi Region and in the Great Lakes, for 1899.

	New York	Michigan	Ohio	Indiana	Illinois	Wisconsin	Minnesota
Mississippi Region	"	"	618	5,078	29,263	1,745	900
Gr. Lakes Region	124,040	1,511	99	84	300	"	"

The table shows that in the States of Ohio, Indiana, Illinois, Wisconsin and Minnesota, the greater part of the eels captured come from the river-system which drains out into the Gulf of Mexico, whilst far fewer of them have come in through the River St. Lawrence. If we also consider, that large quantities of eels are fished in the region of the last-mentioned river (both in the United States and Canada), thus both below Lake Ontario and in this lake itself, that is, not far from the 5 States mentioned, the fact that these States nevertheless fish most of their eels in the Mississippi region seems to be further evidence that it can only be relatively few eels, which pass from Lake Ontario into the other great lakes.

Our main result with regard to the density of the eels in the United States is, therefore, that whilst this fish is lacking in the Western Region, it is found both in the Eastern and the Central Regions. Here however it is very unequally distributed, since in the former, which is 3—4 times smaller than the latter, many more eels are nevertheless fished (respectively 97·90 % and 2·10 % of the total yield of the fishery).

After thus characterizing, as far as it was possible for me to do so, the distribution and density of the eel in the different parts of the United States, I may before leaving these give some countings of vertebrae, which I have made on eel fry from two different places of the Atlantic coast of the United States (see the Tables below). I owe the material to the friendliness of the United States National Museum, Washington, D. C.

Eel Fry (Stage V) from Wood's Hole, Mass., March 1, 1872 (counted by JOHS. SCHMIDT).

(From U. S. Nat. Mus. 13592.)

1) Length	c. 55 mm	Vert.	43 + 65 = 108	No. of vertebrae	No. of specimens
2) —	c. 57	-	43 + 66 = 109	112	o
3) —	c. 53	-	43 + 65 = 108		
4) —	c. 54	-	42 + 64 = 106	111	
5) —	c. 52	-	43 + 66 = 109		
6) —	c. 52	-	43 + 64 = 107	110	o o o
7) —	c. 58	-	43 + 67 = 110	109	o o o o o o
8) —	c. 58	-	43 + 64 = 107		
9) —	c. 52	-	43 + 65 = 108	108	o o o o o o
10) —	c. 57	-	43 + 67 = 110		
11) —	c. 60	-	45 + 67 = 112	107	o o
12) —	c. 59	-	42 + 66 = 108	106	o
13) —	c. 55	-	43 + 66 = 109		
14) —	c. 55	-	44 + 66 = 110	105	
15) —	?	-	43 + 65 = 108		
16) —	c. 63	-	44 + 65 = 109		
17) —	c. 57	-	43 + 66 = 109		
18) —	c. 60	-	44 + x { Glass eel with several fused vert		
19) —	c. 63	-	43 + 65 = 108		
20) —	c. 70	-	43 + 66 = 109		

Eel Fry from Wilmington, N. Carolina (counted by JOHS. SCHMIDT).

Strongly pigmented, very thin, most likely at the approximate minimal length in Stage VI.

1)	Length	45 $\frac{1}{2}$	mm	Vert.	43 + 65 = 108
2)	—	48	- (beat)	-	43 + 64 = 107
3)	—	48	-	-	42 + 67 = 109
4)	—	c. 52	-	-	43 + 66 = 109
5)	—	c. 53	-	-	43 + 66 = 109

These young eels the dimensions of which I have stated in "Contributions to the life-history of the eel" p. 234, (the dimensions there are better than those stated here from xylol specimens) are slightly pigmented and "Glass-eels", except those at 70 or more which are much thicker and probably a year older. The "Glass-eels" here seem thus to have a length of about 5—6 cms¹.

Mexico.

On inquiry the Danish Consul in Mexico, Mr. H. L. WIECHERS, communicates the following in a letter of 2nd June 1908:

"In some of the rivers running into the Gulf small eels (up to one foot in length) are occasionally caught; it is generally supposed that these are young eels which wander up from the sea into the rivers and when they have attained a certain size or development return again to the sea. They are found constantly together in large numbers in the rivers".

MEEK (1904, p. 91) in his work on the Mexican fishes refers to the conditions and says, "that the American eel (*Anguilla chrysypa*) is abundant in the streams of Mexico North of Tampico".

REGAN (1905) gives a list of fishes from Southern Mexico, but the eel is omitted in it. Further, Mr. C. TATE REGAN, of the British Museum, communicates to me in a letter of the 13th April 1908:

"On the continent of America *Anguilla* does not appear to extend further south than Tamaulipas, but in the islands it ranges southwards to St. Croix, St. Vincent, Dominica, Grenada etc. There are specimens from these islands in our collections — — —".

In his well-known work on the apodal fishes KAUP (1840, p. 44) refers to a specimen of *Anguilla* from Vera Cruz in Mexico, the most southerly place in this country from which exact information of the occurrence of this species is to be had.

Our main conclusion is then, that the eel occurs in fair abundance in the northern portion of Mexico, but that the numbers decrease southwards, so that it seems to be absent or at any rate rarer in the most southerly portion. This agrees well with the conditions in the adjacent countries: United States and the Republics of Central America.

The States of Central America.

GÜNTHER (1869, pp. 377—494) in his "Account of the fishes of the States of Central America etc." gives a list of the species which are known from Central America. The limits of the territory are given by the following: Northern limit: "Political boundary of Guatemala", Southern limit: "Isthmus of Darien". It is emphasized that the peninsula of Yucatan is almost unknown ichthyologically. GÜNTHER's list contains 303 species: but no *Anguilla*².

¹ This agrees very well with a statement by Dr. HUGH M. SMITH, in a letter dated April 29, 1909: "Among the collections now in the possession of the Bureau of Fisheries, Washington, are several young eels still in the translucent stage, and running from 2 to 2 $\frac{1}{8}$ inches (i. e. 50—57 mm) in length".

² *Symbranchus marmoratus* from the Atlantic and *Symbranchus immaculatus* from the Pacific portion of Guatemala are the only fish included which go under the name of "Eel".

On inquiry Mr. H. B. WALCOTT, Acting Colonial Secretary for the Colony of British Honduras, communicates in a letter to me dated Belize, 9. June 1908:

"In reply to your letter asking whether the common fresh-water eel occurs in the waters of this Colony, I have the honour to inform you that I have made enquiries and find that it does not appear to do so".

In this connection I may also repeat the observations of Mr. C. TATE REGAN (cf. p. 11):

"On the Continent of America *Anguilla* does not appear to extend further south than Tamaulipas (Mexico)".

All the available statements show that eels are absent from Central American waters. This region is poorly investigated and one cannot be certain that no single specimen will not be found, but at any rate, however, the species can occur but rarely.

Nor does *Anguilla* occur in EVERMANN & GOLDSBOROUGH'S list (1902, pp. 137—159) of 56 species from Central America, (but *Symbranchus marmoratus*).

West Indies.

The eel is known from many stations in the West Indian Archipelago; it is not necessary to enumerate all these in this connection, and I shall therefore confine myself to a few examples.

Danish West Indies. I have had the opportunity of investigating some montées taken at St. Croix in a small brook at "Envy" 14th Feb. 1906 by Dr. TH. MORTENSEN, who has kindly placed them at my disposal. Some are in the VIth stage (cf. SCHMIDT, 1906, pag. 169), some are still further advanced in development, and they measure in mm. 49, 49, 51^{1/2}, 57, 57, 73. After having cleared them in xylol I counted the vertebrae and found the following numbers: 108, 107, 106, 109, 107, 111. From what I have shown earlier (SCHMIDT, 1906, p. 240) they appear to belong to the American eel (*Anguilla chrysypa*). In addition, to give an idea of the frequency of the eel, I may refer to the following observations of Dr. TH. MORTENSEN who was then on an exploring journey in the Danish West Indies:

"There are eels here; but very few; they occur singly. There is only one place, Salt River, St. Croix, where they seem to be in greater numbers and a fisherman at the place was of the opinion that 100 could be collected in the course of 14 days".

Cuba. POEY (1876, p. 192) says that the eel occurs at Cuba. He refers the Cuban eel to the old KAUP species *A. (Muraena) cubana* with the explanation that KAUP'S specimens were from Cuba. Besides his *A. cubana* POEY has an *Anguilla* sp.; but he gives no information whatever concerning the number of eels found at Cuba.

Nor by EIGENMANN is there anything said about the frequency of the eel in Cuba. He restricts himself in his work on the fresh-water fishes of Cuba (1904, p. 222) to mentioning that *Anguilla chrysypa* is taken at San Juan and Paso Real.

Porto Rico. On the occurrence at Porto Rico it is related by EVERMANN and MARSH (1900, p. 68) inter alia that:

"It (i. e. *Anguilla chrysypa*) is caught in considerable numbers in Portorico in the small bamboo traps or "nasas" set in the small rivers".

Jamaica. Mr. W. FAWCETT, Director of the Botanical Gardens, Kingston, in a letter of 2nd November 1908 kindly gives me the following information.

"There are fresh water eels in Jamaica, which Dr. BOULENGER of the British Museum (Natural History) assures me are *Anguilla chrysypa*. Eels are caught and eaten, but the fishing is not of much importance. They are locally called eels".

Mr. C. TATE REGAN of the British Museum, London, communicates to me in a letter of 13th April 1908 the following:

"On the continent of America *Anguilla* does not appear to extend further south than Tamaulipas, but in the islands it ranges southwards to St. Croix, St. Vincent, Dominica, Grenada, etc. There are specimens from these islands in our collection, but none from Trinidad from which island we have a fine series of fresh-water fishes".

Concerning the conditions on the island Key West, lying between Cuba and Florida, JORDAN (1884, p. 111) reports the following:

"A single extremely young eel was taken in a seine in Enteromorpha. The species seems to be entirely unknown to the Key West Fishermen; nor did I find any one who had ever heard the word eel".

Columbia.

STEINDACHNER has given various important contributions on the fresh-water fishes of Columbia; thus in 1878, p. 76 and in 1880, p. 90. In the last mentioned work there is a "Uebersicht der bisher aus dem Stromgebiete des Magdalena-Stromes bekannten Fische" and 70 species (including *Symbranchus marmoratus*) are there specified, but no *Anguilla* or other Muraenoid.

Venezuela.

In his numerous "Beiträge zur Kenntniss der Flussfische Südamerikas", thus in 1879, p. 151—171, STEINDACHNER mentions the fresh-water fish from the Orinoco River. *Anguilla* is entirely absent. The same holds good for PETERS' list of Venezuelan fishes (1879, p. 469) in which 43 species are given and among them *Symbranchus marmoratus* ("calabozo") and *Gymnotus electricus* ("temblador").

British Guiana.

T. SIDNEY HARGREAVES says in his book on "The Fishes of British Guiana" p. 13, Demerara 1904:

"There is a species of Conger Eel (*Leptocephalus conger*), and one or two species of true Eel to be met with; but these are never to be seen in the market as the creoles object to eat them, probably on account of their snakelike appearance, although throughout the West Indies the common Eel is highly valued as a food fish".

More detailed information from the author concerning the eels mentioned here has been obtained from a letter from the Director of the Science and Agriculture Department, British Guiana, Mr. J. B. HARRISON, dated Georgetown 27th March 1908, in which Mr. HARGREAVES communicates:

"there are two species of *Anguilla* found in fresh water trenches. These are *Anguilla chrysypa* and *Anguilla sp.*".

Dutch Guiana.

PALACKY (1891, p. 216) refers to a work unknown to me by KEPPLER (KAPPLER?) on the fresh-water fishes in Surinam, in which he gives no fewer than 70 species. Amongst these in addition to *Symbranchus marmoratus* and *Gymnotus electricus* two eels are also mentioned. Dr. J. BOEKE of Leyden, who, as is known, has undertaken extensive investigations on the fishery conditions in the Dutch West Indian Island of Curaçao, kindly communicates to me in a letter the following:

"As far as I could gather when I was in Surinam, the fresh water eels are rather common there, but I have not seen them myself (I stayed there only a few days)".

French Guiana.

In his "Contribution à l'étude de la faune ichthyologique de la Guyane française et du contesté franco-brésilien" (1900, p. 123—136) VAILLANT gives a list of 40 species of fresh-water fish from the rivers and lakes of Guiana. In this list *Anguilla* is quite absent.

Brazil.

E. A. GOELDI (1898, p. 443—488) gives in his "Primeira contribuição para o conhecimento dos Peixes do valle do Amazonas e das Guyanas" a very detailed list of the fishes occurring in the Amazon River. It contains 114 species including *Symbranchus marmoratus*, but *Anguilla* is quite absent.

EIGENMANN (1907, p. 659—667) gives in his work on the fishes of the Amazon River a list of ca. 46 species. The list treats of that portion of the Amazon River which lies between Para' and Manaos. *Anguilla* is entirely absent.

On inquiry, Dr. E. SNETHLAGE the head of the zoological section of the "Museu Goeldi" in Para' in Northern Brazil, communicates in a letter of 6th May 1908:

"Es ist mir ueber das Vorkommen von *Anguilla* in brasilianischen Gewaessern, speciell im Staate Para', nie etwas zu Ohren gekommen. Wir haben in unserer ziemlich umfangreichen Sammlung wohl Meeraale (*Muraena*); aber der Suesswasseraal scheint absolut zu fehlen".

