SÆRTRYK AF
MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER
SERIE: FISKERI · BIND III · NR. 5 · 1908

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TO
THE BIOLOGY OF THE PLAICE
WITH SPECIAL REGARD TO THE DANISH PLAICE-FISHERY

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IS THE PLAICE INDIGENOUS TO THE TRUE BALTIC?
(WITH TWO TEXT FIGURES)

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A. Earlier investigations.

Whilst, according to investigations carried on in the last decennium, especially from the German side, it must be considered as settled, that the main stock of plaice in the Western Baltic (or the Baltic W. of Gedser-Darsserort) is indigenous to this water, it has, on the contrary, been a still unanswered question how far the main stock of plaice in the true Baltic (or the Baltic E. of Gedser-Darsserort) has been developed there or has immigrated from other areas.

It is a well known fact that only very few plaice of the 0-Gr. were caught during the earlier scientific investigations in the true Baltic in proportion to the capture of older specimens. Dr. Petersen who was the first naturalist to become aware of this apparent want of young plaice mentions it in detail in Report IV of the Danish Biological Station, 1894. At the stage of the investigations at that time we knew of only four plaice from the true Baltic which were so small that they might possibly be counted with the 0-Gr., while larger specimens were caught in thousands. Dr. Petersen then sets forth as his opinion, that the great stock of plaice in the true Baltic were probably developed elsewhere in the Kattegat, or in the Belts, whence they later on had immigrated into the Baltic. He writes about this *inter alia* as follows (p. 4): „There are good reasons, howewer, to think that the plaice of the Baltic Sea generally pass their pelagic larval stage in the Cattegat (or the Belts) and do not enter into the Baltic till they are about one year old." (p. 11—12) „At another place I have shown that certain animals which in the Cattegat are littoral occur in the Baltic on deep water, though certainly also as littoral forms, for instance *Cardium edule*. I imagined therefore the certainly rather far-fetched possibility, that the fry of the plaice perhaps might live on deep water in the Baltic, though it is particularly littoral in the Cattegat, and with the assistance of the „Hauch" I explored the deep with Ammodytes-seines in order to see whether it was living there. It was not."

(p. 18): "While the 0-Gr., so to speak, was completely missing in the Baltic, there being scarcely any specimens under 3 inches (there were 4 exceptions) the 1-group and 2-group are richly represented. ..... The 1-group is, with very few exceptions, not represented at Bornholm, from which we can draw the conclusion that the plaice does not go there till it is more than two years old. The many seine-draughts indicate this very decidedly, and if we study closely the localities in table VII, it will be seen that the further we go west of Møens Klint the more numerously is the 1-group represented, so that Lieutenant Hansen, who undertook these measurements, arrived at the conviction that the plaice immigrate into the Baltic through the Great Belt south of Gjedser, a result which also to me seems very likely."

In 1894 and 1895 Dr. Th. Mortensen continued the Danish investigations concerning the occurrence of the 0-Gr. in the Baltic, and in Report V of the Danish Biological Station, 1896, he gives a review over the number and sizes of the specimens of the 0-Gr. and partly of the I-Gr. which in 1893, 1894 and 1895 were captured off the coasts of the Baltic. The size of the specimens which were determined as belonging to the 0-Gr. and the I-Gr., was as follows (The length is stated in Danish inches. One Danish inch = 26 mm.):

1893.	August 9.	Hesnæs,	Falster	1	specimen	of 0-Gr.	2 inches
„	September 8.	Snogebæk,	Bornholm	3	„	of 0-Gr.	2. $2^1/_2$ and $2^3/_4$″
1894.	July 2.	Sandvig Bay,	„	6	„	of I-Gr.	2. 2. 2. $2^1/_4$. $2^1/_4$. $2^1/_2$
„	„	Faxe Bay,	Sealand	1	„	of I-Gr. (?)	2″
„	August 30—31.	Due Odde and N. of Salthammer Reef,	Bornholm	1	„	of I-Gr.	$2^3/_4$″
				26	„	of 0-Gr.	$1^1/_4$″ (4 spec.). $1^1/_2$″ (9 spec.) $1^3/_4$″ (12 spec.). 2″ (1 spec.)
1895.	July 22.	N. of Salthammer Reef,	„	1	„	of I-Gr.	$2^1/_2$″
„	„ 23.	Sandvig Bay,	„	1	„	of 0-Gr.	1″
„	„ 29.	Faxe Bay,	Sealand	3	„	of I-Gr.	$2^1/_4$. $2^1/_2$. $2^1/_2$″
„	„ 30.	Præstø Fed,	„	4	„	of I-Gr.	$2^1/_4$. $2^1/_4$. $2^1/_2$. $2^1/_2$″

According to the experience which has now been gained through otolith investigations, I regard the age of the specimens caught at Bornholm exactly as Dr. Mortensen does. The age of the specimens caught off Sealand and Falster is doubtful, but the possibility is not excluded that Dr. Mortensen's opinion may also be right concerning these specimens.

Dr. Mortensen sums up his evidence concerning the question how far the stock of plaice is indigenous to the Baltic in the following sentences (p. 58): „The facts to hand suggest perhaps that plaice of some consequence are developed in the Baltic only in certain years, so that the stock of plaice of the Baltic probably for the greater part is recruited through immigration from the Kattegat. In order to obtain a reliable solving of this interesting question continued investigations are necessary, and till the quite young ones below $^1/_2$—1 inch (and best also the eggs) have been found there, we are unable to know for certain whether the plaice on the whole does propagate in these waters."

In a later treatise: "Sind die Ostsee Schollen vom Kattegat her eingewandert?" (Mitt. Deutschen Seefischerei Vereins Bd. XIII, 1897) Dr. Mortensen expresses himself more decidedly in favour of the view that the greater part of the stock of plaice in the true Baltic is not developed in that water but has immigrated from the Kattegat. The author writes concerning this as follows (p. 216): "Die jungen Schollen wandern nun erst nach Vollendung ihres ersten Lebensjahres (wenigstens nach Vollendung des pelagischen Stadiums) vom Kattegat in die Ostsee hinein."

(p. 218): "ob alle Schollen der Ostsee eingewandert sind, oder ein Theil des Bestandes indigen ist, lässt sich vorläufig nicht bestimmt sagen. Bisweilen — aber nicht jedes Jahr — findet man z. B. bei Bornholm junge Schollen von der "0-Gruppe" in grösserer oder geringerer Zahl. Ich finde es nicht wahrscheinlich, dass diese kleinen Fische schon so weit wie vom Kattegat (durch Oeresund vielleicht?) bis nach Bornholm haben wandern können; aber so lange wir nicht mit Sicherheit sowohl die Eier als die verschiedenen Entwicklungsstadien der Jungen dort gefunden haben, müssen wir gestehen, dass es nicht bewiesen ist, dass sie sich dort entwickeln.

Wie das sich nun auch verhält, sicher ist es, dass die wenigen jungen Schollen, die man an den Ostseeküsten finden kann, unmöglich den grossen Schollenbestand der Ostsee allein rekrutiren können. Weitaus der grösste Theil muss eingewandert sein."

During the "Holsatia"s cruise in the Baltic in 1901 (Die Ostsee-Expedition 1901 des Deutschen Seefischerei-Vereins) several hundred grown up plaice from 8—45 cm. were caught, but only one single specimen of the 0-Gr., a tiny specimen of 15 mm. This was not captured near the coasts, but at Adlergrund at a depth of 28 meters, where it was taken with a dredge on September 2nd, 1901. Schiemenz thought this want of young plaice in the true Baltic peculiar and writes about this as follows (p. 180):

"Auffallend ist, dass mit Ausnahme der 15 mm. langen Scholle vom Adlergrund des erste Jahrgang vollkommen und auch der Anfang des 2. Jahrgangs fehlte (bis 10 cm.). Dies stimmt also gut mit PETERSEN's Anschäuung überein."

In 1903 TRYBOM reported in "Svenska hydrografisk-biologiska kommissionens skrifter I" that spawning plaice, both males and females, had been caught in the Swedish fishing experiments in the sea north and east of Bornholm on October 11th and 12th 1901. The pelagic eggs of the plaice had not yet been ascertained with certainty in the Baltic, but in the same year (1903) Trybom was able to communicate that he had found a few of these eggs in the salt bottom water in the Bornholms Deep on November 14th, 1902 (Svensk Fiskeri-Tidsskrift XII).

