MEDDELELSER

FRA

KOMMISSIONEN FOR HAVUNDERSØGELSER

SERIE: FISKERI · BIND III

Nr. 2. J. P. Jacobsen and A. C. Johansen: REMARKS ON THE CHANGES IN SPECIFIC GRAVITY OF PELAGIC FISH EGGS AND THE TRANSPORTATION OF SAME IN DANISH WATERS. (WITH 2 TEXT-FIGURES)

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1908

MEDDELELSER FRA KOMMISSIONEN FOR HAVUNDERSØGELSER
SERIE: FISKERI · BIND III · NR. 2 · 1908

REMARKS
ON
THE CHANGES IN SPECIFIC GRAVITY OF PELAGIC FISH EGGS
AND
THE TRANSPORTATION OF SAME IN DANISH WATERS

BY

J. P. JACOBSEN AND A. C. JOHANSEN

(WITH 2 TEXT-FIGURES)

KØBENHAVN
I KOMMISSION HOS C. A. REITZEL
BIANCO LUNOS BOGTRYKKERI
1908

A. ON THE CHANGES IN SPECIFIC GRAVITY OF PELAGIC FISH EGGS.

1. Introductory remarks.

During the development of the egg in the ovary of fishes with pelagic eggs a series of processes are in progress which among others produce the result that the specific gravity of the eggs approximates to the specific gravity of the sea water, so that generally after spawning they keep just at the surface or suspended in intermediate layers.

In the same locality and at the same niveau the specific gravity of the eggs is not very variable, but if we regard the whole area in which the eggs of a certain species occur, the range of variation in many cases becomes very considerable. The specific gravity of cod eggs varies at least as sea water between 8 and 35 ‰ S., and that of plaice eggs at least as sea water between 10 and 35 ‰ S. The salter the water in which the eggs occur the heavier they are. While it is thus beyond doubt that a connection exists between the specific gravity of the pelagic eggs and that of the sea water in which they are spawned, it has not been made clear whether the specific gravity of the egg is given once for all at spawning, or immediately after this, or whether essential changes may still occur after fecundation has taken place.

As this question is of essential importance for the proper understanding of the transportation of the pelagic fish eggs in our waters, we have tried to elucidate it by some experiments which will be mentioned in a following section.

2. Remarks on earlier investigations.

The question about the possible change in the specific gravity of the pelagic fish eggs has not received any extensive treatment in literature, but not a few authors such as Sars, Hensen, Petersen, Mortensen, Fulton, Milroy, Williamson, Hjort and Dahl, Apstein, Ehrenbaum, Strodtmann, and others, have, however, mentioned or treated different sides of this subject.

G. O. Sars who gives the first information concerning pelagic fish eggs, states that the cod eggs at Lofoten float in the surface water, and that the specific gravity of these is "somewhat though perhaps inconsiderably less than that of the water. Not till the embryo is dead and the yolk, consequently, shrinking, the roe goes to the bottom; in the reverse case it continues to float freely in the water during all further development. Even the newly hatched young floats in a similar way by the very voluminous yolk which still for some time will furnish it with sufficient nourishment".[1]

Sars supposes that the micropyle of the egg "has the double purpose to allow the spermatozoa entrance to the inner part of the egg and also during the later development to suck fresh water, in other

[1] Indberetninger til Departementet for det Indre fra cand. G. O. Sars om de af ham i Aarene 1864—69 anstillede praktisk-videnskabelige Undersøgelser angaaende Torskefiskeriet i Lofoten. Christiania 1869, p. 16.

words to further the fecundation and respiration of the egg .... The milk is also as the roe specifically lighter than the sea water and ascends accordingly immediately after spawning has taken place towards the surface of the water".[1]

HENSEN has shown that when the pelagic fish egg has been spawned an accession of water takes place.[2] He calculated that mature plaice eggs which occurred in the ovarian fluid "Liquor folliculi" had an average size of 1·732 mm. while eggs in salt water had an average size of 1·801 mm. which correspond to an enlargement of the egg's diameter of ca. 4 %. He maintains that an accession of water must have taken place in the inner part of the egg, as the membrane is too thin to allow of such a high swelling.

Hensen considers the possibility that the pelagic fish eggs of the same species may not be of the same specific gravity in all places. He does not show, however, that the specific gravity of the eggs is influenced by the salinity of the surrounding water. Concerning one of his experiences he states as follows (p. 304): "Wenn man die Eier in verdünnterer Salzlösung befruchtet und dann ihre Schwimmfähigkeit prüft, erscheinen sie nicht merklich leichter, als wenn sie sofort in concentrirtere Lösung kommen, oder wenigstens ist der Unterschied gering."

C. G. JOH. PETERSEN found that embryonate plaice eggs which were captured in the Little Belt had a specific gravity as sea water of a salinity between 14·4 ‰ and 18·5 ‰.[3] On the basis of this he concluded that all plaice eggs in our waters would be able to float in sea water of more than 18·5 ‰, and that all plaice eggs would sink to the bottom in sea water of less than 14·4 ‰. Dr. Petersen did not consider the possibility that any change in the specific gravity of embryonate eggs could take place.

TH. MORTENSEN reports that the eggs of Clupea sprattus in the Baltic have a size of 1·2—1·5 mm. and a specific gravity of 1·006—1·007, while the eggs of the same species in the Limfjord have a size of ca. 0·9 mm. and a specific gravity of more than 1·017.[4] Dr. Mortensen accompanies this information with the following remarks (p. 326): "This increase in volume may probably be connected with the decrease in the specific gravity. This seems to me an interesting example showing how an organism can adapt itself to the conditions of nature."

By this important observation Dr. Mortensen lays the foundation for the opinion which is now beginning to prevail, that the specific gravity of the pelagic fish eggs is very variable for most species in our waters and essentially in accordance with that of the water in which they occur.

HENSEN[5] who refers to Mortensen's before mentioned observation adds to this the following remarks (p. 53): "Die Eier passen sich also in der That der Dichte des Wassers so an dass sie grade eben schwimmen. Es wird erlaubt sein, das Gleiche für die Flündereier anzunehmen."