In his work "Velhas Flodens Fiske" based on extensive Danish collections Lütken (1875, p. 123—252) gives a list of 55 species, in which *Anguilla* is not to be found. The river Velhas is a tributary of the Rio S. Francisco, falling into it 2° N. of Lagoa Santa in the State of Minaes Geraes.

The Danish Consul General in Rio Janeiro communicates on inquiry in a letter of 16th June 1908 the following:

"In answer to your request for information whether the common fresh-water eel occurs in Brazil the General Consulate communicated with PROFESSOR MACEDO DE MENDONÇA, Rio de Janeiro. From this gentleman the answer was obtained that this fish, as far as is known, is not to be found in Brazilian waters".

On account of the above similar statements we must conclude that the eel (*Anguilla*) is entirely absent in Brazil.

Argentina and Uruguay.

GÜNTHER in his "Contributions to the knowledge of the Fish-fauna of the Rio de la Plata" (1880, p. 9—13) gives a list of 59 species from which *Anguilla* is absent.

BERG in his "Enumeracion sistematica y sinonimica de los peces de la costas argentina y uruguya" (1895, p. 1—120) and in his "Sobre peces de agua dulce nuevos ó poco conocidos de la República Argentina" (1895 a, p. 121—165) gives very extensive lists from which *Anguilla* is absent.

EIGENMANN and KENDALL in their "Notes on a collection of Fishes from Argentina" (1907, p. 67—108) give a list including 52 species. In this list a Conger (*Leptocephalus*) is mentioned, but *Anguilla* is absent.

On inquiry the Danish Consul General in Buenos Ayres Dr. E. H. LUND communicates the following in a letter of 15th May 1906:

"I have the pleasure to communicate that by personal application to Dr. LAHILLE, the Director of the Fisheries, I have obtained the information that the fresh-water eel is absent here, and that the only fresh water fish which is known in Argentina under the name "anguila" (i. e. eel in Spanish) is *Symbranchus marmoratus*".

SMITT has (1901) published a work "Poissons d'eau douce de la Patagonie etc."; it contains no *Anguilla*.

On the strength of the above information we are undoubtedly entitled to conclude that eels are entirely absent from Argentina.

Finally, I may mention the work of CARL H. EIGENMANN and ROSA S. EIGENMANN (1892, p. 1—81) entitled "A Catalogue of the Fresh-Water Fishes of South America". In this work no fewer than 1134 species are given from the whole of South America; but *Anguilla* is entirely absent, as is specially noted by the authors.

From the above we can see that *Anguilla* is absent from the greatest part of the East Coast of South America. It is necessary to emphasize the fact that the eel-like *Symbranchus marmoratus* occurs in all the lists in question and that it is liable to cause confusion to the non-expert.

I shall here add a description of the conditions on the American Pacific coast beginning with the coast of Chili.

Chili.

On inquiry Dr. JEAN THIERRY, the Danish Consul General at Valparaiso, communicates the following:

"I myself having never seen or heard about fresh-water eels in this country I applied to Mr. CARLOS E. PORTER, Director of the local Zoological Museum. Mr. PORTER tells me that up to the present date no eel has been found in the rivers or lakes of Chili".

DELFIN (1898—1900) does not mention the eel in his "Catalogo de los Peces de Chile".

Peru.

The Danish Vice-Consul in Callao, Mr. HANS HANSEN communicates in a letter of the 12th April 1906 the following:

"The common fresh-water eel does not occur in Peru. Another eel species (*Muraena Helena*) is found here in the sea, but still it is rarely the object of a fishery".

ABBOTT (1899) gives a list of 101 species from Peru, in which there is no *Anguilla*.

Peru and Ecuador.

STEINDACHNER (1879) in his "Beiträge zur Kenntniss der Flussfische Südamerikas" gives lists of Peruvian fishes. *Anguilla* is absent from these.

STARKS (1906) gives a list of 92 species of fresh-water fishes from Peru and Ecuador. *Anguilla* is also absent in this.

STEINDACHNER (1880) gives a list of 12 species of fish belonging to the rivers and brackish waters about Guayaquil. *Anguilla* is not included.

Here may also be mentioned a list of 184 species of shore-fishes from Revillagigedo, Clipperton, Cocos and Galapagos Islands, compiled by SNODGRASS and HELLER (1905), from which *Anguilla* is also absent.

Finally, I may mention again the list of 1134 species collected from all parts of South America, which is given by EIGENMANN and EIGENMANN (1892) and in which *Anguilla* is entirely absent, a fact which is specially noted by the authors.

Central-America.

GÜNTHER (1869, 377—494) may be referred to in regard to the small states on the Pacific Coast of Central America. In the huge list of 303 species which is given here, and which contains both fresh and salt water species, *Anguilla* is altogether absent.

United States.

JORDAN and EVERMANN (1896 a) in their "Fishes of North and Middle America" p. 348 say on the fresh-water eel: "Not found in the Pacific". See also p. 8.

Further, we have the following information received through the Danish Consul in St. Francisco, Mr. H. H. BIRKHOLM in a letter of the 22nd March 1906:

Professor DAVID S. JORDAN, Stanford University, California, reports:

"There are no true eels on this coast. They are plentiful all along the Atlantic coast, in the waters of Japan, and through the South Sea except about Hawaii".

Canada.

According to information kindly communicated by the Danish Consul in Vancouver, Mr. O. MARSTRAND, the fresh-water eel is absent there. In the earlier cited statements (p. 6) from the official Canadian side it is also said that eels only occur in the Eastern Provinces of Canada, a fact which also results from the yield of eels as shown by the official statistics (Dominion of Canada, 1908—09).

Dominion of Canada; Yield of eels 1907.

Province	Value	Quantity	
	Dollars	lbs.	brls.
Pr. Edward Island.....	7,380	"	738
New Brunswick.....	32,870	"	3,287
Nova Scotia.....	28,160	"	2,816
Quebec.....	45,068	729,800	128
Ontario.....	3,000	50,000	"
Manitoba.....	"	"	"
Saskatchewan.....	"	"	"
Alberta.....	"	"	"
British Columbia.....	"	"	"

The conclusion we have now arrived at in the case of the American Continent may be briefly summarised as follows. Along the Atlantic coast we meet with eels first at Labrador. They are found in greatest numbers in the eastern parts of Canada and the United States; but they also appear in numbers in the northern portion of Mexico and this also holds good for the West Indian Archipelago. In the southern portion of Mexico they become scarcer and in Central America they seem to be absent and to judge from the present information this is also the case in Columbia and Venezuela. The only place on the South American Continent from which they are certainly known is Guiana. On the other hand, they are entirely absent from the great river systems of Brazil and the Argentine, a fact which deserves to be specially noticed; and likewise they are entirely absent from the whole of the great American Pacific coast, both South America and North America, as is also very apparent. For the rest, reference may be made to the chart for a rapid survey of what we know.

B. Atlantic Islands.

Spitzbergen.

KNIPOWITSCH (1901, p. 57) gives a list of the fishes of Spitzbergen. The eel is not included.

Iceland.

I have previously recorded that the eel occurs at Iceland (SCHMIDT 1906, p. 207), in greatest numbers on the south and south-west coasts, but also on the west and the western portion of the north land whilst it is absent on the eastern side and in the eastern portion of the north land. I have counted the vertebrae in a large number of specimens and have found that they all without exception belonged to the European *Anguilla vulgaris*.

Faeroes.

Eels occur very generally on most of the islands. They seem to be found in the greatest numbers on the most southern island, Syderø, where I myself have taken half-silver eels in the month of September

in the Vaagfjord amongst the "eel-grass" (*Zostera*) in considerable numbers. I have received through the kindness of Consul O. FINSEN small eels in considerable numbers from Thorshavn taken in the month of April. The Faeroe eels examined by me were typical *Anguilla vulgaris*.

Azores.

GÜNTHER (Cat. 1870, p. 30) mentions specimens of *A. vulgaris* from the Azores, preserved in the British Museum.

Through a letter of 21st September 1908 from the Danish Vice-Consul at S. Miguel, Senhor V. de SEQUEIRA, I have received the following information from Professor, Lieutenant Colonel CHAVES:

"The fresh-water Eel is frequent in the small rivers of all the islands, but is not subject to a fishery of any importance. It is called "iróz", not "eiro" as used in Madeira. This Eel was formerly considered peculiar to the Azores, Madeira und Canary Islands under the name of *Anguilla canariensis*, but is now ascertained to be identical with the *Anguilla* of the European Continent."

It now appeared to me to be of great interest to have the systematic position of the eels living on the Azores somewhat more closely studied, as it might well be imagined that intermediate forms between *Ang. vulgaris* and *Ang. chrysypa* might occur on these islands lying so far out in the Ocean. I therefore applied to Consul de SEQUEIRA who very kindly took up the matter and shortly after sent me a collection of well preserved small eels. The collection made in May 1909 at Ponta Delgada consisted of 34 specimens varying in length from 56 to 141 mm. With the exception of 8 specimens (lengths: 141, 117, 106, 103, 97, 77, 70, 66 mm) belonging to older annual groups the collection consisted of recently transformed "montée" (6th stage) varying in length from 56 to 74 mm (cf. Table I below).

The eels were examined partly by counting the vertebrae partly by determining the distances between end of snout and front of dorsal as well as of anal. Previous investigations (SCHMIDT, 1906, p. 240) had demonstrated that in the number of vertebrae we have a good distinctive character for the separation of European and American eels, while amongst external features the distance from front of dorsal to front of anal in percentage of total length may generally also be used for the separation of the two.

The result of the examination made by cand. mag. A. STRUBBERG was as follows.

In all the 34 specimens examined (length: 56—141 mm) the distance between front of dorsal and front of anal expressed in percentage of total length was found to vary from 9.9 to 13.1 (average 11.5%) and two specimens only exhibited figures less than 10%, namely 9.9 and 9.9%.

As main result of the investigation it may be said that all the eels from the Azores proved to be typical *Anguilla vulgaris*, both with regard to the number of vertebrae and with regard to the other features examined (cf. SCHMIDT, 1906, pp. 239—43).

Bermuda Islands.

For various reasons, which will appear in the following, I was in some doubt as to whether the absence of *Anguilla* from the only list of the fishes of Bermuda available to me by GÜNTHER (1880, Challenger)

¹ When a distinction was made between the vertebrae of the trunk and the tail the following numbers were found: 43 + 71; 44 + 70; 3 (44 + 71); 2 (44 + 73); 45 + 68; 3 (45 + 70); 4 (45 + 71); 46 + 69; 2 (46 + 70); 46 + 71; 47 + 68.

Fresh-water eels from Ponta Delgada, May 1909.

Table I. "Montée" (6 th stage).		Table II. "Montée" (6 th stage).	
Length (mm)	Number of specimens	Vertebrae. ¹	
		Number of vertebrae	Number of specimens
74	o		
72			
70	o	117	o o o
68	o	116	o o o o o o
66	o o	115	o o o o o o o o
64	o	114	o o
62	o o o	113	o
60	o o		
58	o o o o o		
56	o		

was in conformity with the actual conditions. I therefore communicated with the Danish Consul at St. George's, Bermuda, Mr. JOHN S. DARRELL, and received afterwards in a letter of 9th July 1908 the following information from Mr. LOUIS L. MOWBRAY, in charge of the Bermuda Biological Institution and Aquarium:

"*Anguilla chrysypa* is taken in almost all of the inland marshes, harbors, bays, and inlets, and frequently among the reefs. In September 1906 I secured a larval form at St. George's. It was thrown ashore during a strong north-east breeze".

Madeira.

In his synopsis of the Fishes of Madeira LOWE (1841, p. 191) mentions the occurrence of the eel on that island. He refers it to *Anguilla latirostris*, Yarrell, which, as is well known, is the European eel, *Anguilla vulgaris*. The name it is known by in Madeira is "eiro" and it seems to occur in numbers. LOWE says:

"Eels are the only indigenous fresh-water fish of the island. They abound in the torrents, up to the height of about 500 feet above the sea. There are more species or varieties; but I am not sufficiently acquainted with them at present to attempt their classification".

The abundance of the eel on an island lying far out in the sea, where according to LOWE the species is the only "indigenous fresh-water fish", is of very considerable importance for the present research, as will appear clearly in the general portion.

Canary Islands.

According to correspondence (dated 19th February 1908) with Sr. FILIBERTO LALLIER, the Danish Consul in Santa Cruz on Teneriffe, the eel is common on the Canary Islands. Sr. LALLIER states:

"The fresh-water eel ("anguila de agua dulce") occurs on Teneriffe, Palma, Gomera, and Canaria; it is doubtful whether it is found on Hierro, and it does not occur on Lanzarote and Fuerteventura. The place where they occur in greatest numbers is Teneriffe, and especially in the part of "la Laguna" (called thus because there was a lagoon here in earlier times at the side of the town), which is nearest to the town, and also in "Las Montañas", where they are found in numbers in the pools ("charcos") which form in the crevices ("barrancos") where the rivers run. The peasants place in the water the so-called "leche de cardon", the sap of *Euphorbia canariensis*, to stupefy and to catch them".