Through EHRENBAUM and STRODTMANN's work: "Eier und Jugendformen der Ostseefische. I. Bericht" [1] the knowledge of the distribution and frequency of the plaice eggs in the Baltic became greatly extended. In the German investigations it was found that the eggs in February 1903 were distributed over great areas and in certain places were quite numerous. On two stations between Trelleborg and Sassnitz respectively 9 and 33 eggs were taken per square meter surface, and on a station south of Bornholm 9 eggs per square meter surface. The eggs were found as far east as Stoller-Rinne and occurred still singly in the month of May. On May 9th 1903 a pelagic larva was caught between Trelleborg and Sassnitz. Four other larvæ had already been captured in April 1903 south of Møen from the Danish Biological Station (see p. 6), and it was now ascertained that all stages of development of the plaice were able to exist in the true Baltic. But EHRENBAUM and STRODTMANN found it also peculiar that so few young plaice were captured in the Baltic in proportion to the great stock of grown up specimens in this water. For this reason they seemed also most inclined to suppose that the greater part of the stock of plaice in the Baltic is renewed by immigration from other waters, especially from the Belt Sea. They write concerning this subject i. a.:

(p. 122): "Wir müssen zugestehen, dass unsere bisherigen Untersuchungen nicht genügen, die Petersensche Einwanderungshypothese für diesen Teil der Ostsee (it is the true Baltic) zu widerlegen. Wir haben allerdings festgestellt, dass Scholleneier hier in entwicklungsfähigem Zustande abgelegt werden, auch einzelne Larven haben wir konstatiert, von PETERSEN selbst und MORTENSEN sind die ersten Bodenstadien bei Bornholm gefunden, so dass wir mit grosser Sicherheit behaupten können, dass die Scholle ihre ganze Entwicklung auch in der östlichen Ostsee durchmachen kann. Aber ob die Fortpflanzung so regelmässig und so intensiv stattfindet, dass der ganze Bestand davon herstammen kann, entzieht sich unsere Beurteilung. Wir halten es nicht für unwahrscheinlich, dass ein grosser Teil anders woher eingewandert ist; woher, ist allerdings eine andere Frage."

(p. 123—124): "..... für die östliche Ostsee (it is the true Baltic), die PETERSEN vorzugsweise untersucht hat, haben wir allerdings nachgewiesen, dass sich die Scholle hier fortpflanzen kann, wir glauben aber nicht, dass durch diese Möglichkeit das ganzen Bestand gedeckt werden kann. Wir müssen für diesen Teil daher auch eine Einwanderung in grösserem Massstabe annehmen. Der wesentliche Unterschied zwischen unseren und PETERSENS Anschauungen ist der, dass wir nicht das Kattegat als die alleinige Heimat der östlichen Schollen ansehen, sondern dass wir die westliche Ostsee mit dem südlichen Kattegat zu einem gemeinsamen Meeresabschnitt zusammenfassen, aus dem ein Fluchtuiren der Schollenmengen auch in den östlichen Teil stattfindet. Im Jahre 1903 ist sicherlich die westliche Ostsee ein Mittelpunkt für das Laichen der Schollen gewesen."

In "Report XII of the Danish Biological Station" 1905, C. G. JOH. PETERSEN communicated that Johs. Schmidt in an investigation from the Danish Biological Station on September 2nd—5th 1902 had succeeded in catching 16 specimens of the 0-Gr. at ca. 20 meters depth south of Møen. They were taken on

[1] Wissensch. Meeresunters. N. F. VI. Bd. Abt. Helgoland. 1904.

hard sandy bottom with Mytilus together with 1500 older specimens of a length from 6—35 cm. By a later otolith investigation it appeared that a total of 17 specimens belonged to the 0-Gr., and these were of the following sizes: 3 cm. 1 spec., 4 cm. 9 spec., 5 cm. 6 spec., 6 cm. 1 spec.

Thus it was evident that the 0-Gr. of the plaice really might occur in deeper water in the Baltic, but yet it had surely not been found in such numbers that it could approximately compete with the older annual series in richness of specimens.

Dr. Petersen also constantly sticks to his immigration theory, and he writes on the renewal of the stock of plaice in the true Baltic i. a.:

(p. 20): "We can imagine this large stock in the Baltic Sea to be renewed in 3 ways only: either 1) exceedingly slowly, by a very slight, annual propagation, or 2) by a large propagation in certain years, in which the hydrographic conditions then must be very different from the usual, and the fry occur in large multitudes, or 3) by immigration. In the first case the plaice must be very old in the Baltic Sea, of which their otoliths perhaps might give us information. The researches have as yet never indicated any thing about a numerous fry in certain years, and this possibility is most probably excluded, already from a hydrographical point of view. Thy only hypothesis remaining is then that of immigration, which Schiemenz as well as Ehrenbaum and Strodtmann seem inclined also to adopt. It must then especially be the I-group that immigrated from the Belt Sea to the western part of the Baltic. The bodily differences between the plaice in these seas may very well agree with such a hypothesis. But this immigration must be elucidated by renewed investigations into the occurrence of the fry, particularly in the southern part of the Great Belt and along the German shores of the western part of the Baltic Sea; for in this I fully agree with Ehrenbaum that the fry must come either from the Belt Sea or from the western part of the Baltic, scarcely from the Cattegat properly so called."

In 1906 the following four treatises were published which partly concern the stock of plaice in the Baltic.

A. Otterstrøm: Eggs and Young of Fishes in the Danish waters (Report XIII of the Danish biological Station).

S. Strodtmann: Laichen und Wandern der Ostseefische. II. Bericht. (Wiss. Meeresunters. N. F. VII. Bd. Helgoland.)

C. G. Joh. Petersen: Ueber die in den Jahren 1904 und 1905 an den Küsten der Ostsee beobachtete Brut von Plattfischen. (Rapports et Procès-Verbaux etc. Vol. V.)

A. C. Johansen: Ueber die Schollenfischerei im Kattegat und die Mittel, sie zu heben. (Rapports et Procès-Verbaux etc. Vol. V.)

Otterstrøm mentions in his treatise that 4 pelagic young plaice were taken by tow-netting in a 10 minutes' haul on April 25., 1903 south of Møen, from the "Sallingsund" of the Danish Biological Station. He records also that not a few plaice eggs were taken in the waters between Falster, Møen and Rügen in January and March, 1904.

Otterstrøm follows the immigration hypothesis with regard to the Baltic plaice and writes concerning the subject as follows (p. 16. note): "In the deeper parts of the true Baltic numerous eggs of cod and plaice have often been found. We have not up to the present found pelagic cod young in the true Baltic, and the pelagic young of the plaice occur only exceptionally there and only in the western part near Møen. Cod and plaice thus do not develop in the true Baltic, which is probably connected with the extremely low temperature ruling in the deeper, egg-carrying water-layers."[1]

[1] At the present time there is hardly any doubt that the cod can propagate in the true Baltic. See J. Alb. Sandman: "Kurzer Bericht über in Finnland ausgeführte Untersuchungen über den Flunder, den Steinbutt und den Kabeljau." Rapports et Procès-Verbaux etc. Vol. V. 1906; S. Strodtmann (l. c. 1906). J. P. Jacobsen and A. C. Johansen: Remarks on the changes in the specific gravity of pelagic fish eggs etc. Medd. Kommissionen for Havundersøgelser. Serie Fiskeri III. 2. 1908.

STRODTMANN in his work gives much new information concerning the occurrence of plaice eggs and pelagic larvæ in the true Baltic in 1904 and 1905. It is of considerable interest that a pelagic plaice larva was taken so far east as Bornholm Deep (May 4th, 1905). A single plaice egg of 2 mm. in diameter was taken in August, and it has thus been shown that the spawning time for the plaice in the true Baltic lasts at least from August to May. Strodtmann maintains that the majority of the plaice there probably spawn during the period November—February.

In this work Strodtmann sets forth as his opinion that we can say nothing for certain at present with regard to the question, how far the greater part of the stock of plaice in the true Baltic is indigenous or immigrated from the Belt Sea. He sticks to the following hypotheses:

1) The main part of the stock of plaice in the true Baltic has either immigrated from the Belt Sea — and in this case the settlement has not taken place through an immigration in multitudes of one single annual series, but through a slow movement ("Verschiebung") in the direction from west towards east of specimens belonging to many different annual series;

2) Or the main part of the stock of plaice in the Baltic is indigenous in this water, in which case a renewal of the stock takes place slowly through a slight yearly increase. The stock of plaice of the true Baltic must then be regarded as an „accumulated stock" (comp. C. G. Joh. Petersen l. c. 1905 p. 20).

Strodtmann refers in this connection to Dr. Schmidt's find of specimens of the 0-Gr. at 20 meters' depth south of Møen and remarks (p. 193): "Vielleicht hat man die 0-Gruppe an ganz verkehrten Stellen gesucht."

Dr. PETERSEN states (l. c. 1906) that no plaice of the 0-Gr. was found in 1904 during the shore investigations in the true Baltic off Skaane, Møen, Falster and Zingst, and only a few specimens in 1905. He expresses here the opinion, that the stock of plaice in the true Baltic is mainly renewed through immigration of young from the German coasts of the western Baltic (W. of Gedser—Darsserort).