Neither HENSEN nor MORTENSEN express any opinion as to whether this adaptation may be assumed to take place during the maturation of the egg in the ovary or in the sea after spawning.

HENSEN and APSTEIN[5] divide the pelagic eggs into five stages according to their development and explain them in the following way (p. 39): "Keimscheibe, Embryo jung, Embryo gestreckt, Embryo mit Anlage der Augen, Embryo mit Auge. "Keimscheibe" bedarf keiner Erklärung. "Embryo jung" bedeutet Ei mit der Anlage des Embryo. Dann folgt das Stadium "Embryo gestreckt" bei dem noch keine Anlage der Augen zu sehen ist. Als „Embryo mit Anlage der Augen" ist der Embryo so lange bezeichnet, wie das Auge noch nicht pigmentirt ist. "Embryo mit Auge" bedeutet mit fertig gebildetem,

[1] Om Vintertorskens (*Gadus morrhua*) Forplantning og Udvikling. Forhandlinger i Videnskabs-Selskabet i Christiania Aar 1865, p. 242—243.

[2] V. HENSEN: Vorkommen und Menge der Eier einiger Ostseefische. Bericht d. Commission z. wiss. Unters. d. deutschen Meere in Kiel IV. 1877—81.

[3] C. G. JOH. PETERSEN: On the Biology of our Flat-fishes. Report IV of the Danish Biological Station. 1894. — "De danske Farvandes Plankton i Aarene 1898—1901". I. Kgl. Danske Vidensk. Selsk. Skrifter 6. Række, naturv.-math. Afd. XII, 1903.

[4] TH. MORTENSEN: Smaa faunistiske og biologiske Meddelelser. Vid. Medd. Naturh. Forening, København 1897.

[5] V. HENSEN und C. APSTEIN: Ueber die Eimenge der im Winter laichenden Fische. Die Nordsee-Expedition 1895 des Deutschen Seefischerei-Vereins. Wissensch. Meeresunters. N. F. Bd. II. 1897.

pigmentirtem Auge. Letzteres Stadium fällt bei manchen Eiern fort, da der Embryo ohne Augenpigment dem Ei entschlüpft, z. B. Flunder."

The authors attempt by means of a great many vertical hauls to account for the vertical distribution of the different stages. They arrive at the conclusion that the older stages are generally suspended in greater depths than the younger.

FULTON states "that the final change in the maturation of the pelagic ovum, while still within the ovary, is accompanied by a comparatively rapid and relatively great accession of a watery fluid, of low density, from without, which dissolves the yolk-spherules, is associated with the dissolution of the germinal vesicle, and the definite formation of the periblast, distends the ovum to three or four times its former volume, thinning the capsule correspondingly, renders it of crystalline transparency, and reduces its specific gravity so that it is enabled to float in sea-water of ordinary density — in other words to become pelagic ..... A knowledge of the nature of the yolk in pelagic eggs likewise explains the gradual sinking of the larvæ after they are hatched, and even in some cases of the egg containing the advanced embryo. It is in virtue of the watery yolk of low specific gravity that the egg floats, and as this becomes used up in the growth of the little fish, to which it is attached, and transformed into its denser tissues, the specific gravity of the whole is increased, until it exceeds that of the sea water in which it is immersed. Hence the general rule that pelagic eggs are obtained in the surface layers of the sea, while the larvæ are found most abundantly towards the bottom and in the middle layers." [1]

MILROY placed eggs of the plaice in distilled water and noticed that albumins, salts etc. passed from the egg out into the water. He writes about this as follows (p. 148): [2]

"In order to find out the form in which the albumins, salts etc. are bound in the ova, I took weighed quantities of ripe and unripe eggs, and allowed them to circulate through distilled water for fixed periods. All the chloride present as inorganic salt in the vitelline fluid passed out into the water, and, in addition, a small extra amount of chlorides passed out beyond that which had been present as sodium chloride in the yolk. This extra amount of chloride had evidently been bound with albumin, and the combination was broken up during the process of diffusion."

The mature eggs which Dr. Milroy employed in his experiment seem to have been ovarian eggs.

Milroy found that each immature plaice egg contained 0·0031 milligrammes NaCl and each of the mature ones 0·020 milligrammes. "That is to say during maturation there is a marked increase in the chlorides accompanying the increase in water."

WILLIAMSON discusses the question of what governs the vertical distribution of the pelagic eggs. He says about this i. a. (p. 117): [3]

"It is not surprising that, in a property requiring so exact an adjustment as the specific gravity of the egg, considerable variations should occur. It is well known that considerable variation occurs in the size of the egg; a certain amount of variation in specific gravity must almost necessarily also be present. This fact then offers a sufficient explanation of the fact that the eggs do not all float at one depth. It is very improbable that the specific gravity of an egg will, on its extrusion, change through its contact with sea water. Whether during the development of the embryo a change in specific gravity occurs in consequence of physiological processes may be in the meantime disregarded. The eggs will rise to levels where the specific gravity of the water is equal to their own, and while the main mass of the eggs will be found floating within certain limits of depth, a considerable number will have remained

[1] T. W. FULTON: On the Growth and Maturation of the Ovarian Eggs of Teleostean Fishes. Sixteenth Report of the Fishery Board, Scotland. Part III, I. 1898. p. 89—90.

[2] T. R. MILROY: "The Physical and Chemical changes taking place in the ova of Certain Marine Teleosteans during Maturation." Sixteenth Report of the Fishery Board, Scotland. Part III. 1898.

[3] H. CHAS. WILLIAMSON: "On the Pelagic Fish-Eggs and Larvæ of Loch Fyne." Seventeenth Report of the Fishery Board, Scotland. Part III. 1899.

scattered at various greater depths; and even if the main mass does not lie very close to the surface, certain examples will have made their way there. This is borne out by the study of the distribution of eggs in Loch Fyne."