In the splendid work on the Natural History of the Canaries, published by BARKER-WEBB and BERTHELOT (1836—44) VALENCIENNES, pp. 88—89, mentions the Canary eel, which he calls *Anguilla canariensis* Val.; but from the description and figures he gives there is no doubt but that it is the common *Anguilla vulgaris*. VALENCIENNES communicates the following facts about its occurrence:

"On trouve plus particulièrement ces Anguilles dans les mares d'eau laissées çà et là par les ruisseaux qui serpentent au fond des barrancos ou ravins profonds de Téneriffe. Ces ruisseaux, au temps des pluies deviennent des torrents formidables, mais qui se dessèchent quand les eaux manquent dans les bas-fonds. Ces Anguilles restent alors à sec, et on peut les prendre en les piquant avec des dards. On en mange communément aux Canaries".

I have emphasized the last sentence because this statement, combined with the interesting communication from the Danish Consul about the special method by which the natives of the Canaries catch the eel, certainly shows that this fish must occur there in large numbers.

Cape Verde Islands.

The Danish Vice-Consul in St. Vincent, Senhor MANOEL DA SILVA PINTO FERRO, communicates the following in a letter of 27th February 1908:

"In reply to your letter I beg to inform you that fresh-water eels are not to be found at Cape Verde, where fresh-water lakes do not exist. They occur in the rivers of Northern Portugal in great numbers".

TROSCHER (1866) gives a list of 42 species which includes *Muraena helena* but not *Anguilla*.

It would therefore appear that the common eel is absent or at any rate rare on the Cape Verde Islands.

St. Helena.

The Danish Consul at St. Helena, Mr. H. W. SOLOMON, communicates the following in a letter of 22nd May 1908:

"I have the honour to acknowledge the receipt of your letter of the 8th ultimo asking for certain information re fresh water eels, and in reply have to inform you that there are no fresh-water fish at all in this Colony".

C. Eastern Part of the Regions considered.

(Northern Asia, Western Europe, Mediterranean, Western Africa.)

The fresh-water eel (*Anguilla vulgaris*) occurs generally on the Atlantic Coasts of Europe. This is so generally known that I do not need to name all the places recorded and may simply confine myself to referring to the description of the immigration of the young eels, which I have formerly given (SCHMIDT 1906, p. 196—213).

It only remains for me to mention the Mediterranean, the Norwegian Sea, and the Arctic.

Norwegian Sea and Arctic.

The eel is common on the southern and western coasts of Norway but is also found in Northern Norway where it goes beyond the Polar Circle and extends further towards the north than at any other place in the world. Concerning its distribution in Norway COLLETT (1905) gives information in his work on the Norwegian fishes. In it he mentions that it is undoubtedly less numerous northwards from Trondhjem than further towards the south but that it has still been taken both at Tromsø and Magerø, indeed even in the Varangerfjord in Finmark.

Through the kindness of the Norwegian Director of Fisheries, Dr. JOHAN HJORT, I am able to publish here a most interesting statistical account of the eel fisheries in the various districts ("Amter") of Norway in 1908. I have arranged the figures in the Table below, from which it appears very clearly that by far the largest quantities of eels come from the southernmost part of Norway (east and south coast), whilst practically no eels are caught north of Romsdal Amt, i. e. north of ca. 63° Lat. N. The "density" of eels in Norway as shown by the statistics gives further confirmation, if that were needed, that the Norwegian eels do not spawn in the Norwegian Sea but come from the Atlantic.

Table showing by districts ("Amter") the Yield of Eels in Norway in 1908.

I. East and South Coast		II. West Coast, Southern part From ca. 58° Lat. N. to ca. 63° Lat. N.		III. West Coast, Northern part From ca. 63° Lat. N. and northwards	
	kilos		kilos		kilos
East coast					
Smaalenene	83,184	Stavanger	19,657	S. Trondhjem.....	200
Christiania	20,000	S. Bergenhus	10,424	N. Trondhjem	30
Akershus	4,100	Bergen	2,000	Nordland	"
Buskerud	9,000	N. Bergenhus	12,730	Tromsø	"
Jarlsberg & Larvik ..	3,880	Romsdal	19,450	Finmark	"
Bratsberg.....	14,300				
Nedenes	14,040				
South coast					
Lister & Mandal.....	54,150				
Total...	202,654	Total...	64,261	Total...	230

KNIPOWITSCH (1898, p. 1—11) reports on the fishes of the White Sea and the Murman Coast. He divides the territory into 4 areas:

1) Varanger Fjord and the Murman Coast as far as Wostotschnaja-Liza, 2) from there to Kanin-Nos and to the entrance to the White Sea, 3) the Eastern portion of the Murman Sea, and 4) the White Sea. *Anguilla* is given only for the western area (1) and only with doubt, whilst it is absent in the other three areas lying further to the east.

There is thus no doubt about the fact that the eel is very seldom east of North Cape, although possibly, in the most westerly portion of the Russian Arctic coast one may meet with single specimens.

Eels are absent from **Siberia**, according to PALLAS (*Zoogeographia rosso-asiatica*, vol. III, p. 71, 1831).

Spain.

With reference to the Spanish Atlantic coasts I have already given information (SCHMIDT 1906, p. 196 and 205) regarding the ascent of the young eels which occurs there. (Naturally the eel is also found in Portugal, cf. p. 18, and BRITO CAPELLO's work on the fishes of Portugal, *Cat. Peix. Portug.*)

Regarding the coast of Spain in the Mediterranean we may also mention the eel fishery which is carried on in the large Albufera Lagoon in the neighbourhood of Valencia (BELLINI 1907, p. 1).

Eels are also found on the **Balearic Islands**, although there are no other fresh-water fishes there according to PALACKY (1891, p. 175).

Italy.

It is very common knowledge that there are large eel fisheries in Italy. The well known fisheries at Comacchio on the Adriatic, south of Venice, are of the greatest importance (e. g. see JACOBY 1880 and BELLINI 1907).

The Balkan Peninsula.

According to a verbal communication from His Majesty King GEORGE of Greece fresh-water eels occur in Greece, but being little appreciated by the population they are not subject to an important fishery.

BELLINI (1907, p. 1) mentions that an eel fishery takes place in Herzegovina and in the Buru Lake in Turkey.

GÜNTHER (*Cat.*, 1870, p. 31) records an adult specimen of *Ang. vulgaris* from Propontis. On the other hand, the extraordinary fact has gradually been recognised that the eel is absent from the Black Sea region (in the Caspian Sea also it does not occur, but this is not so remarkable in the case of a closed brackish sea). With reference to the Black Sea I cannot do better than quote v. SIEBOLD (1863, p. 345—48), who, in his excellent work on the fresh-water fishes of Mid-Europe, has examined this point thoroughly. He says among other things the following:

“Die geographische Verbreitung des Aals in Mitteleuropa ist eine höchst eigenthümliche. Er wird in allen denjenigen Flüssen und stehenden Gewässern angetroffen, welche mit der Ost- und Nordsee, mit dem atlantischen, mit dem Mittel- und Adriatischen Meere zusammenhängen, fehlt aber in denjenigen Seen und Flüssen, welche ihr Wasser dem schwarzen Meere zusenden. Daher findet sich der Aal nirgends im Flussgebiete der Donau, und fehlt derselbe auch im Dnjestr, Bug, Dnjepr und Don. PALLAS¹ machte bereits auf die Abwesenheit des Aals in den dem kaspischen und schwarzen Meere zufließenden Gewässern aufmerksam; auch EICHWALD² und NORDMANN³ lassen den Aal in ihren Faunen des Caucasus und Pontus unerwähnt. Hiermit stimmen auch die Forschungen des CZERNAY⁴, TCHIHATCHEFF⁵ und KESSLER⁶ überein welche in keinem der südrussischen Flüsse Aale antrafen”.

After this v. SIEBOLD passes on to examine the different statements on the occurrence of the eel in the Danube and he comes to the conclusion that they are all due to a lack of knowledge or to misunderstanding. This is generally acknowledged by later authors, but, of recent years, large numbers of

¹ *Zoographia rosso-asiatica* (vol. III, edit. 1831, p. 71). ² *Fauna Caspio-Caucasia*, 1841. ³ *Observations sur la Faune pontique*, 1840. ⁴ *Bull. Soc. Imp. Nat. Moscou*, Tom. 23, 1850, p. 627. ⁵ *C. R.*, Tome 42, 1856, p. 442. ⁶ *Bull. Soc. Imp. Moscou*, Tome 29, 1856, p. 442.

young eels have been transplanted from Italy and France to the Danube; and here they seem to thrive well, although, naturally unable to propagate. BADE (1902, p. 83) has recently discussed the case as follows:

“Ursprünglich im Gebiete des Kaspischen- und Schwarzen Meeres fehlend, ist der Aal in neuerer Zeit in die Donau, besonders innerhalb Deutschland durch Einsetzung von Aalbrut eingebürgert”.

See further p. 34 where the absence of eels in the Black Sea is discussed.

Asia.

According to GÜNTHER (Cat. 1870, p. 31) the eel (*Anguilla vulgaris*) is found in Palestine (Bahr-el-Kelb). In Cilicia PALACKY (1891, p. 183) mentions the presence of eels.

Egypt.

GÜNTHER (Petherick, 1869) mentions in “The Fishes of the Nile” the occurrence of the eel there, and also in GÜNTHER (Cat. 1870, p. 31) that the eel is said to occur in the Lower Nile. How far up the Nile it goes I do not know, but that it does not go up to the highest part may be seen from the works of BOULENGER cited on p. 24. Eels occur in great numbers in the Nile; and from here an export takes place even to London and Germany (communicated by the firm of Salomonsen and Co., dealers in eels, London).

Tunis.

VINCIGUERRA (1884, p. 52) mentions the occurrence of the eel (*Anguilla vulgaris*, TURT.) in Tunis and says that it is:

“... frequentissima specialmente nel lago di Tunisi ...”.

Algiers.

GERVAIS (1853, p. 16—17) says about the occurrence of the eel in Algiers:

“On vend au marché de Bône et dans d'autres lieux de l'Algérie des Anguilles prises, soit dans les eaux douces, soit dans les eaux saumâtres et littorales de ce pays”.

It is found in such great numbers in Algiers that an export takes place from here to London (communicated by the firm of Salomonsen and Co. in London). The Algerian eel, several specimens of which I have had the opportunity of examining, does not differ from the common *Anguilla vulgaris*. GUICHENOT once gave it as a separate species, *Anguilla callensis* GUICH., but already in 1853 GERVAIS l. c. pointed out that there is no reason for making it a separate species.

BOULENGER (1905, p. 50) in his large and valuable list of the fresh-water fishes of Africa, only gives *Anguilla vulgaris* TURT. for North Africa.

Atlantic (West Africa).

Morocco.

The Danish Vice-Consul in Saffi, Mr. GEORGE P. HUNOT, communicates in a letter of the 14th September 1908 the following:

“The fresh-water eel is found in the rivers and lakes, and also in the underground aqueducts where it is sometimes caught. The natives do not give it great importance although it is much appreciated by them as food. They call it “noon”.

I have myself caught pelagic eelers in the sea off Cape Spartel during the expedition of the “Thor” in February 1909.

Senegal and Gambia.

STEINDACHNER (1870, p. 580—82) gives a list of altogether 50 fresh-water fishes from Senegal. In this list *Anguilla* is absent.

BOULENGER (1900, p. 511 et seq.) writes about the great collections from the River Gambia, made by Mr. J. S. BUDGETT. 40 species are given but no *Anguilla*.

PROSECTOR AUG. BRINKMANN, Kgl. Landbohøjskole, Copenhagen, who was staying in Gambia during the months of February and March 1906, at my request made an examination into the occurrence of the eel in the River Gambia. He communicated the following:

"In Gambia I have repeatedly sought for information at the fish-market of Bathurst as well as over all the river; but always with a negative result".

In the long list of 336 species by ROCHEBRUNE on the fishes of Senegambia there is no *Anguilla*. For an account of the Cape Verde Islands see p. 19.

Liberia.

STEINDACHNER (1894, p. 1—96) gives a list of 96 species; this list is due to the very extensive investigations of Herr BÜTTIKOFER. It does not contain *Anguilla*.

HUBRECHT (1881, p. 66—71) makes a report on a collection of fishes from St. Paul's River, Liberia. This report does not mention *Anguilla*.

Ivory Coast.

SAUVAGE (1882, p. 313—25) describes a collection of 13 species of fish from the "territoire d'Assinie" (Assinee) collected by MAURICE CHAPER. *Anguilla* is absent.

Gold Coast.

GÜNTHER (1867, p. 110) gives a small list from which *Anguilla* is absent, and later (GÜNTHER 1899, p. 716 as well as GÜNTHER 1902, p. 330) gives a long list of the fishes collected by Mr. R. B. N. WALKER on the Gold Coast. *Anguilla* is also absent from these lists.

Nigeria.

GÜNTHER (1896, p. 261) records the fishes collected by Miss M. H. KINGSLEY in Old Calabar, but *Anguilla* is not included.

BOULENGER (1901 a, p. 4) and (1902, p. 324) reports on the collection of fishes made by Dr. W. J. ANSORGE in the delta of the Niger, a list of no less than 80 species but no *Anguilla*.

Cameroons.

PETERS (1876, p. 244) names the fishes collected by Prof. REINHOLZ BUCHHOLZ mostly in the Victoria River, and also in the Cameroons. There is a list of 79 species, but *Anguilla* is absent from it.

LÖNNBERG (1895, p. 179) records the fresh-water fishes collected by Herr Y. SJÖSTEDT in the Cameroons: no *Anguilla*.

French Congo.

SAUVAGE (1880—81, p. 19) gives a long list containing all the fresh-water fishes which are known in this region, "depuis l'embouchure du Senegal jusqu'à l'embouchure du Congo". *Anguilla* is absent.