In my treatise of 1906 I give the result of an otolith investigation of plaice captured in the true Baltic south of Møen on November 16th, 1905. It is evident from this that the stock of plaice in the true Baltic ought just to be regarded as an "accumulated stock", in which each of the younger series forms only a proportionately small part (p. 123—124). Among 576 specimens examined, 0·5 % belonged thus to the I-Gr., 8·5 % to the II-Gr., 5·7 % to the III-Gr., while 77·8 % belonged to the older series from the IV-Gr. and upwards. (As to 7·6 % of the specimens it could not be determined to which of the groups mentioned they belonged.).

In „Mitt. des Deutschen Seefischerei-Vereins No. 2 1907" Dr. J. REIBISCH has published a communication concerning the outcome of the German investigations with regard to the distribution of young flat fishes off the southern coasts of the western Baltic and the true Baltic in 1905 and 1906. Regarded in the light of the investigations which have been undertaken later on from the „Thor" the following observation mentioned by Reibisch on p. 141 is of considerable interest:

"1905 fanden sich je eine Scholle vor Prerow und vor Zingst in ganz flachem Wasser. 1906 war ein Fischen mit dem Hamen in dieser Gegend nicht möglich, die Waade erbeutete dagegen aus 12—13 m. Tiefe 7 Stück in 2 Zügen. In etwa weiteren Zügen, die in flacherem Wasser ausgeführt wurden, fand sich nur noch bei 4 m. ein Exemplar."

This observation did not, however, lead Reibisch to any further search for plaice of the 0-Gr. in deeper water in the true Baltic. Reibisch sets forth in this treatise a similar opinion to that expressed in Strodtmann's hypothesis 1 mentioned above.

B. On the capture of bottom stages of the 0-Gr. of plaice in the true Baltic during the „Thor"s investigations in 1907.

Whilst previously very few specimens of the bottom stages of the 0-Gr. were found in the true Baltic (or the Baltic east of Gedser—Darsserort), we captured quite a considerable number from the "Thor" in March 1907.[1] This did not happen, however, till we had provided the ground rope of the "Thor"s usual otter-trawl with an iron chain of a weight of 30 Kilos. Till this took place we caught none, or sometimes a single plaice of the 0-Gr. in hauls of one hour's duration. But having applied this iron chain to the ground rope we might catch 5—10—15—20 up to 40 specimens per hour in the sea between Falster, Møen, Rügen and Skaane.

At St. 885, situated 11 miles N. 1/2 E. of Darsserort at 54° 39′ N., 12° 29′ E., 17 meters' depth, the otter-trawl was employed both with and without chain. Concerning the capture of the 0-Gr. of the plaice at this station, I have in the "Thor"s journal made the following remarks: "In the first three hauls no chain on the ground rope was employed. The trawl passed lightly over the bottom, took numerous plaice and dabs, but no bottom material and very few Algæ and Mytilus. In these three hauls of a total duration of 3 hours, 2 plaice of the 0-Gr. were caught. We now applied an iron chain of a weight of 30 Kilos. on the ground rope to try if we could capture more of the young when the apparatus penetrated deeper into the bottom. It soon became evident that the more algæ and bottom material the trawl brought up, the more plaice of the 0-Gr. were captured. In three hauls of a total duration of 3 hours, in which not much bottom material was taken up, 8 plaice of the 0-Gr. were caught. On the other hand, in 3 hauls of 2 hours' duration each, where the trawl took up a lot of algæ and sand, 109 plaice of the 0-Gr. were brought forth (one haul 27, one haul 48 and one haul 34 plaice of the 0-Gr.)."

At 5 stations where the age of all the captured specimens was determined, the following total number of the 4 youngest annual series was captured:[2]

0-Gr.	I-Gr.	II-Gr.	III-Gr.
174	125	89	177

The 0-Gr. of the plaice was thus found here for the first time in the true Baltic in such numbers that it might compete with each of the older annual series (I-Gr., II-Gr. etc.) in richness of specimens, and this was repeated at other stations. This fact is the more important as we can surely take it for granted that many more specimens of the 0-Gr. passed through the meshes of the trawl than of each of the older series.

At the end of July and in the beginning of August 1907 an investigation was again undertaken from the "Thor" in the true Baltic, essentially to point out the occurrence and distribution of the plaice hatched in 1907. As fishing apparatus was employed a Young fish trawl provided with wings and chain (see Contributions III p. 5). This apparatus was used on 29 stations between Falster and Middel Bank, and at depths between 8 and 87 meters. We succeeded in capturing plaice of the 0-Gr. on 3 of these stations between Møen and Rügen at 18—21 meters and on one station at Oder Bank at 15 meters. A total number of 22 specimens was taken. That the capture was not greater is probably owing to the circumstance that, on account of the consistence of the bottom, it is very difficult to fish these small animals in the true Baltic. At the depths where the 0-Gr. of the plaice has its main distribution, from ca. 10 — ca. 40 meters, the sea bed is as a rule covered thickly with Mytilus, for which reason the apparatus can easily pass over these without penetrating into the sand bottom. If we finally attach a chain to the ground rope of the young fish trawl in a way that it breaks up the Mytilus cakes from the

[1] It should be remembered that a plaice's year is assumed to commence on April 1st, and that the specimens in question were nearly one year old when captured.

[2] Comp. A. C. Johansen: Contributions to the Biology of the Plaice. III. 1908. (Table I, p. 14 and Figs. 9, 10, 11, 12.)

bottom, it will be quickly filled with these and now fishes badly or breaks. The specimens are at this season still too small to be captured other than singly by an apparatus such as the otter-trawl.

Moreover, it should be remembered that while the plaice of the 0-Gr. in other regions are to be found mainly in a small stretch near the coast, they are present in the true Baltic in a very large area in deeper water. It cannot therefore be expected that the young should appear so thickly there as elsewhere near the coasts.

C. On the capture of pelagic stages of plaice in the true Baltic during the "Thor"s investigations in 1908.

Until the spring of 1908 hardly more than a dozen of plaice larvæ had been caught in the true Baltic, but as there had not been fished much for them by larger apparatus at the right season, there might still be some uncertainty, as to whether they were present in considerable numbers or not. For this reason the author was charged to investigate this matter further during a cruise with the "Thor" from April 28. to May 8. 1908. It appeared that the time was successfully chosen for such an investigation in the true Baltic. Most of the plaice eggs were hatched, and the few which were still found, contained large embryos. Only a few larvæ had, on the other hand, reached such a development that they approached the bottom stage, and none of the young were found on the bottom.

It appeared in this investigation, that the plaice larvæ were present everywhere in the water between Falster and Bornholm, and that they were also to be found further east though in lesser quantities. Still at our most easterly station in Stolpe channel (55° 16′ N. 16° 35′ E.) three plaice larvæ were taken in a haul by Young fish trawl lasting 30 minutes. A view of the capture of plaice at the separate stations as well in the true Baltic as in the Kattegat and the Belt Sea is given on Fig. 1 and Table 1. It appears from this chart and this table, that a few plaice larvæ may still be found where the salinity of the water is as low as 7 ‰. But the investigations show plainly enough that the frequency of the larvæ increased with the salinity of the water. The lowest salinity at which we found a greater number of plaice larvæ was 12·5 ‰. In water of this salinity, 37 plaice larvæ were captured WSW. of Hammeren at Bornholm in a 30 minutes' haul by Young fish trawl. In the southern Kattegat and the Belt Sea the plaice larvæ were on an average more numerous than in the true Baltic, and they were also on an average more advanced in development. A very great part of the larvæ which were found in the true Baltic were so tiny that they must have been hatched quite recently, so nothing suggests that these might have been transported by currents as larvæ from the Belt Sea or the southern Kattegat. The comparatively fresh surface water evidently carries several plaice larvæ out from the true Baltic to the Kattegat and the western Baltic, but in all probability more specimens are transported in the opposite direction by the salter water moving into the true Baltie. We may at any rate take it for granted that an exchange of specimens takes place between the true Baltic and the adjacent waters already while the plaice are in the pelagic stage. This exchange also takes place with regard to the older stages, but concerning these it is quite unknown whether the immigration to exceeds the emigration from the Baltic.

Of the plaice eggs which, as far as we know, cannot float in water of a less salinity than 10 ‰, more assuredly float into the true Baltic than out of it.

In water between 7 and 8 ‰ S. we have in the Baltic caught 20 plaice larvæ by Young fish trawl in hauls of a total duration of $7^3/_4$ hours. This gives 26 specimens per 10 hours' haul. In water between 8 and 12 ‰, 18 plaice larvæ were caught in 4 hours, this gives 45 specimens per 10 hours. In water between 12 and 20 ‰ S. 117 specimens were captured in $5^1/_6$ hours. This gives 226 specimens in 10 hours.

Fig. 1. No. of larval plaice caught per ½ hour by Young fish trawl between April 28. and May 8. 1908.
Underlined figures indicate number of plaice caught per ½ hour. Figures in brackets indicate the salinity at the fishing depth.