Hjort and Dahl have not in their investigations of the Norwegian fiords found any confirmation of Hensen's and Apstein's statement that the older stages of the eggs occur on an average in deeper layers than the younger stages. They found many eggs, and in the main young stages, only in the upper layers, and they supposed that the eggs during development drifted out of the fiords with the surface current. "When we did get eggs in vertical hauls at great depths, they were very few in number, were most often in the very earliest stages, and were regarded by us as being eggs which were about to rise to the surface" (p. 126).[1]

Dr. Mortensen's observations mentioned above, that the eggs of Clupea sprattus are larger and of less specific gravity in the Baltic than in the Limfjord have later on been supplemented by other similar observations by Ehrenbaum & Strodtmann, who in "Eier und Jugendformen der Ostseefische, I. Bericht" write as follows (p. 113):[2]

"Nicht nur auf die Verbreitung der Eier wirkt der Salzgehalt bestimmend ein, auch auf die Grössenverhältnisse äussert er seinen Einfluss. Wie wir ausführlich im speciellen Teil gezeigt haben, sind bei den meisten Species die Eier der Ostsee grösser als die der Nordsee, und wieder die der östlichen Ostsee grösser als die der westlichen. Die einfachste Erklärung dafür wäre die, dass die Eier osmotisch Wasser aufnehmen, sobald sie aus Wasser mit höherem Salzgehalt in Wasser mit geringerem getrieben werden. Dafür scheint auch der Umstand zu sprechen, dass wir den Durchmesser der an der Oberfläche gefischten Eier durchweg grösser fanden als den der vertikal gefangenen. Direkt angestellte, allerdings noch recht lüchenhafte Versuche haben indes diese Anschauung nicht bestätigt. Befruchtete Sprott- und Ctenolabrus-Eier aus der Nordsee liessen bei allmählichen Ueberführen in fast süsses Wasser keine merkliche Grössenzunahme erkennen; es traten schliesslich letale Erscheinungen ein ohne wesentliche Quellung. Wir müssen danach das Vorherrschen grösserer Eier in den oberflächlichen Schichten damit erklären, dass die grösseren Eier auch ein höheres Steigvermögen besitzen.

Wenn eine osmotische Wasseraufnahme der befruchteten Eier nicht wahrscheinlich ist, so liegt noch die Möglichkeit vor, dass eine verschiedenartige Quellung der Eier je nach dem Salzgehalt des umgebenden Wassers bei der Ablage stattfände. Dass bei der Ablage wirklich Wasser aufgenommen wird, hat schon Hensen gezeigt."

In "Laichen und Wandern der Ostseefische, II. Bericht"[3] Strodtmann claims to be able to show, that the superiority in size which the cod eggs in the true Baltic possess in comparison to those in our other seas appears to its full extent already while the eggs are in the ovary.

In the same treatise he states that plaice eggs caught in different places in the western Baltic had not the same specific gravity throughout: The more saline the water in which they occurred, the heavier they were. "Die Scholleneier haben durchweg das spezifische Gewicht des Wassers, in dem sie gefangen werden. Eine geringe Verdünnung des Wassers genügt, um sie zum Sinken zu bringen, während sie in stärker salzhaltigem Wasser direkt an der Oberfläche schwimmen" (p. 151).

[1] Johan Hjort and Knut Dahl: "Fishing Experiments in Norwegian Fiords." Report on Norwegian Fishery and Marine Investigations. Vol. I. Kristiania 1900.

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

[3] Wissensch. Meeresunters. N. F. VII. Bd. Abt. Helgoland. 1906.

3. Investigations on the changes in the specific gravity of pelagic eggs.

The material which we have procured for the present investigation has been collected from the Danish research steamer "Thor", and the determinations of the specific gravity were carried out in the laboratory of the said steamer during two different cruises. The first series between April 2nd and 9th 1906 was carried out by J. N. Nielsen and A. C. Johansen and the second series between April 28th and May 9th 1908 by the authors.

The eggs used in the experiments were *Gadus* and *Pleuronectes* eggs, all containing well developed embryos and belonging to Apstein's and Hensen's 4th and 5th stages of development (see p. 4—5), so that the results of the investigations to hand refer particularly to the later part of the pelagic life of the egg. The first series of the experiments were carried on partly in the North Sea and partly in the Kattegat, the last series in the Kattegat and the Belt Sea.

As all the eggs mentioned except those used in experiment II of 1906 were captured in the Kattegat or the Belt Sea mostly in water of a salinity between 10 and 25 ‰, and as they may be supposed to have remained for some time in water having these low salinities, it is possible that this feature plays a rôle with regard to the proportion and direction of the changes which we have noticed as taking place in the specific gravity.

When a fish egg dies, it increases considerably in specific gravity, and always sinks to the bottom when kept in sea water. This increase in specific gravity does not appear suddenly, but may be distinctly traced also in the later stages of the egg's life time, during which it gradually loses its transparency. It is consequently of the utmost importance to be perfectly certain that the eggs with which we experiment, are not in a dying stage. When the eggs have possessed the clearness and transparency which is natural to the living egg, and when we at the same time have noticed the contraction of the heart in the embryo of the oldest stage of development, we have regarded them as fresh and alive.

We have in many cases succeeded in hatching the eggs with which we have experimented, and have thus obtained a decisive proof that these were not dying during the experiments.

Instead of a direct statement of the specific gravity of the eggs at a certain temperature, we shall in the following pages employ the salinity of the water which will just keep the eggs suspended to characterize the specific gravity of the eggs. On the supposition that the egg possesses the same temperature expansion coefficient as the water in which it is suspended, we gather that in order to characterize the specific gravity of the egg we only need to use one value, viz. the salinity. If we want to know what the real specific gravity of the egg is at a certain temperature, this may easily be calculated, e. g. by means of "Knudsen's hydrographical tables." As will be mentioned later on, we have by experiment been unable to trace an expansion coefficient for the egg differing from that of the water.

When various authors have stated the specific gravity of the egg without adding at which temperature the specific gravity has been determined, it is naturally an incomplete statement.

In the experiments from 2nd—9th April 1906 the eggs were placed in cylindrical glass vessels which contained from 1·5 to 2 liters sea water during the experiments. Only in one case which is stated below, did an artificial addition of common salt (NaCl) take place.