GÜNTHER (1896, p. 261) mentions in his paper on the collections of fishes made by Miss M. H. KINGSLEY in the Ogowe River that 51 species are known from this river, but *Anguilla* is not included in the list.

Congo.

In BOULENGER's great work on "Les poissons du Bassin du Congo" (1901), 221 species of fresh-water fishes are recorded and described, but neither *Anguilla* nor any other Muraenoid is included among them.

As this work is based on very valuable collections and reports on the fish and fisheries of the Congo there is no doubt that the eel is really absent here¹.

Angola.

BOULENGER in the above-quoted work on the fishes of the Congo also mentions the fishes of Angola. But there is no *Anguilla*, neither is the genus mentioned in GÜNTHER (1873, p. 142).

German South-West Africa.

L. SCHULTZE (1906) who has specially studied the fisheries in German South-West Africa does not mention eels. On inquiry, Dr. L. SCHULTZE, in a letter of the 28th February 1908, says as follows:

"The common eel (*Anguilla*) is neither to be found at the coast nor in the river and river-mouths in South-West Africa. The natives only catch Siluroids in the rivers".

South Africa.

In South Africa we again meet with eels of the genus *Anguilla*. It appears amongst others in the huge collective list of all known fresh-water fishes from this continent, a list made up by BOULENGER (1905), the highest authority on African fresh-water fishes. BOULENGER records at p. 50 *Anguilla Delalandii* KAUP from South Africa and *Anguilla bengalensis* HAM. BUCH. from Natal. The latter belongs to the marbled *Anguilla* species.

On inquiry, through the Agent General for the Cape of Good Hope, London, I have received the following information re the fresh-water eels of Cape Colony in a letter from the Acting Chief Clerk to the Secretary for Agriculture, Mr. B. Mc. MILLAN, dated from the Office of the Secretary for Agriculture, Capetown, 19th June 1906:

"In reply to your letter on the above subject, I am directed to inform you that the undermentioned eels are known to occur in South Africa, viz.: *Ophichthys serpens*, *Anguilla delalandii*, *Anguilla labiata*, *Muraena flavomarginata*. Two specimens of *Leptocephalus* are also recorded from South African waters. There is no local literature on the South African eel".

The acting Consul for Denmark in Capetown, Mr. THOMAS OLIVE, communicates in a letter of 8th May 1906:

"I have the honour to inform you that through the good office of the Acting Director of the Cape Town Museum I have obtained the following information from Dr. GILCHRIST, the keeper of Marine Invertebrates and Fishes: The eels in South Africa at present known are five in number: *Anguilla delalandii*, *Anguilla labiata*, *Muraena nebulosa*, *Muraena flavomarginata*, *Ophichthys serpens*. There are therefore only two true eels. There is here no trawling for eels, and no eel industry".

Mr. VALDEMAR JOHANSEN, Acting Consul for Denmark in Durban, Natal, communicates in a letter of 15th January 1908 the following:

"Having made enquiries in the matter, I now beg to inform you that the fresh-water eels are to be found abundantly in practically all rivers, estuaries and lakes of Natal. As a matter of fact, I am told that only in the Mooi River, the eel is extinct owing to the water containing minerals. The size of the eels in streams and rivulets runs from 18" to 2' in length, and in big rivers up to 5 and 6 feet. There are no Government restrictions as to fishing of eels, they are, however, caught only rarely by farmers and hardly ever sold in the towns".

¹ When E. WILVERTH mentions in his work, "Les Poissons du Congo" (Soc. d'Études coloniales, Bruxelles, 1897) that, on a journey in 1896 "entre le Congo et la rivière N'ghiri par la Moboka et le lac Ibana" he discovered that his servants "se mirent en quête de petites anguilles qui pullulaient dans tous les marigots . . .", in this case BOULENGER says that these "petites anguilles" were most likely Siluroids of the Genus *Clarias*.

In the same way I look upon a communication from a non-expert concerning the occurrence of eels in the Congo River, because within the Genus *Clarias* a. o. species are found which are very attenuated and almost eel-like; thus BOULENGER mentions that the Siluroid *Channallabes apus*, which is eel-like and in Boma is called "Doango" in the Lower Congo "Sanga Monteké", is very good to eat.

Regarding the species to which the Natal eel belongs BOULENGER, in his often quoted list of the fresh-water fishes of Africa p. 50, gives *Anguilla bengalensis* HAM. BUCH. as occurring in Natal.

MARTENS (1869—73) in his review of the fresh-water fishes of East Africa, records *Anguilla macrocephala* RAPP. as being found in Natal.

Lastly, it is a pleasure to me to be able to give here a very interesting account of the distribution of the fresh-water eel in South Africa, based upon the personal observations of the well-known authority on the fishes of South Africa, Dr. GILCHRIST, Capetown. Dr. GILCHRIST in reply to my inquiries writes as follows in a letter of 29th December 1908.

"The distribution of the fresh-water eel in South Africa is very peculiar and I have been making inquiries about it for some time back. On a recent visit to Natal I found it occurred in abundance and was caught by Indians as food. The natives (Kaffirs) have a prejudice against eels and there is no regular industry. Further south towards and at Port Elizabeth they do not occur so abundantly. They are found at the south coast in all the rivers as far west as the Breede River where they are in fair abundance. Cape Agulhas or its neighbourhood seems to be the point where they disappear, and practically none occur in the rivers west of this nor on the west coast generally.

The eel however does seem to occur in these rivers but only now and again have specimens been found and then of exceptionally large size. Thus one was found in the Leerbeck, a small stream flowing into Table Bay. One or two have been found in the Orange River. At Pretoria (the watershed between the Crocodile and Orange Rivers) one large specimen has been found in a stream which ultimately joins the Orange River, while they are abundant in the small streams not far off which join the Crocodile River flowing into the Indian Ocean".

I shall here add a description of the occurrence of the eels in the Indian Ocean as a natural supplement to South Africa, with which the report on the Atlantic Ocean closed; I may describe East Africa first.

East Africa.

Portuguese East Africa.

PETERS (1868), who, a little after the middle of last century, made Natural History expeditions to Mozambique, records at pp. 94—103 the fresh-water eels, no fewer than 4 species of which are described. They are: *Anguilla labiata* PETERS, *A. macrophalma* PETERS, *A. mossambica* PETERS, and *A. virescens* PETERS. The first is found in the Zambesi and Licuare Rivers; the natives of Tette (Zambesi) call it "mucúnga"; in Boror it is called "licovóvo". *A. mossambica* is found in the River Molumbo (15 Lat, S.), *Anguilla macrophalma* in the Zambesi at the town of Tette (it is called "mucúnga" at this place as well as *A. labiata*) and *A. virescens* in the River Licuare (Boror).

German and British East Africa.

PFEFFER (1892, p. 159) records among the fishes, collected by Dr. F. STUHLMANN in 1888—1889, *Anguilla labiata* PETERS from a pond at Mhonda, Ungúu and it is said that it is edible. Further, *Anguilla virescens* PETERS is recorded as having been taken in Zanzibar and in the River Pangani (GÜNTHER and PLAYFAIR 1866, p. 124—125).

GÜNTHER (1894, p. 91) in his work on the collection of fishes made on the Expedition to Mount Kenya under Dr. J. W. GREGORY, records *A. bengalensis* GRAY from Thika-thika, Athi, and Tana Rivers.

BOULENGER (1902, p. 224) gives in his report on the fishes collected by Mr. S. L. HINDE in the Kenya district *A. bengalensis* GRAY from Mathoiya River, with the remark added that *A. labiata* PETERS is not separable from this species.

Zanzibar. — PFEFFER (1892, p. 169) records *A. virescens* from Zanzibar.

BOULENGER (1906 a, pp. 557—566) and PELLERIN (1905, pp. 290—94) report on the fish collected from Lake Rudolf in the central part of British East Africa, and BOULENGER (1906, p. 433—445) from

Lake Victoria. No eels are mentioned from these water-systems, which have no outlet to the east coast. The same is applicable to BOULENGER's (1902 a, p. 260—264) large list of 39 species collected at Gondokoro (Upper Nile, N. from Lake Albert Nyanza).

Somaliland.

VINCIGUERRA (1895, p. 27) reports an *Anguilla* from the Juba (Giuba) region which he thinks must be referred to *A. labiata* PETERS.

Coasts of Red Sea.

Jibuti. PELLEGRINI (1904, p. 543—45) describes the collection of fishes made by Mr. Ch. GRAVIER at Jibuti and Obok. *Anguilla* is not included in the list.

Erythrea. From this Colony numerous collections from the Italian part are to hand. GIGLIONI (1888, pp. 67—73) gives a list of the fishes from Assab and Scioa. *Anguilla* is not present.

DEL PRATO (1891) gives a list of the fishes collected by the Italian Captain V. BOTTEGO in Erythrea; but no eels are found in this, nor in BORSIERA's (1904, p. 187—220) contribution to the fish fauna of Erythrea.

KLUNZINGER (1870—71) gives a very exhaustive list of fishes from the Red Sea. *Anguilla* is absent in it, though several other Muraenoids are given.

It is necessary to say about most of the works cited for the coasts of the Red Sea that they are mostly taken up with the fishes which belong to salt or brackish water and for this reason one must be careful in drawing conclusions as to the absence of fresh-water fishes on the basis of the above-quoted statements; but for the rest one must not forget that the conditions necessary for the thriving of fresh-water eels are very bad in this very arid region on the coasts of the Red Sea.

Finally I may just resume MARTENS' (1869—73) and BOULENGER's (1905) lists of all known *Anguilla* species from East Africa and the whole of Africa.

MARTENS (1869—73, p. 144) East Africa.

- 1) *Anguilla labiata* PETERS: Pangani, Zambezi, Licuare.
- 2) — *Johanne* GÜNTHER: Johanna Island.
- 3) — *Mossambica* PETERS: River Molumbo (15° Lat. S.).
- 4) — *macrothalma* PETERS: Zambezi.
- 5) — *virescens* PETERS: Licuare.
- 6) — *macrocephala* RAPP.: Natal.
- 7) — *marmorata* QUOY & GAIMARD: Réunion.
- 8) — *ambiodon* GÜNTHER: Seychelles.

BOULENGER (1905, p. 50) All Africa.

- 1) *Anguilla vulgaris* TURT, 1807: N. Africa.
- 2) — *bengalensis* HAM. BUCH. 1822: E. Africa.
- 3) — *virescens* PETERS 1852: E. Africa.
- 4) — *Delalandii* KAUP 1856: Madagascar, S. Africa.
- 5) — *ambiodon* GÜNTHER 1866: Seychelles.
- 6) — *Hildebrandtii* SAUVAGE 1891: Madagascar.

Islands in the Indian Ocean.

Seychelles.

GÜNTHER in GÜNTHER and PLAYFAIR (1866, pp. 124—125) describes an eel-species, *Anguilla ambiodon*, from the fresh water on the Seychelles. It a marbled form attaining a considerable size (the original specimen was 2 feet long).

Comoro Islands.

GÜNTHER in GÜNTHER and PLAYFAIR (1866, p. 124—125) describes an eel-species *Anguilla Johanna* from the island of Johanna. It is a marbled form.

Madagascar.

SAUVAGE (GRANDIDIER, 1891, p. 498) records the Madagascar eels in the following way:

"Les Malgaches appellent les Anguilles "Amalonã". On distingue l'Amalombandanã (Anguille rayée), l'Amalondriatsa (Anguille noire), l'Amalonkorakã, l'Amalontsorondranõ, l'Amalontserikã. Les Malgaches de l'Ouest (au Ménabé) leur donnent aussi le nom de "Henalava" (litt. viande longue), "Lamarankenã", "Lonã", "Sakamalonã" (les jeunes), "Voninamalonã" (litt. fleur d'Anguille ou le fretin) et les Hova celui de "Kirija".

SAUVAGE refers the Madagascar eels to two species: *Anguilla Hildebrandti* SAUV., which is found in the N. W. part of Madagascar as well as "sur le versant oriental de cette même île dans les hautes forêts," and *Anguilla Delalandii* KAUP, about which he communicates that it bears the name of "Tona" on the east coast.

Réunion.

MARTENS (1869—73, p. 144) states that *Anguilla Marmorata* QUOY & GAIMARD occurs on Réunion.

Mauritius.

PETERS (1876, p. 445) mentions *Anguilla labiata* PETERS among the fishes collected by Prof. K. MÖBIUS on Mauritius.

Asia.

Whether the eel is found in Southern Arabia is unknown to me and it is likewise unknown to me whether any ichthyological literature dealing with the region at all exists.

Gulf of Persia.

According to PALACKY (1891, p. 185) the Chesney-Expedition found eels in the River Tigris.

British India.

DAY (1878, p. 659—660) refers the Indian eels to two species,

1) *Anguilla bicolor*, with the following synonyms:

- Muraena anguilla* RUSSELL, Fish. Vizag., 8, p. 22, t. 31.
- A. bicolor* MC. CLELLAND, Calc. Journ. Nat. Hist., V, p. 178, t. 6, f. 1.
- A. moa* BLEEKER, Java, p. 22: KNER, Novara, Fische, p. 369.
- A. bicolor* and *mowa* BLEEKER, MURÆL., 16, 17; KAUP, 51, 53, fig. 44; KNER, Novara, Fische, p. 368; GÜNTHER, Cat., VIII, 36.
- A. Malgumora*, *Celebensis*, *Bleekeri*, *Malabarica* and *Cantori*, KAUP, Apod. F., KNER, Novara, p. 367.
- M. moa*, *malgumora* and *sidat*, BLEEKER, Atl. ichthyol., IV, p. 10, 11. "Jee-tah-dah" Andamanese.