If we regard the "Thor"s capture of plaice larvæ in the beginning of May 1908 as representative of that part of the true Baltic situated west of 17° E. long. and south of Södra Udde we may indicate a lower limit for the number of plaice larvæ which were present in the true Baltic in May, 1908.

The opening of the „Thor"s young fish trawl was in front 2·7 square meters. In the course of 1 hour the trawl moved ca. 2 miles or ca. 3704 meters. In the course of 10 hours a water volume is thus filtrated, which is less than 27×3704 m.^{3} = 100008 m.^{3} or less than 10^5 m.^{3}. According to calculations of cand. mag. J. P. Jacobsen the waters in the true Baltic west of 17° E. long. consisted of the following volumina in the beginning of May 1908.

Water of 7—8 ‰ S. ca. 15×10^{11} m.^{3}
„ „ 8—12 „ ca. 3×10^{11} m.^{3}
„ „ 12—20 „ ca. $1{\cdot}7 \times 10^{11}$ m.^{3}

Table 1. Number of larval plaice caught by the "Thor" in the Kattegat, the Belt Sea, and the Baltic between April 28. and May 8. 1908. Apparatus: Young fish trawl.

Station No.	Date	Locality	Central position N	Central position E	Depth m.	Temperature & Salinity m.	Temperature & Salinity ° C.	Temperature & Salinity ‰	Depth of fishing* meters	Hour shot	Duration of fishing hours	No. of Pleuronectes platessa 5—9 mm.	10—12 mm.	13—15 mm.
		The Kattegat.												
1197	1908 April 28	S. of Store Middelgrund.	56°32′	12°07′	27	27	4·9	34·7	c. 26	8^{30} a. m.	1/2	1	4	..
»	» »	»	»	»	..	0	5·4	17·8	c. 0—2	9^{20} a. m.	1/2	..	..	.
						5	4·9	17·9						
1198	» » 28	E. of Kobbergrund.	57°09′	11°24′	37	0	5·8	20·9	c. 0—2	5^{15} p. m.	1/2	..	..	..
						5	4·7	23·9		6^{00} p. m.				
»	» »	»	»	»	..	37	4·6	34·8	c. 37	7^{00} p. m.	1/4	..	..	..
1199	» » 29	4 miles S. by E. of Skagen L.V.	57°42′	10°46′	26	0	5·5	20·4	c. 0—2	0^{25} a. m.	1/4	3	..	..
						5	4·7	24·0						
1200	» » 29	Læsø Rende.	57°26′ 57°22′	10°44′— 10°42′	30—17	10	4·5	33·2	c. 10	4^{10} a. m.	2	..	..	..
1201	» » 29	N by W of Tangens Light buoy.	56°45′	10°55′	10	0	5·9	18·9	c. 0—2	0^{25} p. m.	1/2	..	..	..
						5	5·8	18·7						
1202	» » 29	7 miles SSE 1/2 E of Fornæs.	56°21′	11°06′	19—21	15	4·2	30·9	c. 18	4^{50} p. m.	1/2	14	28	5
						21	4·4	33·8						
»	» »	»	»	»	..	0	6·0	18·7	c. 0—2	5^{35} p. m.	1/2	1	..	..
						5	5·9	18·7						
		The Belt Sea.												
1204	» » 30	SE 1/4 E of Spodsbjerg.	54°55′	10°52′	28—35	20	4·3	24·0	c. 22	0^{10} p. m.	1/2	12	10	1
						25	4·0	25·8						
»	» »	»	»	»	..	0	6·4	14·4	c. 0—2	0^{45} p. m.	1/2	..	..	..
						5	6·2	14·4						
1205	» » 30	SSE of Langeland.	55°40′	10°48′	22	0	6·7	13·1	c. 0—2	3^{10} p. m.	1/2	..	..	..
						5	6·4	13·2						
»	» »	»	»	»	..	22	3·9	21·6	c. 21	3^{50} p. m.	1/2	19	16	..
1206	» » 30	9 miles S by W of Skjoldnæs.	54°49′	10°13′	28	20	3·6	19·9	c. 25	8^{40} p. m.	1/2	34	33	4
						28	2·9	23·5						
»	» »	»	»	»	..	0	6·0	13·1	c. 0—2	9^{20} p. m.	1/2	21	8	1
						5	6·0	12·9						
1207	» May 1	9 miles SSE of Staber Huk.	54°17′	11°28′	21	18	4·7	15·9	c. 19	5^{45} a. m.	1/2	55	7	1
»	» »	»	»	»	..	0	6·7	10·7	c. 0—2	6^{40} a. m.	1/2	..	..	..
						5	6·5	12·4						
		The true Baltic.												
1208	» » 1	NE by E of Gedser L. V.	54°32′	12°16′	26—28	24	3·7	18·8	c. 24	2^{45} p. m.	1/2	15	6	..
»	» »	»	»	»	..	0	7·2	9·3	c. 0—2	3^{30} p. m.	1/2	3	1	..
						5	5·7	12·1						
1209	» » 1	SE 1/2 S of Hestehoved Light.	54°46′	12°18′,6	21	0	6·1	8·2	c. 0—2	5^{50} p. m.	1/2	..	..	..
						5	5·6	8·1						
»	» »	»	»	»	..	21	4·0	18·9	c. 21	6^{30} p. m.	1/2	5	..	..
1210	» » 1	5 miles ESE1/2E of Møen's Light.	54°56′	12°42′	25	0	5·0	7·6	c. 0—2	11^{00} p. m.	1/2	2	..	..
						5	4·9	7·6						
»	» » 2	»	»	»	..	25	4·3	8·4	c. 24	0^{10} a. m.	1/2	1	..	..
1211	» » 2	19 miles SE 1/2 S of Møen's Light.	54°44′	12°56′	28—30	0	4·6	7·1	c. 0—2	2^{40} a. m.	1/2	2	..	..
						5	4·6	7·3						
»	» »	»	»	»	..	30	4·0	10·0	c. 30	4^{10} a. m.	1/2	10	..	..

* See Contributions III, p. 25.

Table 1. Continued.

Station No.	Date	Locality	Central position		Depth	Temperature & Salinity			Depth of fishing	Hour shot	Duration of fishing	No. of Pleuronectes platessa		
			N	E	m.	m.	°C.	‰	meters		hours	5–9 mm.	10–12 mm.	13–15 mm.
		The true Baltic.												
1212	1908 May 2	11 miles NE ½N of Arkona Light.	54°50′	13°36′	45	45	3·1	19·6	c. 45	9^{30} a. m.	½	9	7	..
»	» »	»	»	»	..	30	5·1	9·2	c. 30	10^{25} a.m.	½	..	..	..
»	» »	»	»	»	..	0	4·6	7·4	c. 0—2	11^{05} a.m.	½	..	..	..
						10	4·4	7·6						
1213	» » 2	14 miles NW by W ½ W of Adler Gr. L. V.	54°55′	13°59′	44	0	5·8	7·8	c. 0—2	1^{50} p.m.	¼	..	..	..
						10	4·5	8·0						
»	» »	»	»	»	..	44	3·4	18·1	c. 44	2^{10} p. m.	½	8	7	1
1214	» » 4	17 miles SW ¼ S of Due Odde Light.	54°46′	14°49′	55	0	4·3	7·5	c. 0—2	9^{45} a. m.	½	..	..	..
						10	4·2	7·4						
»	» »	»	»	»	..	55	2·7	10·0	c. 55	10^{25} a.m.	½	..	..	..
1215	» » 4	24 m. S. of Due Odde Light.	54°36′	15°10′	57	57	2·7	11·5	c. 57	1^{40} p. m.	½	..	..	..
1216	» » 4	26 m. SE ½ S of Due Odde Light.	54°43′	15°37′	70	65	2·5	13·1	c. 67	5^{00} p. m.	½	3	..	..
»	» »					70	2·6	16·4						
»	» »	»	»	»	..	0	4·2	7·3	c. 0—2	5^{40} p. m.	½	..	..	..
						15	4·0	7·5						
1217	» » 4&5	21 miles E by S ¼ S of Due Odde Light.	54°58′	15°41′	85	0	3·9	7·1	c. 0—2	..	1	..	..	..
						20	3·8	7·4						
»	» »	»	»	»	..	50	2·8	7·4	c. 50	..	½	8	..	..
						60	2·6	12·4						
»	» »	»	»	»	..	85	2·8	16·6	c. 85	3^{40} a. m.	1/6	4	..	..
1218	» » 5	17 miles E of Christiansø.	55°22′	15°40′	93	90	2·8	17·6	c. 90	9^{15} a. m.	½	..	..	..
»	» »	»	»	»	..	70	3·3	15·8	c. 70	11^{25} a.m.	½	2	..	..
»	» »	»	»	»	..	0	3·8	7·3	c. 0—2	0^{20} p. m.	½	..	..	..
						20	3·7	7·3						
1219	» » 6	Stolpe Channel.	55°16′	16°35′	61	60	2·7	7·6	c. 60	0^{00} a. m.	½	3	..	..
1220	» » 6	15 miles N of Christiansø.	55°34′	15°09′	80	80	3·5	16·4	c. 80	8^{30} a. m.	½	4	..	..
1221	» » 6	9 miles WSW of Hammeren.	55°12′	14°32′	47	0	4·5	7·4	c. 0—2	0^{40} p. m.	½	..	..	..
						10	4·9	7·4						
»	» »	»	»	»	..	47	3·9	12·5	c. 47	1^{40} p. m.	½	6	29	2
1222	» » 7	16 m. SE by S of Smygehuk Light.	55°08′	13°42′	45–47	46	3·5	18·7	c. 47	8^{05} p. m.	½	5	4	..
»	» »	»	»	»	..	0	4·7	7·1	c. 0—2	8^{40} p. m.	½	1	1	..
						10	4·8	7·1						
1223	» » 8	13 miles SE of Falsterbo.	55°10′	13°07′	35	0	4·9	6·9	c. 0—2	1^{50} a. m.	½	..	..	..
						10	4·8	7·0						
»	» »	»	»	»	..	35	4·2	7·8	c. 35	2^{30} a. m.	½	3	..	..
1224	» » 8	4 m. E ¼ S of Stevns Light.	55°18′	12°35′	24	0	5·2	7·4	c. 0—2	7^{00} a. m.	½	..	..	..
						10	5·3	7·5						
»	» »	»	»	»	..	24	5·7	8·3	c. 23	7^{45} a. m.	½	3	..	..
		The Sound.												
1225	» » 8	2½ miles W of Landskrona.	55°52′	12°46′	48	20	5·2	34·3	c. 20	3^{30} p. m.	½	16	15	3
»	» »	»	»	»	..	0	7·0	10·2	c. 0—2	4^{15} p. m.	½	..	..	..
						5	6·9	12·7						