The transfer from one vessel to another took place by means of a pipette. By stirring the water in the vessels we took care that it should be somewhat homogeneous before the eggs were placed in it. The temperature of the atmosphere in the laboratory varied during the experiments from ca. 12° to ca. 20° C.

Table 1. General view of experiment I in April 1906 concerning changes in the specific gravity of pelagic fish eggs.

No. of Egg	Date and hour for observation of specific gravity etc.	Egg floats in surface (Salinity ‰). Sp. Gr. <	Egg keeps in intermediate layers. (Salinity ‰). Sp. Gr. =	Egg sinks to the bottom. (Salinity ‰). Sp. Gr. >	Specific gravity of water where the egg is placed	Temperature at determination of specific gravity of the water	Time in which the egg has remained in water of the salinity stated before	Species	Remarks
1	2/4 1^{55} p. m.	24·3	..	..	1·0203	4·0	2/4 1^{55} p. m.— 2^{30} p. m.	Pleuronectes limanda (or flesus .	
	2/4 2^{30} p. m.	32·3	..	..	1·0266	5·2	2/4 2^{30} p. m.— 3^{30} p. m.		...
	2/4 3^{30} p. m.	35·0	..	..	1·0287	5·4	2/4 3^{30} p. m.-3/4 9^{15} a. m.	..	...
	3/4 9^{15} a. m.	27·8	..	..	1·0225	10·0	3/4 9^{15} a. m.— 9^{40} a. m.	..	The egg sinks immediately to the bottom, but rises after ca. 5 min. again to the surface.
	3/4 9^{40} a. m.	..	26·5	..	1·0211	12·8	3/4 9^{40} a. m. —10^{15} a. m.	..	The egg keeps suspended near the bottom.
	3/4 10^{15} a. m.	..	..	21·2	1·0171	12·4	3/4 10^{15} a. m.—11^{00} a. m.	..	
	3/4 11^{00} a. m.	31·1	..	..	1·0254	7·6	3/4 11^{00} a.m.-4/4 12^{15} p.m.	..	
	4/4 12^{15} p. m.	33·8	..	..	1·0278	5·0	4/4 12^{15} p.m.-5/4 11^{30} a.m.	..	
	5/4 11^{30} a. m.	..	..	..	..	..	...	..	Egg hatched, the young alive.
2	2/4 1^{55} p. m.	24·3	..	..	1·0203	4·0	2/4 1^{55} p. m.— 2^{30} p. m.	Pleuronectes limanda (or flesus).	
	2/4 2^{30} p. m.	32·3	..	..	1·0266	5·2	2/4 2^{30} p. m.— 3^{30} p. m.		
	2/4 3^{30} p. m.	35·0	..	..	1·0287	5·4	2/4 3^{30} p. m.-3/4 9^{15} a. m.	..	
	3/4 9^{15} a. m.	27·8	..	..	1·0225	10·0	3/4 9^{15} a. m.— 9^{40} a. m.	..	The egg sinks immediately to the bottom, but rises after ca. 1. minute.
	3/4 9^{40} a. m.	..	26·5	..	1·0211	12·8	3/4 9^{40} a. m.—10^{15} a. m.	..	The egg keeps suspended near the bottom.
	3/4 10^{15} a. m.	..	..	21·2	1·0171	12·4	3/4 10^{15} a. m. —11^{00} a. m.	..	
	3/4 11^{00} a. m.	31·1	..	..	1·0254	7·6	3/4 11^{00} a.m.-4/4 11^{30} a.m.	..	
	4/4 11^{30} a. m.	..	..	..	..	..	...	..	Egg hatched, young alive.
3	2/4 1^{55} p. m.	24·3	..	..	1·0203	4·0	2/4 1^{55} p. m.— 2^{30} p. m.	Gadus callarias.	
	2/4 2^{30} p. m.	32·3	..	..	1·0266	5·2	2/4 2^{30} p. m.— 3^{30} p. m.	..	
	2/4 3^{30} p. m.	35·0	..	..	1·0287	5·4	2/4 3^{30} p. m.-3/4 9^{15} a. m.	..	
	3/4 9^{15} a. m.	27·8	..	..	1·0225	10·0	3/4 9^{15} a. m. — 9^{40} a. m.	..	
	3/4 9^{40} a. m.	..	26·5	..	1·0211	12·8	3/4 9^{40} a. m. —10^{15} a. m.	..	The egg keeps suspended from ca. 3—12 cm. under the surface.
	3/4 10^{15} a. m.	..	..	21·2	1·0171	12·4	3/4 10^{15} a. m. —11^{00} a. m.	..	
	3/4 11^{00} a. m.	31·1	..	..	1·0254	7·6	3/4 11^{00} a. m.-4/4 12^{15} p. m.	..	
	4/4 11^{30} a. m.	..	31·1	..	1·0254	7·6	...	..	Temp. of water now 12·0 C.
	4/4 12^{15} p. m.	33·8	..	..	1·0278	5·0			The experiment is not carried further.
4	2/4 1^{55} p. m.	24·3	..	..	1·0203	4·0	2/4 1^{55} p. m.— 2^{30} p. m.	Gadus callarias.	
	2/4 2^{30} p. m.	32·3	..	..	1·0266	5·2	2/4 2^{30} p. m.— 3^{30} p. m.	..	
	2/4 3^{30} p. m.	35·0	..	..	1·0287	5·4	2/4 3^{30} p. m.-3/4 9^{30} a. m.	..	
	3/4 9^{30} a. m.	32·8	..	..	1·0263	10·5	3/4 9^{30} a. m.— 4^{00} p. m.	..	
	3/4 4^{00} p. m.	27·3	..	..	1·0218	12·5	3/4 4^{00} p.m.-4/4 12^{45} p. m.	..	
	4/4 12^{15} p. m.	..	27·3	..	1·0218	12·5	...	..	
	4/4 12^{45} p. m.	33·8	..	..	1·0278	5·0	...	..	The experiment is not carried further.
5	2/4 1^{55} p. m.	24·3	..	..	1·0203	4·0	2/4 1^{55} p.m.— 2^{30} p.m.	Pleuronectes platessa.	
	2/4 2^{30} p. m.	32·3	..	..	1·0266	5·2	2/4 2^{30} p. m.— 3^{30} p.m.		
	2/4 3^{30} p. m.	35·0	..	..	1·0287	5·4	2/4 3^{30} p.m.-3/4 9^{30} a.m.	..	
	3/4 9^{30} a. m.	32·8	..	..	1·0263	10·5	3/4 9^{30} a. m.— 4^{00} p.m.	..	
	3/4 4^{00} p. m.	..	27·3	..	1·0218	12·5	3/4 4^{00} p. m.— 6^{30} p.m.	..	The egg is suspended from ca. 2—10 cm. under the surface.
	3/4 6^{30} p. m.	31·1	..	..	1·0254	7·6	3/4 6^{30} p.m.-4/4 12^{15} p.m.	..	
	4/4 12^{15} p. m.	33·8	..	..	1·0278	5·0	4/4 12^{15} p. m.-5/4 12^{05} p.m.	..	
	5/4 12^{05} p. m.	..	..	..	..	..	...	..	The hatching of the egg has begun, the young alive.