2) *Anguilla bengalensis*, with the following synonyms:

- M. anguilla* & *maculata*, HAM. BUCH., Fish. Ganges, p. 22, 23; DAY, Fish. Mal., p. 244 (in part).
- A. bengalensis*, GRAY & HARDW., Ill. Ind. Soc.; GÜNTHER, Cat. VIII, p. 27.
- A. Elphinstonei*, SYKES, Transact. Zool. Soc. London, II, 377, pl. 67; JERDON, M. J. L. and Sc., 1849, p. 346.
- A. Mauritaniana*, BENNETT, Proceed. Zool. Soc., 1831, p. 113; GÜNTHER, Cat., VIII, p. 25.
- A. labrosa*, RICHARDS., Voy. Erebus and Terror, Fishes, p. 113.
- A. brevirostris*, *variegata*, *nebulosa* and *Arracana*, MC. CLELLAND, Calc. Journ. Nat. Hist., V; BLEEKER Beng., p. 153.
- A. marmorata*, KAUP, Apodal Fish., p. 43 (not QUOY & GAIMARD).

Further, DAY l. c. p. 660 says:

"*A. Mauritaniana* BENNETT, *A. labrosa* RICHARDSON, *M. maculata* BLEEKER, *A. Johannæ* GÜNTHER, *Muraena marmorata* KNER, are terms employed for an Eel which appears to be a variety of this fish in which the origin of the dorsal fin is only about $\frac{1}{2}$ the length of the head before the vent".

In his second chief work on the Indian fishes DAY (1889, p. 86, 87) also mentions the Indian fresh-water eels, which he here again refers to two species: the marbled *Anguilla bengalensis* and the uniformly coloured *Anguilla bicolor*. It seems from DAY that there is no characteristic difference in the distribution of the two species; the first one, it is said, inhabits the islands of the Indian Ocean, the Continent of India and Burma and the Andaman Islands, while the latter is said to inhabit the coasts of India to the Andaman Islands etc.

Eels do not seem to play any great part economically, at all events for the Europeans. DAY mentions in this connection:

"Being seldom eaten except by the lower classes, there is but little demand for them".

DAY does not specify where in British India the eels occur, but that they are found everywhere in the coast regions is evident from the statements of many other workers. Specimens are recorded e. g. from Bombay (*Ang. Cantori*, KAUP, 1856, p. 52); from the coast of Malabar (*A. dussumierii*, GÜNTHER, Cat. 1870, p. 37; *A. malabarica*, KAUP, 1856, p. 53), Madras, Nilgherries and Ceylon (*A. bengalensis*, GÜNTHER, Cat. 1870, p. 27), Almora (*A. mauritiana*, GÜNTHER, Cat. 1870, p. 26), Ganges (*Muraena anguilla*, HAM. BUCH., Fish. Gang. p. 22) etc., etc.

VINCIGUERRA (1890, p. 358) gives *A. bicolor* Mc. CLELL. from Rangoon in Burma. He adds that it is probable that *A. sidat* BLEEKER and *A. virescens* PETERS are not specifically different from *A. bicolor*. As mentioned above, DAY says that both *A. bicolor* and *A. bengalensis* occur on the Andaman Islands.

East Indian Archipelago.

I shall not enter here on the numerous works which record the occurrence of fresh-water eels in the East Indian Archipelago, which in reality belongs to the Pacific region. These will be dealt with at a later period, partly because it would be more suitable before doing so to try and clear up the systematic position of the eels occurring in the Indian Ocean. I have an excellent opportunity for this as I have received from Mag. sc. HJ. JENSEN, Java, some very large collections of excellently preserved eels. I shall therefore only mention two works here. WEBER (1894, p. 428) records *A. sidat* BLEEKER from Manindjau (Sumatra) and explains that this fish is called "Bale Masapi" in Tempe.

BLEEKER (1864, p. 8) records the following:

"Les Anguilles de l'Inde archipélagique pourraient remplir un rôle assez important comme nourriture des populations indigènes tant par leur chair exquise, que par leur nombre et par leurs dimensions, mais il ne paraît pas qu'on les mange partout, pas même à Java, où en general elles sont peu recherchées, si ce n'est que par les Européens et les Chinois".

We may therefore be contented with stating that the eel (both marbled and uniformly coloured) appears in numbers in the East Indian Archipelago and thus on the eastern borders of the Indian Ocean as well as on the western.

III. ON THE CAUSES WHICH DETERMINE THE DISTRIBUTION OF THE FRESH-WATER EELS.

As the main result of the investigation on the distribution of the fresh-water eels, we have found that they occur on the Atlantic coasts of North America and in the West Indies but are absent on the Atlantic coasts of South America (except in Guiana) as well as on the Pacific coasts of both North and South America. They are found on nearly all the Atlantic Islands lying north of the Equator; they are absent from the Arctic coasts of Siberia and North Russia but present from the North Cape on the northernmost part of Norway and southwards; as well as on the coast-lands of Northern and Western Europe. Further, they are to be found on all the coasts of the Mediterranean, except the Black Sea, and are present on the north-west coast of Africa at least as far south as the Canary Islands. On the other hand, they are absent from the region of Senegal and southwards on the west coast of Africa, on the coast of Guinea, Nigeria, the Cameroons, Congo, Angola and German South-West Africa. We first meet with fresh-water eels, though other species, again at Cape Colony and after that they are found up the whole of the east coast of Africa (besides on the islands off the coast), at all events, as far north as Somaliland (whether

fresh-water eels are to be found on the coasts of the Red Sea cannot be stated with certainty). Finally, they are present on the southern coasts of Asia at least from the Gulf of Persia and further eastwards in British India to the Malay Peninsula and Malay Archipelago.

From this short survey it is seen that the fresh-water eels have a very wide distribution. If we take *Anguilla vulgaris* and examine where it occurs, we will see that it is distributed in the north from Iceland and the North Cape (Norway) to the Mediterranean, North-West Africa, Madeira and the Canary Islands on the south, whilst the American fresh-water eel (*Anguilla chrysypa*) occurs right from South Greenland and Labrador southwards to the West Indies and Guiana, i. e. in arctic, temperate and purely tropical regions. This is very uncommon for a fresh-water fish, and it is also uncommon that we find both the European and American *Anguilla* on several purely oceanic islands, e. g. the first on Madeira and the Azores, the second on the Bermuda Islands, although fresh-water fish are entirely absent from several of the islands where the eels occur. But what is most remarkable (see distribution chart) is to see how the eel which, for example on the western side of the Atlantic, inhabits both the arctic, temperate and a large part of the tropical zones, stops short in the northern part of South America, so that in the greatest part of South America there are no eels; and something similar can be seen on the eastern side of the Atlantic, even if it does not reach fully so far southwards as on the western side. In the following I shall discuss the different probable causes leading to this characteristic distribution of the eels.

Before we begin this discussion I may emphasize two conditions which are of importance: 1) The fresh-water eels breed in the sea. At the present time this fact may probably be regarded as finally settled (cf. p. 36). In any case it has been proved both for the European eel (*A. vulgaris*) and for the American eel (*A. chrysypa*), because the larval stages of both of them (*Leptocephalus*) have been found out in the sea far from the coast (see SCHMIDT, 1906, p. 194—95 and EIGENMANN and KENNEDY, 1902, p. 84). For the other *Anguilla*-species there is no proof as yet, but there is indeed scarcely any probable reason why they should not also spawn in the sea. For the rest, we are here only occupied with the European and American eels, which are those we know best in all respects. 2) Fishes in order to accomplish their reproduction often demand quite different conditions from those under which their growth and other vegetative periods of life are passed. This I have discussed more fully on several earlier occasions (SCHMIDT, 1906, p. 234 etc., 1907, p. 11—12, 1909 a, p. 11—12) and I need not go further here. But when we as here endeavour to understand why for example a fish is absent from one or other region, it will be seen that the question in reality divides itself into two: whether for the place in question the conditions for reproduction are not present or if the reason is that the conditions are such that they are unfavourable for the vegetative periods of life, thus for example during growth. It will be clearly seen from the following how important it is to distinguish between these two conditions.

When a fish, more particularly one which lives in fresh water, can have such an extraordinarily wide distribution as the American and European eel, one cannot but wonder, on seeing the chart of distribution, that it should stop suddenly in this southern distribution just where it does, since a species such as this with an exceptionally long-continued pelagic life in the early stages (cf. SCHMIDT, 1906, p. 262) has in a very high degree the conditions necessary to widen its range during the history of the species. Considering the conditions as they are, we might well begin by asking, just why neither of the two species have been able to press further southwards so that they are absent in the great river-systems of both South America and West Africa? At the outset we might think of one or other of the following reasons:

- (1) Adverse temperature conditions;
- (2) Want of available fresh-water;
- (4) Want of suitable food, or the water unsuitable for the eels thriving owing to the chemical conditions;
- (4) Want of supply of young eels.

Concerning the conditions mentioned under (1) it may be said at once that the reason for the absence of the eel in South America and West Africa cannot be due to the lack of such water temperatures as are necessary for their thriving, for in both South America and West Africa we find the same temperature conditions as those under which they thrive excellently well, e. g. in North America and in the West Indies. Concerning (2) it can immediately be said that in South America and West Africa some of the biggest and most important rivers in the world are to be found (e. g. Amazon, La Plata, Gambia, Niger and Congo) and thus this possibility is immediately excluded¹. Nor have the reasons mentioned under (3) any probability, because both those regions are full of rivers rich in fish and one may think therefore that they contain enough food for eels to live there if the conditions were otherwise suitable. That fresh-water fish (e. g. carp, salmon and trout) have been most successfully introduced at many places in the world, where such were formerly absent, e. g. in North America from the Atlantic States to the Pacific States and from Europe to several of the islands of the Atlantic and Pacific Ocean, seems also to show that it is not due to the lack of food or special chemical conditions in the waters of the regions concerned that there is a lack of eels. I shall also call to mind that in the United States of America experiments have been made in the transplantation of the fresh-water eel from the coast of the Atlantic to the coast of the Pacific, where they are absent. As far as I can find out the eels have thrived very well, just like those transplanted to the River Danube where eels are also naturally absent, and this fact is of great interest in this connection. (It is quite another matter, of course, that the eel has not succeeded in establishing itself; neither was this the case with those in the River Danube transplanted from Italy. If eels are transplanted to places to which they have no natural access, we may be sure that there can only be a question of rearing the transplanted specimens, and not of their propagation; see further p. 36 et seq.).

We have now reached so far in our discussion that we may accept the conditions as mentioned under (4), viz. the want of supply of young eels, as an explanation of the absence of eels in South America and West Africa. With this of course we come to the question why there is a want of supply of young eels and from this we are led further to consider the spawning places and the other factors which determine these. Here we have reached the crux of the question. In my first work on the eel (1906) I showed that the eels of the north-eastern part of the Atlantic Ocean spawn in the sea west of Europe far from the coasts outside the 1000 meters line, but only at such places where the temperature is high in deep water, viz. over ca. 7° in 1000 meters depth. It is for this reason that for example the whole of the Norwegian Sea west of Norway is excluded as spawning place on account of the low temperature, under 0° in 1000 meters depth.

For obvious reasons I now wanted to test if the conditions then discovered were also valid for other regions of the world where *Anguilla vulgaris* and its closely allied relative *Anguilla chrysypa* were to be found. Then by the friendly aid of the hydrographers Cand. mag. I. N. NIELSEN and Mag. Scient. H. HANSEN I obtained from the temperature curves of the Challenger, Valdivia and other deep-sea expeditions the temperature curves for 1000 meters drawn on a chart of the world, such as is to be seen on the Chart Pl. 1². If one looks at this for the Atlantic Ocean it seems to me that the absence of eels in South America and West Africa is at once understood. The water in the depths at these places is too cold for the eel to spawn. We see that the 6° and 5° isotherms run from the West Indies eastwards over to Cape Verde so that the whole of the greater part of the Atlantic Ocean south from there has a lower

¹ As an explanation of the lack of eels on the Pacific coasts of America I have seen the argument put forward about the absence of large rivers. This can scarcely be a good enough reason if there had been plenty of young eels in the sea outside, for if the latter had been the case they would be able to find whatever fresh or brackish water there is. Thus we have heard that there are swarms of eels on the almost fresh-water-less Bermudas (see p. 18) and young eels easily find their way to rivulets of the West Indian Islands which are dried up for most of the year.

² The chart given by KRÜMMEL (1907, p. 429) was also used.

temperature in 1000 meters depth. Off the greater part of Brazil the temperature is here even only between 3° or 4° C., off the west of Africa a little higher, for the greater part between 4° or 5°, but nowhere reaching here the height which in the investigations with the "Thor" in 1904—1906 off North and West Europe I found must be the minimum temperature for the spawning of the *A. vulgaris*, viz. ca. 7° in 1000 meters depth.

On the Pacific coasts of America, as we see from the chart, the temperature is also low in deep water, in no place reaching 7° in 1000 meters depth, while in the greater part of the region it is under 5°. On the other hand, on the east of Africa in the Indian Ocean as well as on the south of Asia we meet with a somewhat higher temperature. As the chart shows, we here again meet with fresh-water eels (see also p. 23 et seq.), though not the same species as in the Atlantic region.