As a lower limit for the number of the plaice larvæ the following figures are thus obtained:

$$\text{In water of } 7\text{—}8\ ^0/_{00}\text{ S.} = \frac{15 \times 10^{11} \times 26}{10^5} = 390 \text{ millions}$$

$$\text{„ „ „ } 8\text{—}12^0/_{00}\text{ S.} = \frac{3 \times 10^{11} \times 45}{10^5} = 135 \text{ „}$$

$$\text{„ „ „ } 12\text{—}20^0/_{00}\text{ S.} = \frac{1.7 \times 10^{11} \times 226}{10^5} = 384 \text{ „}$$

or a total of 909 millions of larvæ.

The number of marketable plaice captured in the true Baltic annually is naturally very small (presumably 5—10 millions of specimens) in proportion to the number of larvæ stated above.

The find of a numerous 0-Gr. of plaice in the true Baltic, both of bottom stages and pelagic stages, has invalidated the basis for the immigration hypothesis. From the moment when a considerable 0-Gr. is found to exist in the Baltic we know nothing at all whether the number of the bottom stages of plaice immigrating to the Baltic is smaller or greater than that emigrating from the Baltic. The solving of this problem with regard to the older series must now be carried on by means of marking experiments.

D. On the size and rate of growth of plaice in the true Baltic and the adjacent waters.

That a great part of the stock of plaice in the true Baltic is indigenous to that water we are already led to suppose by the fact that the specimens are there continually of a less size than those of the same age-group from the Kattegat and the Belt Sea. It is immaterial which age-group of plaice we regard: they are smaller in the true Baltic than in the Kattegat and the Belt Sea. This fact is due to two causes, first, that the plaice in the true Baltic on an average become hatched a little later in the year than in the Kattegat and the Belt Sea, secondly, that the increase in growth of the specimens is slighter in the former than in the latter area.

If we first regard the pelagic stages it will be seen in Table 1, that the specimens found between April 28. and May 1. in the Kattegat and Belt Sea have been larger, on an average, than those captured in the true Baltic some days later, between May 1. and 8. The investigations have left no doubt that the pelagic stages in the Baltic were both smaller and less advanced in development than those in the Kattegat and the Belt Sea.

The bottom stages of the 0-Gr. are in the true Baltic considerably smaller than those which are present simultaneously in the Kattegat and the Belt Sea. The specimens which are present in deeper water, and which form the main stock of the 0-Gr. in the true Baltic, have in the beginning of August an average size of 30—35 mm. whilst the specimens in the southern Kattegat and the Belt Sea by this time have an average size generally of 40—60 mm. At the end of their first year of growth the Baltic plaice have reached an average size of ca. 50 mm. while specimens at the same time in the Southern Kattegat and Belt Sea usually have an average size of 65—90 mm. (See Tables 2 and 5 and moreover Apstein[1], Duncker[2], A. C. Johansen l. c. 1906, C. G. Joh. Petersen l. c. 1905 and 1906, Reibisch l. c. 1907, Strodtmann l. c. 1906). Even in Neustädter Bay we find the specimens of the 0-Gr. to be larger than those which are present contemporaneously in deeper water in the true Baltic (comp. Tables 2 and 3).

[2] C. Apstein: Junge Butt (Schollen, Pleuronectes platessa) in der Ostsee. Wissenschaftl. Meeresunters. N.F. Bd. 8. Abt. Kiel. 1904.

[2] G. Duncker: "Junge Goldbutt (*Pleuronectes platessa* L.) in der Neustädter Bucht". Mitt. Deutsch. Seefischerei-Vereins. Bd. XX, 1904.

Table 2. Size of plaice of the 0-Gr. of 1906 and

Date	Locality	Central position N	Central position E	Depth m.	Apparatus	Duration of fishing (hours)	29	30	31	32	33	34	35	36	37	38	39	40	41	42
	True Baltic.																			
1907 March 13	11 miles N 1/2 E of Darsserort.	54°39′	12°29′	17	50 f. Otter-trawl	12	..	.	..	..	..	..	..	1	1	..	..	..	1	2
» » 24	8 miles E of Gedser.	54°35′	12°12′	17	»	1	..	..	..	..	..	..	..	..	..	..	1	2	2	4
» » 24	Off Zingst.	54°32′	12°45′	14	»	1	..	..	..	..	..	..	..	..	..	..	..	..	1	..
» » 25	15 miles ESE of Ranzow Light.	54°32′	14°04′	17	»	1 1/2	..	..	..	1	..	..	..	..	..	1	..	..	1	..
» » 26	7 miles SW by W of Møens Light.	54°52′	12°25′	17	»	2	..	..	..	..	..	1	..	..	..	1	2	2	..	..
» » 26	12 miles SSE of Møens Light.	54°47′	12°43′	18	»	2	..	..	..	..	..	..	..	..	..	..	1	..	..	..
» » 26	NV of Kriegers Flak.	55°07′	12°42′	30	»	1	..	..	..	..	..	..	..	..	..	1	..	..	..	..
» » 26	14 miles SE by E of Falsterbo Light.	55°08′	13°06′	36	»	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..
1907 July 23	7 miles NE 3/4 E of Greifswalder Oie.	54°20′	14°04′	15	Young fish trawl	1 1/2	..	..	..	1	..	..	..	..	..	..	..	..	..	..
» August 3	11 miles SE of Møens Light.	54°50′	12°48′	21	»	2 1/2	2	..	1	1	3	2	1	..	..	..	..	..	..	..
» » 3-4	11 1/2 miles SE 3/4 S of Møens Light.	54°49′	12°47′	19	»	2	..	..	1	1	1	..	1	..	1	1	..	..	.	..
» » 4	12 miles SE 3/4 S of Møens Light.	54°48′	12°49′	18	»	2 1/2	..	..	..	..	..	..	2	..	2	1	..	..	..	..

* Otoliths of largest specimens investigated.

Table 3. Size of plaice of the 0-Gr. in Neustädter Bay. (After S

Month	Date	Year	Locality	Depth (meters)	Fishing apparatus
June	28	1905	Travemünde	The beach	Hand shove net
July	10	1905	S of Neustadt	»	»
»	11	1905	E of Wiek	»	»
»	22	1905	Travemünde	»	»
August	5—6	1904	Timmendorfer Strand	0—6	Eel Seine
»	14—15	1906	Travemünde	The beach	..
»	16	1906	Niendorfer Strand	»	..
»	18	1906	Travemünde	»	..
»	22	1903	»	»	Hand shove net
September	8—10	1905	»	»	»
»	8—10	1905	»	»	Seine
»	25—30	1903	»	»	Hand shove net
October	12—20	1905	»	»	Seine
November	7—10	1905	»	»	»
»	18—29	1905	»	»	Hand shove net

* Otoliths of 4 specimens of 70—79 mm investigated by Reibisch. ** Some specimens of the I-Gr. probably included.

The bottom stages of the 0-Gr. in the true Baltic have the peculiarity that the specimens occurring in deeper water are smaller, on an average, than those staying in more shallow water. This was observed during the investigations in March 1907 and earlier investigations point in the same direction (see Tables 2 and 4).

1907 caught from the "Thor" in the true Baltic in 1907.