In determining the specific gravity of the fish eggs, our starting point was that when eggs were kept suspended in intermediate layers in the vessels for some time without showing any distinct tendency to rise or sink, they had practically the same specific gravity as the water in the vessel.

The indications of the salinity of the water stated below are based upon the determinations of the specific gravity.

Experiment I, 1906.

Some eggs are taken in the surface by "tow-netting" 6 miles N. $^{1}/_{2}$ W. of Trindelen's light-vessel by 57° 32′ N. lat. 11° 13′ E. long. on April 2. 1906 at 1^{55} p. m. The temperature of the water 2·8°. Salinity 24·3 ‰. Specific gravity 1·0203 at 4·0° C. As stated in Table 1, the experiment was carried out with 5 eggs floating in the surface water. (Tab. 1, see pag. 8.)

Experiment II, 1906.

On April 6. 1906 at 5^{25} p. m. ca. 14000 eggs were taken in the surface water by Young fish trawl, 36 miles WNW. of Horns Reef light-vessel at 55° 42′ N. 6° 19′ E. The salinity of the water was 34·9 ‰. Temp. 4·5° C. The specific gravity 28·6 (i. e. 1·0286) at 5·2° C. Some of the eggs were placed in surface water, where they floated at the surface or kept suspended in intermediate layers.

At 6^{45} p. m. 40 *Gadus* eggs with embryo, suspended intermediately in surface water ot 34·9 ‰, were placed in a vessel containing the same water.

April 7. At 10^{30} a. m. All the eggs are still suspended in the same water. (30 of the eggs are placed in another glass to be hatched. On April 8. at 4^{15} p. m. a young one of *Gadus callarias* has been hatched. Whether all the eggs in the experiment were of *Gadus callarias*, is not known).

April 7. 3^{30} p. m. The 10 eggs are still suspended intermediately in the same water of 34.9 ‰.

April 8. 4^{00} p. m. 4 of the eggs still remain suspended intermediately. 6 eggs are lying on the bottom and apparently dead. The 4 eggs are now placed in water of a specific gravity of 28·6 at 16·6° C. (Addition of common salt.) They float on the surface. April 9. 1^{00} o'clock p. m. The 4 eggs lie on the bottom and are dead.

Employing the same method as in 1906 in the experiments from April 28.—May 8. 1908 the eggs were placed in glass vessels containing ca. 1·5—2 liters sea water to be subjected later on to investigation of the changes which might have taken place in them. The principle of the determination of the specific gravity — the suspension method — was the same as in 1906. Only a little water was, however, used: ca. 50 ccm. in a small glass, in which the specific gravity was varied in small degrees by the addition of equal quantities of distilled water from a Burette, under constant stirring. As in this way it would be rather troublesome to add distilled water so that the eggs were just suspended intermediately, since, on approaching the complete adjustment, it takes rather a long time to determine whether the egg is ascending or descending, it was easier to notice the rise or fall when there was a difference between the specific gravity of the egg and that of the water, and even if we do not in this way obtain that perfect exactness with which a determination of the specific gravity may be made, the proceeding mentioned has however the advantage partly that it is easier and may be carried out more quickly than the complete adjustment, partly that it is safer. The mean error of observation may be put down to a value corresponding to ca. 0·5 ‰ S.

As the small quantity of liquid which we used for the determination of the specific gravity of the egg, made it difficult to undertake the determination by means of a hydrometer, the quantity of chloride was instead determined by titration. Water samples for the titration were taken from the water in which the egg just sank, when the determination of the specific gravity was completed, and from the known quantity of fluid in the glass and the known added quantities of distilled water, the specific gravities were calculated for the fluid in which the egg was just rising, eventually rising slowly, suspended, sinking, or sinking slowly.

In Table 2 (see pag. 12—15) the results of the experiments carried out are indicated together with statements with regard to the places where the eggs have been captured, at what time, the salinity of the water and so on, also remarks concerning their vitality etc. With regard to the statement of the salinity of the water in which the eggs were fished, it should be remarked that we have stated both the salinity of the surface water and the salinity of the water at the depth at which the Young fish trawl was fishing or more correctly at a depth a little below this.

It is thus probable that the eggs in most cases have been fished in water of a salinity approaching the last indicated figure.

The experiments show that changes in the specific gravity have taken place in all the fish eggs originating from the seas inside (or E. of) the Skagen, and that the changes are very considerable with regard to the plural of the eggs. An increase in the specific gravity corresponding to 2—6 ⁰/₀₀ salinity has thus often been noticed in the course of 24 hours or even in a shorter time. In one single case we have noticed an increase in the specific gravity corresponding to more than 10·4 ⁰/₀₀ S. in the course of 22 hours. Among the outside conditions which might be supposed to influence these changes in the specific gravity, we shall here consider the salinity and the temperature.