That the distribution of the eels southwards on the coast of the Atlantic is in very good agreement with the temperature in deep water, is easily seen from the chart, and we have thus reached so far in our considerations that we can enunciate the following, without further explanation apparently paradoxical, statement: In South America and West Africa, where there are some of the warmest regions of the world, it is nevertheless too cold for the eel to exist — this fish which in certain stages of its life can even thrive north of the Polar Circle — because at one period of its life, viz. the reproductive period, it requires a higher temperature than is found off that part of the world in such great depths of the sea as it demands to be able to reproduce itself.

It is now time to examine how far the suggested explanation of the absence of eels in South America and West Africa can be connected with the actual distribution of these fishes within the other parts of the Atlantic area.

For the eastern part of the Atlantic region (West Europe and North-West Africa, the Azores, Madeira and the Canaries) a glance at the chart shows that the explanation agrees well enough, for we see that the eel (*Anguilla vulgaris*) is to be found everywhere in these regions which are situated where the temperature at a depth of 1000 meters is from ca. 7° and above, i. e. such temperatures at which the reproduction, according to my investigations with the "Thor", takes place. There is thus reason to remark that the oceanic island groups, the Azores, Madeira and the Canaries, which are rich in eels, are all situated in that part of the Atlantic where the temperature in deep water is highest, viz. above 8° in 1000 meters depth. A little closer examination of the chart immediately shows however that these conditions are not everywhere so plain, that the eels are confined exclusively to those regions where the temperature of the sea at a depth of 1000 meters is above ca. 7°. This is seen very plainly in the north of Europe (e. g. Norway) and it also shows that other points have to be reckoned with. I have already (SCHMIDT, 1906, p. 204—231) discussed this matter with respect to Northern Europe and have proved how the whole west and north of Europe is supplied with young eels from the great centres of production which lie west of the British Islands and France, and how the quantities of young which any place receives depend in the first instance on the distance of the place from these spawning centres and on the extent to which the prevailing currents are in favour of the passive and active immigration to the place. From this we could understand why the eels decrease so markedly the further we go up the Baltic and likewise why it is so common in the south and west of Norway but gets scarcer and more seldom northwards in this country, until at last it disappears (cf. p. 19). We saw that in the young stage the eel could travel very considerable distances and by this means it widens its distribution-area to regions far away from its spawning places, (e. g. from the sea west of the British Islands and France to the inner Baltic), though, of course, there are limits for this because a region may be situated so far away from the spawning places that there is no possibility for the young to reach so far in the passive and active journey which they have the power to carry out¹. We saw also that the eel was absent or very scarce east of

¹ In my work on the spawning places of the North Atlantic Gadoids (SCHMIDT, 1909 a, p. 156) I have mentioned in detail that a considerable drift of pelagic organisms takes place from the Atlantic north of the British Islands into the North Sea and

North Cape in the north of Norway, but that it can reach so far as this and also to the inner Baltic alone gives us an excellent example of the distances it can travel from the spawning centre, a fact of great value to have established, when it is a matter of understanding the conditions in the other regions of the world, particularly the east coast of America, as we shall soon see.

I may now go on to speak about the conditions in the western part of the Atlantic where the question no longer concerns *Anguilla vulgaris* but the nearly related *Anguilla chrysypa*. We are here met with the difficulty that we have to do with another, although very nearly related form, so that we are not justified as a matter of fact in taking it for granted that it is identical in its biological conditions with the European fresh-water eel. However, the following will show that it is probably very similar to it and that its distribution must find a similar explanation.

Whilst the spawning places of the European eel are comparatively well known by the discovery of many hundreds of the larval stages over a very large territory (see chart)¹, concerning the American eel only three larvæ have up till now been recorded on which to base our argument as to where the reproductive places of the species are situated. EIGENMANN and KENNEDY (1902, p. 84) report on two of these. They were taken at 38°47'20" N. Lat., 72°37'00" W. Long., on the 5th of Nov. 1883 and at 38°25' N. Lat., 72°40' W. Long. The third one, which has already been cited in this work p. 18, was found cast ashore on the Bermudas Islands in September of 1906. These three captures are marked on the chart and from this one sees that they occur just within or near the region where the temperature in deep water is the highest in the whole western part of the Atlantic². That it is just from this region that we have information about the occurrence of the larvae of *Anguilla chrysypa* and along with this to a certain degree information on the spawning places of this species, I cannot consider due to chance; on the contrary, I believe that just here about 35° North Latitude and 70° West Longitude we are near the centre of the spawning regions of the American eel, which after all probably makes somewhat similar demands on temperature and salinity as its European relative. When we study on the chart the distribution of the American eel, we see that its occurrence in the West Indies, with

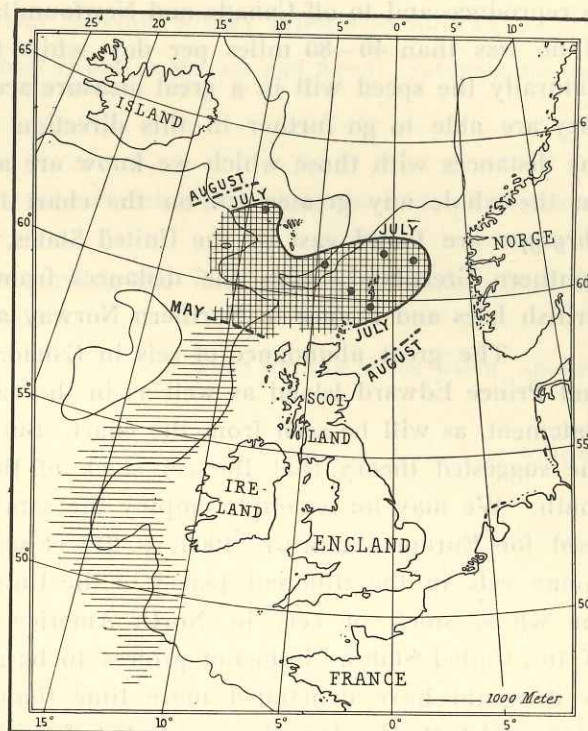


Fig. 1.

Drift of Salps (*Salpa fusiformis*) according to the investigations of the "Thor". The shaded areas indicate the distribution of the Salps in May—July 1905. In May the northern and eastern limits were west of Scotland; in July they had moved far towards the north and in August still further.

the Norwegian Sea. Here I give a figure which shows the extent of the drift in the summer of 1905 and from this it is plainly seen that the easterly journey of the immigrating young eels is largely favoured by this drift. As a direct proof that this drift has value for the transportation of the young eels it may be said that, owing to a kindly communication from Dr. HELLAND-HANSEN, a partly metamorphosed larval form (in the third stage, see SCHMIDT, 1906, p. 168) of the common eel was found in October 1907 among the islands near Bergen.

¹ During my last cruise with the "Thor" (winter 1908—09) to the Mediterranean and adjacent parts of the Atlantic I found the larvae of the eel as far south in the Atlantic as off the west coast of Morocco. I have thus found them occurring along the whole distance from W. of the Færoes to W. of Morocco.

² At this place I may add the remark, that after having the temperatures at 1000 meters drawn on the chart and studied their distribution I felt sure that the American eel must occur on the Islands of Bermudas which are close to the centre of the high temperatures. I was not therefore satisfied that the only list of the fishes of Bermuda available to me (GÜNTHER, Challenger, 1880, p. 8—9) did not give the fresh-water eel there, and I therefore searched more closely into the matter as is mentioned on p. 17, with the result that it was proved that *Anguilla chrysypa*, in spite of the lack of fresh-water on the Bermudas, occurs generally all over these islands.

Guiana, Mexico and the United States offers no special peculiarities¹. More remarkable is its occurrence in Canada, Newfoundland and Labrador, because as the chart shows the temperature in deep water outside the last-mentioned countries is very low, only ca. 2° to 3° in depths of 1000 meters. From what we have learnt about the European eel and its very great power to undertake extensive journeys both as fry and in the older stages, its occurrence is more explicable especially when we have a chart of the currents before us. From such a one, as e. g. Chart No. 2640 (3528) published by the English Admiralty under the title "Pacific, Atlantic and Indian Oceans, Mean directions and velocities of their stream and drift currents", we can see that there is probably no place in the world where such conditions exist for an effective passive transportation of pelagic organisms by the help of the sea currents as just off the coast of the United States and northwards, that is to say, from the region where the American eel is known to reproduce and to off Canada and Newfoundland. Thus the current chart gives here a maximum speed of no less than 40—80 miles per day while the minimum speed is given as being from 10—15 miles. Naturally the speed will in a great measure accelerate the journey of the eel fry northwards and probably they are able to go further in this direction than they would otherwise be able to do. If we compare the distances with those which we know are accomplished by the European eels, they are by no means on the whole any greater (cf. on the chart the distances from the places where the larvae of *Anguilla chrysypa* are found east of the United States, to Canada, Newfoundland, and Labrador, indeed even to Southern Greenland, with the distances from the spawning places of the European eels west of the British Isles and France to Northern Norway and the inner Baltic).

The great abundance of eels in Canada's most maritime Provinces, New Brunswick, Nova Scotia, and Prince Edward Island as well as in the eastern part of the United States agrees very well with this statement, as will be seen from the chart. But we have also another method of testing the correctness of the suggested theory that the eel stock of these northern lands is recruited from places lying further south. We may for example employ the same test for the coast of North America as I have previously used for Europe (SCHMIDT, 1906, p. 217 et seq.), namely, examine whether the time of ascent of the young eels in the different places in the United States, Canada, and so on, agrees with the view that the whole stock of eels in North America is derived from the spawning places off the east coast of the United States. I do not profess to be able to enter into a detailed investigation in this direction, as it would have demanded more time than I have at my disposal and besides it may be done more easily and better by American naturalists for whom there is here a neat problem that will probably repay the labour. I shall therefore restrict myself here to some few comments which undoubtedly show that the train of reasoning in question is quite right. The information which is known about the periodic appearance of the larvae of the American eel and the arrival of the glass eels is far from being so complete as that for the European ones. However it is sufficient to show that these phenomena do not fall at the same season. Thus, whilst the first larval stage of *Anguilla vulgaris* appears chiefly in the spring the corresponding stage of *Anguilla chrysypa* was hitherto only found in the autumn; and in the same manner it seems, as far as the scarce information goes, that the following developmental stages (5th and 6th stage or

¹ Consideration of the Chart will show, that the temperature in 1000 meters depth in the Caribbean Sea is only between 5° and 6°, nor is there anything to indicate that eels are produced in this Sea. On the contrary the lack or at any rate the scarcity of this fish in Central America and the adjacent parts of the north coast of South America (Venezuela, Columbia) seems almost to point to the reverse, whilst the definitely known occurrence of eels on the northern boundary of the Caribbean Sea over the whole of the part directly washed by the Atlantic, from Cuba and eastwards over the West Indian group of Islands to the contiguous Guiana, can very well be explained as connected with the places of production in the Atlantic.

With regard to the question, whether the eel spawns in the Gulf of Mexico where the temperature in 1000 meters depth is only between ca. 4½° and 6° (KRÜMMEL, 1907, p. 459), we have certainly no direct observations in this direction, so far as known to me, and there is nothing to show that this might be the case. In any case there can scarcely be any talk of large production. This can be seen from the relative scarcity of eels in the Central Region of the United States (cf. p. 8), where in fact only ca. 2% of the total yield of the States was taken, and further from the fact that the eel, according to the available data, is not a very common fish in Mexico, where towards the south it even seems to quite disappear.

"colourless elvers" and "montée") of the American eel appear ca. $\frac{1}{4}$ — $\frac{1}{2}$ year later than the corresponding stages of the European eel. We may review the period for the ascent of the young eels at some of the places on the east coast of North America, about which I have been able to procure information.

Time of ascent of the young eels.

The eel fry mentioned p. 10, on which I counted the vertebræ, came from Woods Hole, Massachusetts, which is situated on the open sea-coast. The fry, which were taken on March 1st, are very weakly pigmented ("glass-eels"). The period of capture thus gives a rather useful criterion for judging as to the time of year at which the glass-eels arrive at this part of the United States coast; consequently already at the end of winter and in early spring.

On inquiry Mr. BARTON A. BEAN of the U. S. National Museum kindly reports as follows:

"The young eels swarm in their migration up our east coast rivers in March and April (Susquehanna and Potomac); in southern rivers earlier".

SMITH and BEAN (1899, p. 183) say:

"In spring the young ascend the river, large straggling schools being seen along the rocky shores above Georgetown".

NORNY (1885, p. 315) is somewhat more precise regarding the date and he communicates the observations taken at Odessa, Del. about the middle of April:

"At the same time the flats here at low water, just at the water's edge, when the sun shone warm, showed myriads of young eels, not larger than a cambric needle".

On inquiry Dr. HUGH M. SMITH, Acting Commissioner of Fisheries, Washington, writes as follows in a letter dated April 29th, 1909:

"The "elvers" or "glass-eels" appear in streams on our Atlantic coast in spring. In Maine, they have been observed early in May".

SAWYER (1887, p. 218) says:

"— — — as early as May large numbers of little eels can be seen ascending the streams".

This observation refers to Millrift, Pike Country, PA., about 150 miles farther up the Delaware River than the above-mentioned Odessa. This statement, which as can be seen agrees very well with that from Odessa, cannot be used for comparison with the observations from the earlier mentioned places, which lie in the neighbourhood of the coasts.