Size in millimeters																																														Total number	Average size (mm)
43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	90		
1	2	1	7	11	8	6	10	14	9	10	6	11	6	6	1	..	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	119*	51·3
1	4	7	4	1	1	1	3	2	2	3	..	..	.	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	39	46·2
2	..	..	..	..	1	..	..	..	..	..	1	..	2	..	1	..	..	4	2	..	1	2	1	..	1	1	..	1	1	..	..	..	1	..	1	..	1	..	25*	61·6
..	1	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	47·6
2	1	..	..	..	1	2	..	2	2	..	1	3	..	..	..	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	23	48·3
..	..	..	..	1	1	2	2	1	1	..	..	..	..	..	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9	48·3
..	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	42·3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	29·0
..	..	..	..	..	..	..	..	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	32·0
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	32·3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	34·3
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	36·4

Strodtmann — 1906; Duncker — 1904; and Reibisch — 1907.)

Investigator	Size in centimeters															Total number	Average size (cm)	Correction to average size (cm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
Strodtmann	26	115	44	29	10	..	..	..	..	..	..	..	..	..	..	224	2·5	+ 0·4
Reibisch	..	..	5	4	..	..	..	..	..	..	..	..	..	..	..	9	3·4	+ 0·5
»	..	..	1	7	3	..	..	..	..	..	..	..	..	..	..	11	4·2	+ 0·4
Strodtmann	..	6	23	22	21	1	..	..	..	..	..	..	..	..	..	73	3·8	+ 0·5
Duncker	..	..	10	64	96	36	4	1	..	..	..	..	..	..	..	211*	4·8	+ 0·3
Strodtmann	..	..	8	38	17	3	1	..	..	..	..	..	..	..	..	67	4·3	+ 0·5
»	..	..	10	12	4	..	..	..	..	..	..	..	..	..	..	26	3·8	+ 0·4
»	..	..	21	79	54	18	3	..	..	..	..	..	..	..	..	175	4·4	+ 0·5
»	..	..	4	42	55	22	7	3	2	..	..	..	..	..	..	135	5·0	+ 0·5
»	..	..	2	15	27	14	10	5	3	..	..	..	..	..	..	76	5·5	+ 0·5
»	..	..	1	8	12	23	34	28	33	13	4	2	3	1	..	162**	7·7	+ 0·5
»	..	..	16	110	115	43	10	1	..	..	..	..	..	..	..	295	4·7	+ 0·5
»	..	..	..	..	4	5	5	23	13	8	10	1	2	2	2	75**	9·0	+ 0·5
»	..	..	..	..	4	2	1	5	6	6	9	1	4	2	2	42**	9·9	+ 0·5
»	..	..	1	5	4	1	6	2	..	..	..	..	..	..	..	19	5·7	+ 0·4

This feature is quite the reverse of that observed in the North Sea, the Kattegat and the Belt Sea (by Bolau, Garstang, A. C. Johansen, Redeke, Strodtmann, Wallace and others) where the size of the specimens of the 0-Gr. and I-Gr. etc. increases on an average with the depth. It is, however, rather probable that specimens which from the beginning of their bottom stage have lived in

deeper water are smaller than specimens which from the beginning have lived in shallower water also in other waters than the Baltic. But the specimens in the first mentioned category occur only in quite slight numbers outside the Baltic and are only sparsely represented in the captures. If we find, during an investigation, that the specimens of the 0- and I-Gr. etc. on an average increase in size with the depth in most of our waters, the majority of the specimens captured in deeper water (e. g. 10—20—30 meters) originate probably from the coasts, and the phenomenon must then be explained in the way, that the largest and strongest specimens on an average go farthest out, and not in the way, that the specimens which have begun their bottom stage in deeper water have found better life conditions there than those which commensed their bottom stage in shallower water.

In the Great Belt we have found in deeper water a few specimens of the 0-Gr. which were on an average smaller than those present at the coasts. This will be seen from Table 5 p. 17.

Table 4. Average size of bottom stages of plaice of the 0-Gr. caught in the true Baltic from 1893—1907.

Month	Date	Year	Locality	Depth (meters)	Fishing apparatus	Investigator	Average size mm	Total No.
			1. Coastal Grounds.					
June	22	1903	Næsgaard, Falster	The beach	Hand shove net	A. Otterstrøm	27	1
»	23	1905	S of Dragør, Amager	»	»	C. G. Joh. Petersen	46	4*
July	6	1894	Faxe Bay, Sjælland	»	»	Th. Mortensen	c. 52	1*
»	17	1905	Off Zingst	»	»	J. Reibisch	40	1
»	18	1905	Off Prerow	»	»	»	42	1
»	23	1895	Sandvig Bay, Bornholm	»	»	Th. Mortensen	c. 26	1
»	29	1895	Faxe Bay, Sjælland	»	..	»	c. 63	3*
»	30	1895	Præstø Fed	»	..	»	c. 62	4*
August	9	1893	Hesnæs, Falster	»	..	C. G. Joh. Petersen	c. 52	1
»	30—31	1894	Off Due Odde, Bornholm	»	..	Jessen	41	26
September	6	1906	Off Zingst-Prerow	4—13	Seine	J. Reibisch	61	8
»	8	1893	Snogebæk, Bornholm	The beach	..	Th. Mortensen	c. 63	3
November	16	1905	S of Møen	»	Hand shove net	A. C. Johansen	53	1
			2. Offshore Grounds.					
July	23	1907	Oder Bank	15	Young fish trawl	A. C. Johansen	32	1
August	3	1907	Between Møen and Rügen	21	»	»	32	10
»	3—4	1907	Between Møen and Rügen	19	»	»	34	6
»	4	1907	Between Møen and Rügen	18	»	»	36	5
September	2	1901	Adler Ground	28	Dredge	Schiemenz	15	1
»	2—5	1902	S of Møen	20	50 f. otter-trawl	Johs. Schmidt	c. 44	17
March	13	1907	N by E of Darsserort	17	»	A. C. Johansen	51	119
»	24	1907	E of Gedser	17	»	»	46	39
»	24	1907	Off Zingst	14	»	»	62	25
»	25	1907	E of Rügen	17	»	»	48	7
»	26	1907	S of Møen	17	»	»	48	23
»	26	1907	SSE of Møen	18	»	»	48	9
»	26	1907	NV of Kriegers Flak	30	»	»	42	3
»	26	1907	SE of Falsterbo	36	»	»	29	1

* Doubtful if 0-Gr. or 1-Gr.

Table 5. Size of plaice of the 0-Gr. caught at different depths in the Great Belt off Lundeborg—Elsehoved on March 20—22, 1907.

Length of specimens cm	No. of specimens caught at 0—2 m depth	No. of specimens caught at 14 m depth
3	3	..
4	4	5
5	6	2
6	40	..
7	65	1
8	54	..
9	58	..
10	28	..
11	16	..
12	9	..
13	4	..
Total No.	287	8
Average size ...	8·08+0·5=8·58 m	4·63+0·5=5·13 m

The number of specimens captured at ca. 14 meters' depth is so small, that we naturally dare not attach much importance to the difference in size between the two groups of specimens. It would have been of no consequence whatever, if the fishing in deeper water had been undertaken by a more fine-meshed apparatus than the fishing in more shallow water, but just the reverse was the case. We have fished by Young plaice trawl at 0—2 meters' depth, and by 50 feet otter-trawl at 14 meters' depth.

The difference in size which appears between the 0-Gr. in the Baltic and the 0-Gr. in the Belt Sea and the southern Kattegat increases with regard to the following series. This fact appears from the analyses to hand concerning the age and size of the plaice in these waters. An extract of these analyses is given in the Tables 6 and 7. Others are published by the author in the treatise Ueber die Schollenfischerei etc. 1906.

A consideration of the size of the specimens of the same age in the Baltic, the Belt Sea and the southern Kattegat thus goes decidedly against the hypothesis that the majority of the specimens in the true Baltic should have immigrated either as 0-Gr. or as I-Gr. or as II-Gr. etc. There is, on the other hand, nothing to contradict the presumption that some specimens may have immigrated as 0-Gr. and some as I-Gr. etc.

In Tables 6 and 7 the specimens are set up in 5 different groups according to their age: 0-Gr., I-Gr., II-Gr., III-Gr. and IV+Gr. of which the latter group comprises all the specimens of more than 4 years. The difficulties concerning the determination of age by means of the otoliths commence generally as regards the males about the 4th year and as regards the females about the 5—8 year. But even if the otoliths do not enable us to determine the exact age of the older specimens, it is, however, plain enough that numerous specimens occur in the Baltic and Belt Sea, both males and females which exceed the age of 10 years.

It will be seen from Table 8 that the plaice in the true Baltic have the character of a dwarf form in a higher degree than the plaice in the Belt Sea and southern Kattegat. The size when the number of mature and immature specimens is equally great is in the true Baltic ca. 14 cm., in the southern part of the Belt Sea ca. 18 cm. The average size of the mature males is in the true Baltic ca.