That the salinity of the water influences the changes in the specific gravity may be seen from the fact that the eggs have kept differently in no slight degree as they have eventually remained in water of a relatively high or a relatively low salinity. For the eggs which have been placed in water of a greater specific gravity than their own, it will be seen that a considerable increase in their specific gravity has appeared continuously. This holds good for all the eggs from experiment I, 1906, also for the eggs No. 3, 4, 5 and 6, 9, 10, 11, 12 and 13 from 1908. For the eggs placed in water of a lesser specific gravity than their own we have, on an average, noticed a considerably less increase in the specific gravity than in those before mentioned, and in one single case even a decrease. As the experiments with these eggs are less complete than the before mentioned ones, we shall here regard them separately.

In the experiments of 1908 the eggs No. 1, 2, 7, 8 and 14 were transferred from salt water of relatively great specific gravity into salt water of lesser specific gravity.

For the egg No. 1 which was not hatched, an increase correspording to 1 ⁰/₀₀ salinity in ca. 6 hours was noticed.

Concerning egg No. 2, it may be said that there has probably not been any considerable increase, or any considerable decrease in the specific gravity. Eggs No. 7 and 8 have shown an increase, but only corresponding to 0·6 ⁰/₀₀ S. Though this is not much, and perhaps even at the limit of the error of observation (see Table 2), it must however be regarded as certain that the specific gravity of the eggs at any rate has not been diminished (in the course of 7 ½ hours). The specific gravity of egg No. 14 increases in ca. 20 hours more than the amount corresponding to 5 ⁰/₀₀ salinity. It was living at the last determination of specific gravity, but we feel rather doubtful as to whether it was perfectly sound.

The experiments in which the eggs are placed in water of a relatively low salinity are proportionately difficult to carry out.

With regard to egg No. 4, it will be seen in Table 2 that it was placed in water of greater specific gravity than its own to begin with, also that its specific gravity had increased from the value corresponding to 22·9 ⁰/₀₀ salinity to more than that of 33·3 ⁰/₀₀ salinity from April 29^{th} till April 30^{th}. On the $^{30}/_{4}$ at 12^{30} p. m. it was placed in fresher water of 26 ⁰/₀₀ and gradually into water of less and less salinity.

On $^2/_5$ at 7^{30} a. m. the egg had a specific gravity corresponding to 32·4 ‰ S. A decrease corresponding to ca. 1 ‰ S., probably not much more, must thus have taken place. It will be seen that this egg only shows a decrease corresponding to 1 ‰ S. in water of a relatively low salinity in the course of ca. 24 hours, while in salter water it showed an increase corresponding to ca. 10 ‰ S. in ca. 24 hours.

Whether the increase in specific gravity which is again observed on the 3rd of May is in connection with the circumstance that the egg was not perfectly sound at that time cannot be known. The embryo was at any rate not dead at the determination of the specific gravity on May 3rd, and it was quite alive at the determination of the specific gravity on May 2nd.

While we now turn to the influence of the temperature it will be natural to regard separately the pure thermic expansion which the egg is subjected to, as we suppose this takes place so quickly that it cannot be accompanied by other changes in the egg. In order to test the thermic expansion we have undertaken two determinations of the specific gravity of the same eggs: No. 12 and 13 in Table 2, succeeding each other immediately at different temperatures, and it has not been possible to point out any change in the specific gravity of the eggs in proportion to the specific gravity of the sea water for a temperature interval of $8^1/_2$° (see Table 2). Taking into consideration the exactness with which these determinations of the specific gravity were made, we conclude that within the limits fixed thereby the thermic expansion coefficient is the same as for sea water of the same specific gravity as that of the egg. On this fact the proceeding is based for characterizing the specific gravity of the egg by the salinity of the sea water in which it is suspended.

The rôle which an influence of different temperatures for a longer time may play concerning the increase in the specific gravity of the egg, has been investigated in a few cases, namely for the eggs No. 9, 12 and 13 which were left for a day to the influence of the temperature of the atmosphere in the open air (ca. 8° C. mean), while eggs No. 10 and 11 were placed in the "Thor"s laboratory where the mean temperature was ca. 15°. All these eggs were on the whole rather equal, fished at the same station and kept in water of the same salinity for the same time. As the increase in the specific gravity was considerably less for the three eggs kept in the open air than for the two kept in the laboratory, it is reasonable to suppose that the process by which the specific gravity of the egg increases was checked by the cold, or, as this temperature more closely approaches the normal life conditions of the egg, it may have been quickened by the higher temperature.

The experiments have only in a single case comprised eggs originating from the North Sea (Experiment II, 1906). These eggs have so far kept otherwise than we might feel inclined to expect after the experiments carried on with eggs from the seas inside (or E. of) the Skagen, as they did not increase in specific gravity whilst remaining in water of the same specific gravity as their own for more than one day. For eggs which from the spawning time have remained in relatively salt water (such as the North Sea water) there will surely not be any possibility of a similar high increase in the specific gravity as is the case with eggs which from the spawning have remained in water of a relatively low salinity, but it is quite possible that the eggs in question had a somewhat less specific gravity at the spawning time than at the capture, and that before capture they had obtained as high a specific gravity as on the whole they were able to obtain in the present surroundings. Their specific gravity was at the capture like sea water of 34·9 ‰ S, and this was the salinity of the water at the place of capture both on the surface and at the bottom.

It is natural that the change in the specific gravity should not take place suddenly. For egg No. 4 (1908), for instance, an increase in the specific gravity corresponding to 4·4 ‰ salinity was observed after 6 hours, and 15 hours later an increase of the specific gravity corresponding to more than 6 ‰ S. was again noticed. These changes in the specific gravity which have appeared in most of the experiments, have however assuredly taken place at a quicker rate than is generally the case in nature.