The data given are sufficiently in agreement to show, that the ascent of the eel fry on the east coast of the United States about 40° N.L. takes place in the early spring or begins even at the end of the winter. According to Mr. BARTON A. BEAN's statement as quoted above, the ascent takes place earlier in the rivers situated more to the south.

Canada. As previously stated, Professor E. E. PRINCE, Commissioner of Fisheries for Canada communicates the following in a letter:

"The elvers ascend from the sea in July and August".

This must be enough to show that on the east coast of America the appearance of the young eels in the fresh water seems to occur earlier in the year further south, that is to say, earlier in those parts of the United States which are adjacent to the places where the eel from the capture of *Leptocephali* is known to spawn than further north, e. g. in Canada. The conditions are therefore apparently quite parallel to those I have mentioned earlier concerning the European eel: the further away from the spawning areas the later

the appearance of the young. But we have by no means as yet so full information from America as from Europe and we must therefore hope that this interesting matter will be taken up for closer examination by the American naturalists. We know so much already, however, that the time of appearance extends from the earliest spring to the autumn (cf. March in Massachusetts and August in Canada), thus as in Europe over a period of several months, but apparently later in the year than in Europe in agreement with the fact that the larval stages seem to appear later than the bulk of the larvae of the European eel.

In this connection I may also refer to what has been shown earlier (cf. p. 8) regarding the density of eels in the United States on the basis of the official statistics. We saw from these that of the eel fisheries, amounting to 3,822,434 lbs., the Eastern Region north of Florida took 3,740,395 lbs. (or 97·90 %). But we can carry this consideration further. For example we may consider the stretch between Cape Hatteras and Cape Cod, between which points the distance is only ca. 480 miles. It appears nevertheless, that of the 3,822,434 lbs., comprising the total yield of the eel fisheries in the United States, over 3 million lbs. must come from eels which have run up into the fresh-water on the short distance between Cape Hatteras and Cape Cod¹, which as can be seen from the Chart lies a little more to the north than the region where the highest temperature is to be found in deep water.

We thus see, that all the present data, by which the question can be elucidated, about the spawning places of the American eel, point to the fact that the centres of production at this side of the Atlantic, from which even the most northerly regions such as Canada, Newfoundland, Labrador and even the southernmost parts of Greenland are supplied with young, are situated out from the Easterly States of the United States, that is to say, in that part of the West Atlantic where the temperature is highest in deep water. The American eel in its biological conditions seems therefore to be very similar to the European eel, the spawning places of which are also restricted to a comparatively small part of the East Atlantic with a high temperature in deep water (at most, probably from the Faeroes to south of the Canaries, but certainly from the Faeroes to Morocco, the most southerly point where I found the larvae; see chart).

Having thus seen that the absence of fresh-water eels on large parts of the shores of the Atlantic must be due to a too low temperature and salinity² at the depths in which the propagation takes place, there is every reason to investigate if this explanation holds true everywhere inside the Atlantic territory. This is most easily done by examination of the chart of distribution. From this it is evident that the explanation always seems to be correct as regards the Atlantic proper as well as the inland seas which are in connection therewith. There is only one exception, namely the Black Sea, on the shores of which eels are lacking in spite of the high temperature in deep water, viz. 9°. The conditions of the Black Sea are therefore entitled to a little more thorough consideration here. From KRÜMMEL (1907, p. 300) I may therefore cite some of the measurements published by LEBEDINTZEFF which were made in the Black Sea in the years 1891—92 during the summer.

These figures explain immediately why the eel is lacking in the Black Sea and the rivers connected therewith. In deep water where the temperature is high enough to permit of the propagation of the eel, the water contains sulphuretted hydrogen which excludes all higher organic life, and, even setting aside this fact, the salinity is undoubtedly also too low, viz. only ca. 22 ‰, while in the Atlantic we found that it must at least exceed 35·20 ‰.

¹ This is readily seen by adding together the product of the eel fishery in the States or parts of States where the rivers flow into the Atlantic Ocean within the stretch mentioned.

² With low temperature in the deep water-layers of the ocean always follows low salinity, as with high temperature follows high salinity. For this reason it is practically impossible to decide whether it is the low value of the one or the other of these factors or perhaps of both which prevents the propagation of the eel.

The Black Sea.

Depth (meters)	Temperature (C)	Salinity (‰)	Sulphuretted hydrogen (H ₂ S, cc)
0	24°0	18.1	0
9	21°5	18.5	0
18	12°8	18.3	0
27	8°9	18.5	0
91	8°0	20.6	0
183	8°8	21.6	0.39
366	8°9	22.1	1.88
1464	9°0	22.5	4.44
2120	9°0	22.5	6.00

Thus it is evident that the eel cannot propagate in the Black Sea proper, and taking into consideration the extremely narrow passage leading into this sea, it is evident also that only a few young eels will succeed in entering from the Mediterranean to pass onwards to the large rivers debouching into the Black Sea.

From Italy and France eel-young have been transplanted into the Danube, where the eels have been thriving well though of course without propagating (cf. pp. 20—21 and 36 et seq.).

IV. CONCLUDING REMARKS.

Although much is still wanting before the most important biological conditions of the eels of the Atlantic region are made clear, we have learnt from the previous pages, that even at present some points have already been made out. It has been seen that the distribution of the fresh-water eels in America, Europe and Africa, finds a natural explanation on the view, that it is the temperature (and salinity) in the depths of the sea along with other secondary factors (the currents' rate and direction, the distance from the spawning places etc.) which regulate the distribution of these fishes in those regions of the Atlantic, where the climatic conditions are such that the growing eels can in any way thrive¹.

In this work we have concerned ourselves only with the American and European eel, particularly as these two are the best known within the genus *Anguilla*. In the Pacific region there are other species in regard to which the biological conditions most probably differ from those of the Atlantic eels, but although a considerable number of investigations have already been made, these eels can only be treated biologically when the investigations on their systematic position have been brought to a satisfactory conclusion. This, it is hoped, may be the case in the course of a few years.

Judged in connection with my earlier investigations on the biology of the European eel, the conditions here displayed can only be said to bring further confirmation. Thus the validity of several of the contentions brought forward has been tested on a wider scale, on a much wider region, also because the southern limit for the occurrence of the eels in the Atlantic region has been included in the investigation, which at an earlier stage had to be limited to the northern limits and thus could not

¹ In purely arctic regions where the fresh-water is nearly always frozen, no eels naturally will be able to live, even if the conditions were ever so good for the access of the young. This, of course, also applies to waters containing poisonous minerals or gases.

give the same certainty to the conclusions, e. g. concerning the determination of the minimal and maximal temperature for the propagation and so on¹.

If there still should be any one who doubts whether the fresh-water eel spawns in the ocean, the views here propounded will, it is hoped, contribute to remove this doubt. The fact, amongst others, that the eel occurs on islands quite isolated out in the ocean where other fresh-water fish are absent (e. g. several of the Bermudas, Azores, Madeira, and also the Balearic Islands) would otherwise be quite impossible to understand, but, as has just been shown in the foregoing, this in a great measure has helped to strengthen the views suggested, that the reproduction of the eel takes place out in the sea², where it is the prevailing physical conditions (temperature and salinity) which decide if this can take place and are thus the principal factors which determine the distribution.

If, finally, as is quite legitimate, when judging a work dealing with a species of fish of great economic value, any one were to put forward the question whether this work had brought to light new points and results of practical interest, we may answer that even if it is apparently without interest for the practical eel fisheries of Europe and America to understand the reason for the distribution of the eels in these regions, this view does not hold true on closer examination. Thus, putting aside the fact that increase of knowledge always offers possibilities which sooner or later may be of value, there is even now a condition which deserves to be emphasized. I would recall here the transplantation of eels and eel fry, such as has already been realised in several places for a long time, and which from the results of the investigations on the eel in recent years, will probably be done on a much larger scale (cf. the experiments of LÜBBERT, the Director of Fisheries in Hamburg, in the transplantation of young eels from the Bristol Channel to the Baltic, FISCHER & LÜBBERT, 1908).

After what has been said in the foregoing, it is evident that if we wish to transplant eels or young eels, we must be clear as to whether we intend the transplanted specimens to breed or merely to grow in size. We saw that large areas, rich in fresh water, both in America and Africa were without eels, e. g. the greater part of West Africa, the whole of West America and the east coast of South America. If we were to transplant young eels of the European or American species to these places, just as other fresh-water fish, especially of the genus *Salmo*, have been introduced at various places from quite other regions of the world, then we would be disappointed if we expected that the transplanted eels, like the salmon etc., would gain a footing and propagate so that in the future eels might be fished where previously they were not found. We understand now that this cannot be done, because the conditions for reproduction are, as we have seen, not present, and the utmost we can attain in these regions, by means of transplantation, would thus be to find suitable nurseries for the transplanted individuals. In this way the

¹ In the earlier investigations (l. c., 1906) I had come to the conclusion, that ca. 7° in a depth of ca. 1000 meters would approximately represent the minimal temperature at which reproduction could take place, and after what has been written in the foregoing pages, the conditions at the southern limit seem to lead to almost the same result. On the other hand, starting from the fact that according to the Italian authors the eel spawns in the Mediterranean where the temperature in deep water does not fall much below 13°, it seems as if the maximum temperature for reproduction cannot be under 13°, so that the range would thus be at least ca. 6°. Perhaps 13° represents the maximum-temperature but we have no means of confirming this, as has been done for several of the Gadoids (SCHMIDT, 1909 a), because the temperature in deep water is at no place so high as in the Mediterranean, with the exception of the Red Sea, where it reaches the phenomenal height of 21° at a depth of 1000 meters. I am unfortunately unable to conclude from the present too incomplete reports from the regions close to the Red Sea, whether the apparent lack of eels is really synonymous with the fact that the fish is quite absent, even if this is most probable. This question deserves a closer examination, because one could imagine that if the eel is really absent from the countries bordering on the Red Sea, the reason for this is that the temperature and the salinity in deep water are too high for reproduction just as we saw that in the other places they were too low. Yet other conditions may also be determinative in regard to the apparent absence of eels from the coasts of the Red Sea, namely, the extreme aridness of these coasts and the lack of fresh water.

² I may recall on this occasion the discovery of a large (90 cm. long) *Anguilla vulgaris* in the stomach of a Cachalot killed in the sea at the Azores (VAILLANT, 1898, p. 1429—30 and SCHMIDT, 1906, p. 145).

present investigation may help us to escape from mistakes, when we wish to transplant fresh-water eels to places where they were previously absent.

In this connection, finally, it is of great interest to study more closely the transplanting experiments which have been made in the United States. In an extremely interesting report ("A review of the history and results of the attempts to acclimatize fish and other water animals in the Pacific States, U. S. Bulletin", 1896, pp. 379—472), HUGH M. SMITH discusses the great work which has been carried out on a large scale with the transplantation of fishes from the Eastern to the Pacific States. Quite a number of fishes are mentioned, which have been transplanted to the Pacific coast with the greatest success and have there obtained a firm foothold and by their fertility have become so numerous as to be of great importance for the fisheries. Among these are noted such species as the shad (*Clupea sapidissima*), striped bass (*Roccus lineatus*), various carps (*Cyprinus carpio* and varieties), various species of salmon, catfish (*Ameiurus*-species etc.) etc., etc. It is especially of great interest to read, how certain of these fishes alter their spawning period in the new conditions under which they live, and how they multiply to such an extent in their new home, that in several cases they quickly spread over large areas.

The experiments which mainly interest us here are naturally those made with a view to acclimatizing in the Western States the eel (*Anguilla chrysypa*) which is of common occurrence in the Eastern. They were begun by the well-known Mr. LIVINGSTON STONE of the U. S. Commission of Fish and Fisheries, who has done such great service in the development of fish-culture and fish-acclimatization and who transported the fish intended for transplantation over the Continent in a so-called "aquarium car".

The experiments were made in the years 1874, 1879 and 1882 and several thousands of small and large eels were successfully transplanted in the living condition. These were set out at various places in fresh and salt water in the neighbourhood of San Francisco. In the Reports of the Commissioners of Fisheries of the State of California information is given during the following years regarding the further fate of the transplanted fish. I may quote the following from the reports of HUGH M. SMITH.

- 1874—75. "Of the fresh-water eels placed in a tributary of the Sacramento River, we learn that one had been caught in Willow Slough, in Yolo County, which had grown to be more than a foot in length. We have no knowledge that the salt-water eels placed in Sacramento Bay have ever been seen".
- 1876—77. It was stated that a few eels had been caught, but they had not become numerous. The next report recorded the capture of several "taken in the fresh water, near Sacramento, full grown, and 3 feet in length".
1880. "Occasionally we hear of an eel being captured, but as yet they have not shown an increase in proportion to that of other imported fish".
1882. "The San Francisco Chronicle of February 8 reports the catch by George Bird of the first eel resulting from the plant of 12000 made by the California fish commissioners. It was caught on the easterly shore of San Francisco Bay and measured 3 feet in length".
- 1883—84. "Eels, placed in our waters by the former commissioners, have not been a success. It is probable that the place where they were deposited and where they have made their home has not yet been discovered, at all events, none have been taken since they were planted. It seems to us that they ought to do well in our inland waters, as they are fond of the bottoms of ponds or streams where mud prevails, as is the case in our lakes and rivers".