Table 6. Size and age of plaice captured in the true Baltic between Falster, Møen, Rügen and Skaane, March 1907. 50 f. Otter-trawl. 14—47 meters. Otolith investigations.

(The age analyses represented in this Table do not comprise all the captured specimens.)

("Thor" St. 885, 906, 908, 911, 912, 915—918.)

Length cm	Males								Females								Males and females						Length cm
	I		II		III	IV+	Age doubtful		I	II		III		IV+		Age doubtful								
	im.	mat.	im.	mat.	mat.	mat.	im.	mat.	im.	im.	mat.	im.	mat.	im.	mat.	im.	mat.	0	I	II	III	IV+	?Gr.	
2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	2
3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	11	..	..	..	..	..	3
4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	86	..	..	..	..	..	4
5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	102	..	..	..	..	..	5
6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	20	..	..	..	..	..	6
7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	..	..	..	..	..	7
8	2	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	1	4	..	..	..	..	8
9	11	..	..	..	..	..	..	..	10	..	..	..	..	..	..	..	..	1	21	..	..	..	..	9
10	18	2	..	..	..	..	..	..	18	..	..	..	..	..	..	..	..	..	38	..	..	..	..	10
11	12	19	..	..	..	..	..	..	13	..	..	..	..	..	..	..	..	..	44	..	..	..	..	11
12	9	15	..	2	1	..	3	..	19	..	..	..	..	..	..	1	..	..	43	2	1	..	4	12
13	8	4	1	10	2	..	1	2	14	7	..	..	..	..	..	..	..	..	26	18	2	..	3	13
14	6	2	1	19	3	..	1	3	2	11	..	1	1	..	..	4	..	..	10	31	5	..	8	14
15	1	3	..	9	2	1	1	9	1	15	1	8	3	..	..	1	..	..	5	25	13	1	11	15
16	..	..	..	11	6	1	..	8	1	14	3	14	13	..	1	2	..	..	1	28	33	2	10	16
17	1	..	..	3	8	5	..	10	1	..	6	15	27	..	3	5	3	..	2	9	50	8	18	17
18	..	..	..	..	2	14	..	5	..	3	1	12	22	2	5	..	4	..	..	4	36	21	9	18
19	1	..	..	1	..	15	..	1	..	1	1	7	17	..	11	..	3	..	1	3	24	26	4	19
20	..	..	..	..	..	9	..	..	1	..	..	5	9	1	14	..	1	..	1	..	14	24	1	20
21	..	..	..	..	..	12	..	..	..	..	..	..	8	1	24	..	1	..	..	..	8	37	1	21
22	..	..	..	..	..	8	..	..	..	1	..	1	2	..	22	..	..	..	..	1	3	30	..	22
23	..	..	..	..	..	6	..	..	..	..	..	..	4	..	18	..	3	..	..	..	4	24	3	23
24	..	..	..	..	..	5	..	..	..	..	..	..	..	..	22	..	..	..	..	..	..	27	..	24
25	..	..	..	..	..	2	..	..	..	..	..	..	1	..	13	..	1	..	..	..	1	15	1	25
26	..	..	..	..	..	1	..	..	..	..	..	..	..	..	14	..	..	..	..	..	..	15	..	26
27	..	..	..	..	..	2	..	..	..	..	..	..	..	..	14	..	..	..	..	..	..	16	..	27
28	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9	..	..	..	..	..	..	9	..	28
29	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	..	..	..	..	..	..	6	..	29
30	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	..	..	..	..	..	..	8	..	30
31	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	3	..	31
32	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	2	..	32
33	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	2	..	33
34	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	..	..	..	..	..	..	5	..	34
:																								:
39	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	39
Total	69	45	2	55	24	81	6	38	82	52	12	63	107	4	197	13	16	226	196	121	194	282	73	Total
Average size*	11·22	11·87	13·50	14·56	15·75	20·36	13·00	16·05	11·40	15·17	16·83	17·21	18·26	19·25	24·07	15·38	19·69	4·66	11·44	15·03	17·61	22·93	16·48	

* 0·5 cm. to be added.

Table 7. Size and age of plaice captured in the Great Belt and SW. of Langeland. March 1907. 50 f. Otter-trawl. 14—25 meters. Otolith investigations.

(The age analyses represented in this Table do not comprise all the captured specimens.)

("Thor" St. 891, 893, 895, 896, 897.)

Length cm	Males								Females								Males and Females						Length cm
	I		II		III	IV+	Age doubtful		I	II		III		IV+		Age doubtful		0	I	II	III	IV+	?	
	im.	mat.	im.	mat.	mat.	mat.	im.	mat.	im.	im.	mat.	im.	mat.	im.	mat.	im.	mat.							
4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	..	..	..	..	..	4
5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	..	..	..	..	..	5
6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	6
7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	7
8	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	8
9	1	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	2	..	..	..	1	9
10	3	..	..	..	..	..	1	..	2	..	..	..	..	..	..	..	..	..	5	..	..	..	1	10
11	4	..	..	..	..	..	1	..	1	..	..	..	..	..	..	..	..	..	5	..	..	..	1	11
12	3	..	..	..	..	..	..	..	2	..	..	..	..	..	..	..	..	1	5	..	..	..	..	12
13	6	1	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	..	14	..	..	..	..	13
14	3	1	..	..	..	..	..	..	5	..	..	..	..	..	..	..	..	..	9	..	..	..	..	14
15	2	3	..	1	..	..	..	1	5	..	..	..	..	..	..	..	..	..	10	1	..	..	1	15
16	3	..	..	..	..	1	2	..	3	1	..	..	..	..	..	1	..	..	6	1	..	1	3	16
17	1	..	1	..	1	2	2	1	2	..	..	..	..	..	..	..	..	..	3	1	1	2	3	17
18	1	1	..	3	..	4	3	5	1	1	..	1	..	..	..	..	..	..	3	4	1	4	8	18
19	3	..	2	3	..	3	2	3	1	..	1	..	..	..	1	..	..	..	4	6	..	4	5	19
20	1	..	..	1	..	1	..	3	2	..	3	1	..	1	1	4	..	..	3	4	1	3	7	20
21	..	..	..	..	..	1	1	..	1	4	..	..	3	..	2	4	..	..	1	4	3	3	5	21
22	..	..	..	..	1	..	2	..	1	1	..	..	..	2	3	2	..	..	1	1	1	5	4	22
23	..	..	..	..	..	..	..	..	..	2	..	..	1	..	2	2	..	..	..	2	1	2	2	23
24	..	..	..	..	..	2	..	..	..	1	..	3	1	1	3	2	..	..	..	1	4	6	2	24
25	..	..	..	..	..	1	..	1	..	1	..	..	1	1	1	2	..	..	..	1	1	3	3	25
26	..	..	..	..	..	..	..	..	..	..	..	1	2	..	1	..	..	..	..	..	3	1	..	26
27	..	..	..	..	..	2	..	..	..	..	..	1	1	..	6	..	1	..	..	..	2	8	1	27
28	..	..	..	..	..	1	..	..	..	..	..	..	1	1	5	..	1	..	..	..	1	7	1	28
29	..	..	..	..	..	2	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	4	..	29
30	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	1	..	..	..	..	2	1	30
31	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	2	..	31
32	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	32
33	..	..	..	..	..	1	..	..	..	..	..	..	..	..	3	..	..	..	..	..	..	4	..	33
34	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	2	..	34
35	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	35
36	..	..	..	..	..	1	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	2	..	36
37	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	37
38	..	..	..	..	..	1	..	..	..	..	..	..	..	..	2	..	..	..	..	..	..	3	..	38
39	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	39
40	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	40
41	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	1	..	41
Total	32	6	3	8	2	23	15	14	34	11	4	7	10	6	44	17	3	19	72	26	19	73	49	..
Average size*	13·66	15·00	18·33	18·25	19·50	23·48	16·86	18·86	14·76	21·36	19·75	23·29	24·20	23·50	28·66	21·65	28·33	5·21	14·29	19·79	23·37	26·60	19·79	..

* 0·5 cm. to be added.