Table 2. General view of the experiments in April—May 1908

No. of Egg	Station No. *	Date and hour of capture	Depth of capture (buoy line)	Salinity at the place of capture		Date and hour of the determination of Sp. Gr.	Sp. Gr. <	Egg ascending	Egg ascending slowly	Egg suspended **	Egg descending slowly	Egg descending	Sp. Gr. >
				Depth	‰								
1	1197	28/4 9^{00} a. m.	26	0	17·8	28/4 ca. 10^{00} a. m.	..	33·9	..	(32·1)	..	30·3	..
	..	..	..	27	34·7	28/4 12^{30} p. m.	..	33·1	..	(32·8)	..	32·5	..
	..	..	..	..	..	28/4 7^{00} p. m.	..	34·1	..	(33·8)	..	33·6	..
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..
2	1198	28/4 7^{15} p. m.	37	0	20·9	..						..	..
	..	..	..	37	34·9	29/4 11^{00} a. m.	..			(> 32·8)	..	..	32·8
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	30/4 9^{00} a. m.	..	..	..	(> 33·4)	..	..	33·4
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	1/5 8^{00} a. m.	..	..	..	(> 33·5)	..	..	33·5
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	2/5 9^{10} a. m.	..	..	..	(> 33·6)	..	..	33·6
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..
3	1199	29/4 0^{40} a. m.	0	0	20·4	..	..	..	..	..	..	..	..
	..	..	..	5	24·0	29/4 8^{00} a. m.	..	20·9	..	20·5	20·3 [1]	..	..
	..	..	..	..	..	29/4 4^{00} p. m.	..	22·5	..	(22·2)	..	21·9	..
	..	..	..	..	..	..	..	..	..	..	..	..	..
4	1199	29/4 0^{40} a. m.	0	0	20·4	..	..	..	..	..	..	..	..
	..	..	..	5	24·0	29/4 10^{00} a. m.	..	23·3	..	(22·9)	..	22·5	..
	..	..	..	..	..	29/4 4^{30} p. m.	..	28·1	..	(27·3)	..	26·5	..
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	30/4 8^{00} a. m.	..	..	..	(> 33·3)	..	..	33·3 [2]
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	30/4 4^{30} p. m.	..	..	..	(> 33·4)	..	..	33·4
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	1/5 7^{30} a. m.	..	..	..	(> 33·5)	..	..	33·5
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	2/5 7^{30} a. m.	.	33·7 [3]	..	32·4	..	31·2	..
	..	..	..	..	..	2/5 ca. 7^{45} a. m.	..	33·7	..	(< 33·7)	..	..	..
	..	..	..	..	..	..	..	..	..	..	..	..	..
	..	..	..	..	..	3/5 6^{50} p. m.	..	..	..	(> 34·0)	..	34·0	..

* The central position of the stations was as follows: St. 1197: 56° 32′ N. 12° 07′ E. St. 1198: 57° 09′ N. 11° 24′ E. St. 1199: 57° 42′ N. 10° 46′ E.

** The figures in brackets are found by calculation.

concerning changes in the specific gravity of pelagic fish eggs.

Temperature at determination of Sp. Gr.	Salinity of water where the egg was placed	Time in which the egg has remained in water of the salinity stated in the previous column	Species of Egg	Remarks
17	..	...	..	
16	17·8	$^{28}/_{4}$ 1^{00} p. m.—$^{28}/_{4}$ 7^{00} p. m.	..	Specific gravity determined by addition of salt water.
ca. 14	34·0	$^{28}/_{4}$ 8^{00} p. m.—$^{29}/_{4}$ 9^{30} a. m.	..	
..	33·0	$^{29}/_{4}$ 9^{30} a. m.—$^{29}/_{4}$ 7^{00} p. m.	..	
..	33·8	$^{29}/_{4}$ 7^{00} p. m.—$^{30}/_{4}$ 7^{45} a. m.	..	The egg lost on $^{30}/_{4}$ 7^{45} a. m.
..	ca. 34·0	$^{28}/_{4}$ 7^{30} p. m.—$^{29}/_{4}$ 11^{00} a. m.	Gadus callarias	
ca. 12	18·7	$^{29}/_{4}$ 11^{30} a. m.—$^{29}/_{4}$ 7^{00} p. m.	..	
..	19·1	$^{29}/_{4}$ 7^{00} p. m.—$^{30}/_{4}$ 9^{00} a. m.	..	
18	19·1	$^{30}/_{4}$ca. 9^{30} a. m.—$^{30}/_{4}$ 10^{00} p. m.	..	$^{30}/_{4}$ 10^{45} a. m. Egg No. 2, observed alive.
..	ca. 23·5	$^{30}/_{4}$ 10^{00} p. m.— $^{1}/_{5}$ 8^{00} a. m.	..	$^{30}/_{4}$ 2^{40} p. m. — — — —
..	ca. 23·5	$^{1}/_{5}$ 8^{30} a. m.— $^{1}/_{5}$ 9^{00} p. m.	..	$^{1}/_{5}$ 8^{30} a. m. Pulsation of the heart in the embryo.
..	19·3	$^{1}/_{5}$ 9^{00} p. m.— $^{2}/_{5}$ 9^{10} a. m.	..	$^{2}/_{5}$ c. 9^{30} a. m. Noticed that the embryo in egg No. 2 was alive, though perhaps not in good condition.
17	19·3	$^{2}/_{5}$ 9^{30} a. m.— $^{2}/_{5}$ 8^{40} p. m.	..	
..	15·0	$^{2}/_{5}$ 8^{40} p. m.— $^{3}/_{5}$ 9^{40} a. m.	..	$^{2}/_{5}$ 8^{40} p. m. Doubtful if egg No. 2 was alive.
..	..	...	..	$^{3}/_{5}$ 9^{40} a. m. Egg No. 2. probably dead, covered with dirt.
..	20·4	$^{29}/_{4}$ca. 1^{00} a. m.—$^{29}/_{4}$ 8^{00} a. m.	Pleuronectes platessa	
ca. 18	33·0	$^{29}/_{4}$ 9^{00} a. m.—$^{29}/_{4}$ 4^{00} p. m.	..	1) Experimented twice.
18	33·0	$^{29}/_{4}$ca. 4^{30} p. m.—$^{29}/_{4}$ 7^{00} p. m.	..	$^{29}/_{4}$ 4^{30} p. m. It was noticed that the embryo was living, pulsation of the heart.
..	33·8	$^{29}/_{4}$ 7^{00} p. m.—	..	$^{30}/_{4}$ 7^{00} a. m. Observed that egg No. 3 was hatched.
..	20·4	$^{29}/_{4}$ca. 1^{00} a. m.—$^{29}/_{4}$ 10^{00} a. m.	Pleuronectes flesus or limanda	
16	33·0	$^{29}/_{4}$ca. 10^{30} a. m.—$^{29}/_{4}$ 4^{30} p. m.	..	
ca. 18	33·0	$^{29}/_{4}$ca. 5^{00} p. m.—$^{29}/_{4}$ 7^{00} p. m.	..	$^{29}/_{4}$ ca. 5^{00} p. m. Pulsation of the heart noticed in the embryo.
..	33·3	$^{29}/_{4}$ 7^{00} p. m.—$^{30}/_{4}$ 8^{00} a. m.	..	
19	33·3	$^{30}/_{4}$ca. 8^{30} a. m.—$^{30}/_{4}$ 12^{30} p. m.	..	2) Experimented twice.
..	26·0	$^{30}/_{4}$ 12^{30} p. m.—$^{30}/_{4}$ 4^{30} p. m.	..	
..	26·0	$^{30}/_{4}$ 5^{00} p. m.—$^{30}/_{4}$ 10^{00} p. m	..	
..	ca. 23·5	$^{30}/_{4}$ 10^{00} p. m.— $^{1}/_{5}$ 7^{30} a. m.	..	
15	ca. 23·5	$^{1}/_{5}$ 8^{00} a. m.— $^{1}/_{5}$ 9^{00} p. m.	..	$^{1}/_{5}$ c. 8^{00} a. m. Observed that egg No. 4 was living, the embryo moved vivaciously.
..	19·3	$^{1}/_{5}$ 9^{00} p. m.— $^{2}/_{5}$ 7^{30} a. m.	..	
..	..	...	..	3) Before the determination the egg was stirred and washed on filter with water of 33·7 ‰.
..	19·3	$^{2}/_{5}$ ca. 8^{30} a. m.— $^{2}/_{5}$ 8^{40} p. m.	..	$^{2}/_{5}$ ca. 8^{20} a. m. The egg had received a bump. The embryo moved vivaciously.
..	15·0	$^{2}/_{5}$ 8^{40} p. m.— $^{3}/_{5}$ 6^{50} p. m.	..	
16	..	...	..	$^{3}/_{5}$ 9^{40} a. m. Observed that the egg was living.
				$^{3}/_{5}$ 6^{50} p. m. Observed that egg No. 4 was alive. At the determination the egg ascended immediately in the 34 ‰ water, but descended afterwards.