Regarding the conditions 10 years later HUGH M. SMITH reports as follows on the basis of his own experience:

"In 1894, when the writer visited the Pacific Coast, no eels were at any time seen in the markets of San Francisco or other cities, and the following statement, based on his observations, was printed in a report embodying the data on certain phases of the fishing industry obtained at the time: "Inquiries regarding the results of the attempted acclimatization of the eel (*Anguilla chrysypa*) on this coast are apt to elicit misleading information unless great care is exercised. In the San Francisco markets one learns that eels are not infrequently exposed for sale, and that both salt water and river fishermen catch them occasionally, but an examination of the reported eels usually shows them to be lampreys".

HUGH M. SMITH concludes his account of the experiments on the acclimatization of the eel in California with the following words:

"In view of the hardiness and great prolificness of the eel, it is somewhat remarkable that it has not gained a firm hold in California and become abundant. It is, of course, possible that the failure to catch more of them has been due to the absence of suitable pots or traps, but the fact that the fish are so seldom taken with the various forms of apparatus now used can only be explained by their actual scarcity, and in their last report (1894—95) the California fish commissioners regard the eel as one of the fish from whose attempted introduction "no result can be said to have come".

With our present knowledge it is not difficult to understand why these attempts at acclimatizing the eel on the Pacific coasts failed. On the contrary, so far as it is possible to judge from the available reports, they seem to have proceeded exactly as might be expected. In the first years after the introduction a few eels were taken now and then, some of which seem to have grown very quickly, perhaps owing to the favourable localities chosen for the experiments. But after the course of a few years the end came, without as in the case of the other transplanted species any fry appearing to replace and increase the stock set out.

It may be said beforehand that any repetition of these experiments will end in the same way, since whatever care is taken to procure the transplanted eels as favourable conditions as possible for their life and growth, no human power can obtain for them the conditions outside in the sea which they require for reproduction.

It is quite another matter naturally, to consider it advantageous to transplant from the Eastern to the Western States a number of eel fry, with a view to later "gathering in" the same individuals when they are grown up, as occurs for example at several places in Europe where the eel fisheries are technically highly developed or where the price for eels, sold in the living condition, is very high. But there can scarcely be any talk of this in America, at least not so long as the eel fisheries do not play a greater role than at present.

V. RÉSUMÉ OF THE MOST IMPORTANT RESULTS.

Fresh-water eels (the *Anguilla*-genus) are widely distributed all over the world; thus, they are found in the Atlantic as well as in the Indian and Pacific regions. Only those occurring in the Atlantic region, i. e. *Anguilla vulgaris*, TURT. which lives in the eastern and *Anguilla chrysypa*, RAF. which has its home in the western part of this region and both of which are uniformly coloured, have been discussed here as they are the only ones which are fairly well characterized in systematic and biological respect.

Besides uniformly coloured, marbled *Anguilla* are also found in the Indian and Pacific regions but at present too little is known of them to enable us to discuss the particulars of their distribution in a similar way as has been done for the Atlantic forms (cf. pp. 3—4 and 23—27).

While fresh-water eels are lacking on the Pacific shores of North and South America they are found on the Atlantic shores of North America and Mexico, most richly represented in the easternmost parts of Canada and the United States, but they are for the rest found right from the southernmost Greenland and Labrador to the West Indian Archipelago and Guiana. On the other hand they are lacking in South America south of Guiana, thus in the large river systems of Brazil and Argentina, so that the place where they disappear must lie somewhere in Northern Brazil or thereabout (cf. p. 16 and the chart).

They occur besides on practically all the islands of the Atlantic Ocean north of the Equator (Bermudas, the Azores, Madeira, the Canaries, Iceland etc.) and, what deserves especially to be pointed out, they occur on islands where other fresh-water fishes are completely lacking (cf. pp. 16—18 and the chart).

On the eastern side of the Atlantic Ocean the distribution of the eels is as follows. They are lacking on the north coast of Asia and Russia, but are found almost from North Cape in Northern Norway and southwards along the coasts of Europe, on all the coasts of the Mediterranean (the Black Sea excepted) and on the north-western part of the coast of Africa. Here they disappear, probably in the Rio del Oro region or in Senegal, and are then lacking on all the west coast of Africa, e. g. in the large river systems of the Niger and the Congo (cf. pp. 22—23 and the chart).

In South Africa near Cape Agulhas we again meet with fresh-water eels as also on the east coast of Africa, the south coast of Asia and on the islands in the Indian Ocean, as is seen immediately from the chart of distribution. The relation between the *Anguilla*-species occurring here, among which there are uniformly coloured as well as marbled, and the Atlantic *A. chrysypa* and *A. vulgaris* has not yet been finally ascertained.

Thus it has been found that the Atlantic fresh-water eels occur in tropic, in warm and in cold temperate, indeed even in Arctic regions, but just on account of this astonishing power to submit to the most varied outer conditions, their actual distribution becomes apparently incomprehensible. This is most clearly seen by the peculiarity that the distribution, as observed immediately from the chart, shows an extraordinarily sudden stoppage southwards so that the greater part of South America and West Africa, where some of the largest and most fish-abundant fresh-water systems are found, are entirely destitute of eels, in spite of the fact that to all appearances many places here would offer excellent conditions for their thriving. Also the occurrence of the eels on the oceanic islands where fresh-water fishes otherwise are lacking is apparently incomprehensible.

In order to understand the distribution of the eels, especially that in spite of their great indifference to the varied outer conditions they have not been able to penetrate further southwards on the coasts of the Atlantic, it has been necessary to recall some of the results which have been gained through later years' marine investigations. I may mention here the ascertained fact that very often the sensitiveness of a species of fish to its surroundings differs a great deal in its growth-period and in its spawning-time, so that during the latter its requirements as regards the outer conditions (depth, temperature, salinity) are much more definite and very different from those during the first, the effect of which is that the distribution during the spawning-time may often be very different from that during growth (cf. SCHMIDT, 1909 a, p. 11, 151). The result of this is that it is in the first instance the requirements as regards the outer conditions during the spawning-time which influence the distribution; or in other words, to understand the distribution we must ascertain: what are the conditions required by the species in order that it may be able to effect its propagation? We have now come to the substance of the matter.

Investigations made since 1904 with the Danish investigation-steamer "Thor" and the Irish "Helga" in the Atlantic west of Europe had shown (SCHMIDT, 1906, p. 256) that the European fresh-water eel in order to be able to propagate requires great depths (at least ca. 1000 meters) besides a high salinity and temperature of the water, namely, more than 35.20 ‰ and more than 7° at a depth of 1000 meters. Taking this as a basis the distribution and migration of the eel in the northern part of Europe became quite comprehensible (cf. pp. 28—30).

We may now apply the conditions ascertained for the north-eastern part of the Atlantic to the whole region. On looking at the chart of distribution on which the temperatures in a depth of 1000 meters are given, the distribution of the Atlantic fresh-water eels at once becomes quite clear. Thus

we understand that the absence of eels in all the large fresh-water systems of South America, western North America and West Africa is due to the fact that the temperature in the deeper layers of the adjacent seas is too low to permit of the propagation. We may therefore say, though it almost sounds a paradox, that in these regions, which contain some of the warmest countries in the world, it is too cold for the existence of the fresh-water eel (cf. p. 30 and the chart).

But the actual occurrence of the eels in the Atlantic regions also becomes comprehensible if we take it for granted that they propagate in the sea, only however where the temperature and salinity in deep water exceed the above-mentioned values.

The occurrence of the fresh-water eels on oceanic islands where fresh-water fishes are otherwise completely lacking is only comprehensible if the propagation takes place out in the sea (cf. p. 30 and the chart). From the chart it is seen that all those oceanic islands in the Atlantic where fresh-water eels occur lie inside the region where the temperature in deep water is high.

As to the eastern part of the Atlantic region I have now proved with the "Thor" that the propagation of *Anguilla vulgaris* takes place over the whole long stretch from the Faeroes to the west coast of Morocco (cf. the chart). I have previously described (SCHMIDT 1906) how the fry from the spawning-places west of the British Islands and France during and after the metamorphosis move eastwards and how the eel-stock of all North-eastern Europe is recruited from here. From my description it was evident that the migrations of the fry, which are favoured by the direction of the current and by the extraordinarily long duration of the pelagic life, may be of a very surprising length (cf. the distance from the interior of the Baltic or from the northernmost Norway to the 1000 meters curve in the Atlantic west of Europe; cf. p. 30 and the chart).

In consideration of these facts the distribution of the American eel (*Anguilla chrysypa*) in the western part of the region is quite comprehensible and it seems as if its biological conditions are much like those of the European eel, which is only natural considering that they are very closely related. By discoveries of larvae it has been proved that *Anguilla chrysypa* propagates in that part of the sea off the United States where the temperature in deep water reaches the greatest height in all the western part of the Atlantic Ocean (cf. the chart where the data are marked).

The actual distribution of the American fresh-water eel seems also to prove to a certainty that the centre for the production of this species must lie here. In the first place the American fisheries statistics tell us that no less than ca. 98% of the eels caught in the United States come from the Atlantic region and only 2% from waters which are tributary to the Gulf of Mexico. Still more striking perhaps is the fact that of the 3,822,434 pounds which make the total quantity of the eel fisheries in the United States, more than 3 million pounds consist of eels which have penetrated as fry into fresh-water on the short distance between Cape Cod and Cape Hatteras, which as can be seen from the chart lies a little more to the north than the region where the highest temperature is to be found in deep water (cf. p. 34).

So far as has been ascertained from the scarce information available, the time for the ascent of the eel-fry into the fresh water at the different places on the east coast of the United States and Canada, seems also to point in the same direction (cf. pp. 33—34).

All indicates therefore that the centre of production of the American eel (*Anguilla chrysypa*), from which even the northernmost regions (Canada, Newfoundland, Labrador, Greenland) are provided with fry, must be situated off that part of the east coast of the United States, where the temperature in deep water reaches the greatest height in all the western part of the Atlantic (cf. p. 34 and the chart).

Even though the distances from this place to the northernmost part of the region where *A. chrysypa* lives (Newfoundland, Labrador, South Greenland) are very considerable they are however not greater than

those which many of the European eels must cover from the breeding-places west of Europe, and the migration will be considerably facilitated by the force and direction of the currents off the east coast of North America (cf. p. 32 and the chart).

A secondary factor of great importance for the distribution of the eels is therefore the sea-currents, which may cause their occurrence to be extended to regions lying far from the breeding-places, as was seen to be the case in Northern Europe as well as in Northern America, where the direction of the currents favoured the distribution northwards from the breeding-places. On the other hand the direction of the currents is not favourable for a similar distribution in a southerly direction from these places, the result of which is, that the southern boundary of the eels lies far more to the north compared with the breeding-places, than was to be expected after having seen how far north of the breeding-places their occurrence extends (cf. p. 32 and the chart).

From a comparison between the chart of distribution and a chart showing the ocean currents it appears clearly that the distribution of the eels corresponds fairly well with the periphery of the great anticyclonic circulation of the water masses in the North Atlantic.

That the eels also may cover very large distances after having entered into fresh-water has been amply exemplified by the preceding description. Thus I may refer to South Africa where in the neighbourhood of Pretoria eels are found which have migrated all the long way from the sea through the Crocodile or the Orange systems. Still more striking examples are found in the United States of North America where eels even occur in some of the states which border upon the Great Lakes and lie very far from the sea (cf. pp. 24 and 9). It is very peculiar to find eels in the very same state, e. g. in Ohio, Illinois and Indiana, some of which have penetrated from the Gulf of Mexico through the Mississippi, and others from the Atlantic proper through the St. Lawrence system. In South Africa we find a similar peculiarity near Pretoria where eels of very different origin, namely from the Indian and the Atlantic Oceans respectively, occur in fresh waters which lie very close to each other (cf. pp. 10 and 24).

We have seen that the distribution of the fresh-water eels inside the Atlantic region is in the first instance dependent on the temperature in the depths of the ocean, as the possibility of propagation is determined by this. But that it is not always the temperature alone which decides whether the eel is able to propagate at a place in the sea where the depth is sufficiently great, is shown by the Black Sea; in this sea where the temperature even in the greatest depths does not go down below ca. 9°, no eel fry is produced, this being clearly proved by the fact that all the great rivers having outlet to the Black Sea are destitute of eels. Other factors must therefore have influence here, and on closer examination of the hydrographical conditions we find that the water in the deeper layers is not salt enough, ca. 22 ‰ at the utmost, and that it also contains considerable quantities of sulphuretted hydrogen which excludes all higher life (cf. p. 34).

At different places of the world where fresh-water eels are absent, the experiment has been made to set out some fry in the hope that they would thrive and propagate like several other fresh-water fishes with which such experiments had proved a success. These experiments have however always

been disappointing. The present investigation explains this failure and shows that any repetition of the experiments will give the same negative result, as it is beyond human power to bring about such conditions in the sea as are required for the propagation of the eel if these are not present beforehand. It is quite a different thing that in some cases it may be very useful to liberate and rear eel fry in places where eels are not found beforehand, or where they are not present in sufficiently great numbers. This has been tried already at several places in Europe, on the largest scale in Germany and in the Danube, and undoubtedly the experiment may be carried out successfully also at other places, in countries where the prices for eels are high and the methods of fishing greatly developed. But we must be fully aware that we can only hope to rear (and "gather in") the specimens set out, not to propagate them, as has been done successfully with other fresh-water fishes; for, strictly speaking, the eel is not a fresh-water fish; on the contrary, it is a true Atlantic deep-water fish, the fate of which is in the first instance decided out in the great open ocean (cf. pp. 36 et seq.).

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