Table 8. Size and Maturity of plaice

Epoch	Area	Sex and maturity	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1905. Nov. 16	**True Baltic.** S. of Møen. 21—22 meters. "Thor" St. 707 & 708	♂ immature	..	..	..	..	..	..	..	..	..	1	1	..	..	..
		♂ mature	..	..	..	..	..	..	..	..	..	2	..	9	9	11
		♀ immature	..	..	..	..	..	..	..	..	..	2	..	2	2	1
		♀ mature	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1907. March	**True Baltic.** Betw. Falster, Møen, Rügen & Skaane. 14—16 meters. "Thor" St. 885, 886, 887, 906, 908, 911, 912, 915, 916, 917, 918	0-Gr. ♂ & ♀ immat	1	11	86	102	20	4	1	1	..	..	..	..	..	..
		Older series ♂ immature	..	..	..	..	..	..	2	13	19	15	14	11	10	4
		Older series ♂ mature	..	..	..	..	..	..	..	..	3	21	21	20	40	62
		Older series ♀ immature	..	..	..	..	..	..	3	10	20	19	26	25	21	31
		Older series ♀ mature	..	..	..	..	..	..	..	..	..	..	..	..	1	4
1907. March	**The Belt Sea.** Great Belt and S. of Langeland. 0—25 meters. "Thor" St. 891, 893, 895, 896, 897, 898, 901	0-Gr. ♂ & ♀ immature	..	3	11	14	42	66	54	58	28	16	10	4	..	..
		Older series ♂ immature	..	..	..	..	..	..	1	2	4	5	3	8	12	11
		Older series ♂ mature	..	..	..	..	..	..	..	..	..	..	..	1	1	4
		Older series ♀ immature	..	..	..	..	..	..	..	2	1	1	2	8	10	16
		Older series ♀ mature	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1906. October 23—24	**The Belt Sea.** Off Samsø. 1—2 meters. "Thor" St. 855—858.	0-Gr. ♂ & ♀ immature	..	..	28	70	57	41	32	12	8	..	1	..	..	..
		I-Gr. ♂ & ♀ immature	..	..	..	..	..	..	..	..	..	..	1	5	5	15
1905. Septbr. 19 —Nov. 10	**Southern Kattegat & Sound** (S. of Fornæs Kullen). 0—23 meters. "Thor". 563, 565, 609, 610, 611, 612, 614, 615, 616, 683.	0-Gr. ♂ & ♀ immature	..	..	1	4	9	11	10	2	3	..	1	..	..	..
		Older series ♂ immature	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Older series ♂ mature	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Older series ♀ immature	..	..	..	..	..	..	..	..	..	..	..	..	..	..
		Older series ♀ mature	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1906. October 28—30	**Southern Kattegat & Sound.** North Sealand. 1—3 meters. "Thor". St. 873—877 & 879—880.	0-Gr. ♂ & ♀ immature	..	3	19	47	58	80	67	36	12	2	..	..	..	..
		I-Gr ♂ & ♀ immature	..	..	..	..	..	..	..	..	..	..	..	..	..	1

* 0·5 cm. to be added.

20 cm., in the Belt Sea and the southern Kattegat ca. 23—25 cm. The average size of the mature females is in the true Baltic ca. 23 cm., in the Belt Sea and the southern Kattegat ca. 28—30 cm. Among the specimens which have obtained a size of 20 cm. or more the number of immature ones is in the captures in the true Baltic only 1 per Cent, in the Belt Sea 12 per Cent and in the southern Kattegat 17 per Cent.

in the southern Danish waters.

Size in centimeters																												Total No.	Average size*
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	..45		
1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	14·50
27	28	61	56	57	52	50	34	19	11	7	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	435	19·73
4	4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	15	14·87
1	6	8	9	9	10	8	16	11	9	9	14	5	2	3	1	1	..	..	..	..	..	..	..	..	..	..	..	122	23·11
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	226	4·66
1	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	91	11·55
103	166	307	359	353	277	196	121	68	35	24	10	4	2	2	..	..	..	..	..	..	..	..	..	..	..	..	..	2194	19·45
37	25	20	9	8	2	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	259	14·42
20	46	39	42	44	60	42	33	36	25	24	21	12	10	12	8	3	3	5	..	..	..	..	1	..	..	..	..	491	22·03
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	306	7·91
11	9	5	8	3	1	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	85	15·18
2	4	13	17	28	29	24	40	34	20	13	11	14	4	..	..	..	1	..	..	1	..	1	..	..	..	..	..	262	22·62
16	9	7	2	10	9	7	4	8	4	1	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	119	17·89
..	..	..	3	5	6	3	9	13	8	13	14	15	8	12	9	8	12	9	8	7	7	4	2	..	2	1	..	178	29·09
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	249	6·21
19	18	10	7	1	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	82	16·29
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	41	7·20
..	..	1	1	..	..	..	1	1	2	1	1	1	1	1	4	..	1	1	..	..	..	..	..	..	..	..	..	17	27·35
..	1	4	4	7	8	6	17	17	17	7	14	14	8	3	5	..	1	..	..	..	..	..	..	..	..	..	..	133	24·74
..	..	..	..	1	3	..	1	1	4	2	1	1	3	..	2	1	1	..	..	1	..	..	..	..	..	..	..	22	26·68
..	..	..	..	..	3	2	2	5	8	4	5	3	6	7	4	4	1	1	3	..	..	..	..	1	..	..	1	60	28·15
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	324	6·88
1	2	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	16·60

E. Marking experiments with plaice in the southern Danish waters.

Information concerning the question whether more of the grown up plaice migrate from the Kattegat and the Belt Sea to the true Baltic than the opposite way, might be obtained by means of extensive marking experiments in the named waters. A series of experiments has already been carried out,

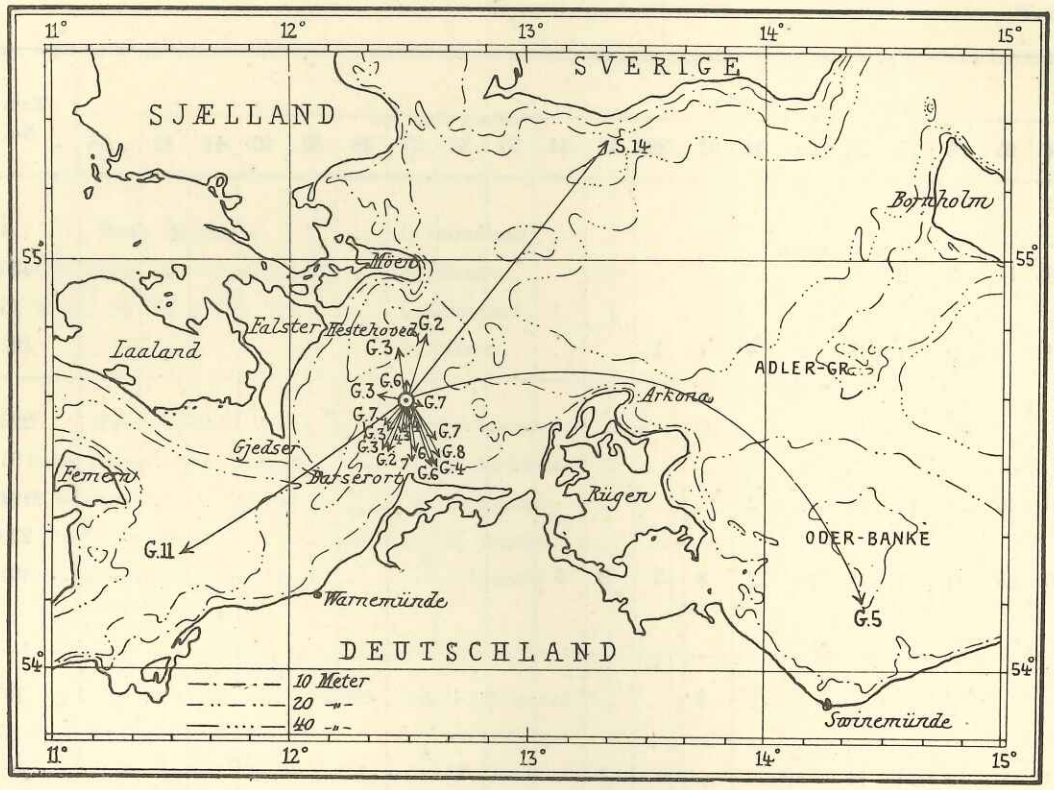

Fig. 2. A marking experiment with plaice in the true Baltic E. of Falster. March 1907.
The circle indicates place of liberation, the arrow heads represent place of recapture.
The arabic numerals indicate the number of months between liberation and recapture.
G = captured by German fishermen.
S = captured by Swedish fishermen.

but as yet the question has not been elucidated sufficiently. A marking experiment at the northern entrance to the Sound with mature plaice of the southern form has shown that the migrations have a tendency in a southern direction (A. C. Johansen: Contributions II. 1907, Pl. I). By an experiment in the Great Belt off Kerteminde in March of 1907, almost all the recaptured specimens were caught south of the place of liberation, whereas an experiment SW. of Langeland in the same month did not show that the migrations had any special tendency towards the true Baltic. Of considerable interest is an experiment which was carried on in March 1907 E. of Falster on the border between the western Baltic and the true Baltic (see Fig. 2). It appeared here that the plaice have wandered in all directions, and that the tendency to wander in an eastern direction is not more marked than the tendency to wander in a western direction.

The number of recaptures in a certain area at a certain time is naturally much influenced by the amount of fishing. In the present case I am unable to point out which areas have been most visited by fishing boats in the different months.

It will be seen that all the recovered marked plaice, except one, were caught by German fishermen.

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