Table 2. Continued.

No. of Egg	Station No. *	Date and hour of capture	Depth of capture (buoy line)	Salinity at the place of capture: Depth	‰	Date and hour of the determination of Sp. Gr.	Sp. Gr. <	Egg ascending	Egg ascending slowly	Egg suspended **	Egg descending slowly	Egg descending	Sp. Gr. >
5 & 6	1207	$^1/_5$ 6^{15} a. m.	19	0	10·7	$^1/_5$ 10^{00} a. m.	..	17·9	17·1	(17·0)	16·7	16·3	..
	..	..	..	18	15·9	$^1/_5$ 6^{00} p. m.	..	19·0	..	(18·3)	..	17·6	..
5 only	..	..	..	22	20·6	$^2/_5$ 10^{30} a. m.	..	18·9	..	18·3	..	17·7	..
	..	..	..	..	..	..	..	..	..	..	..	..	..
7 & 8	1207	$^1/_5$ 6^{15} a. m.	19	0	10·7	$^1/_5$ 10^{00} a. m.	..	17·9	17·1	(17·0)	16·7	16·3	..
	..	..	..	18	15·9	$^1/_5$ 6^{00} p. m.	..	18·3	..	(17·6)	..	17·0	..
	..	..	..	22	20·6	..	..	..	..	..	..	..	..
9	1207	$^1/_5$ 6^{15} a. m.	19	0	10·7	$^1/_5$ 10^{00} a. m.	..	17·9	17·1	(17·0)	16·7	16·3	..
	..	..	..	18	15·9	$^2/_5$ 11^{30} a. m.	..	20·0	..	19·3	..	18·6	..
	..	..	..	22	20·6	..	..	..	..	..	..	..	..
10	1207	$^1/_5$ 6^{15} a. m.	19	0	10·7	$^1/_5$ 1^{45} p. m.	..	18·8	..	(17·5)	..	16·3	..
	..	..	..	18	15·9	$^2/_5$ 12^{50} p. m.	..	21·3	..	(20·9)	..	20·6	..
	..	..	..	22	20·6	..	..	..	..	..	..	..	..
11	1207	$^1/_5$ 6^{15} a. m.	19	0	10·7	$^1/_5$ 1^{45} p. m.	..	18·8	..	(17·5)	..	16·3	..
	..	..	..	18	15·9	$^2/_5$ 1^{00} p. m.	..	22·3	..	21·4	..	20·6	..
	..	..	..	22	20·6	..	..	..	..	..	..	..	..
12&13	1207	$^1/_5$ 6^{15} a. m.	19	0	10·7	$^1/_5$ 1^{45} p. m.	..	18·8	..	(17·5)	..	16·3	..
	..	..	..	18	15·9	$^2/_5$ 2^{30} p. m.[3])	..	20·2	..	19·5	..	18·8	..
	..	..	..	22	20·6	$^2/_5$ 3^{15} p. m.	..	20·7	19·8	(19·5)	19·1[4])	18·7	..
	..	..	..	..	..	..	..	..	..	..	..	..	..
14	1225	$^8/_5$ 3^{00} p. m.	20	0	10·2	$^8/_5$ 5^{30} p. m.	..	18·5	17·9	(17·8)	..	17·2	..
	..	..	..	20	34·3	$^9/_5$ 1^{00} p. m.	..	..	..	(>23·0)	..	..	23·0

* The central position of the stations was as follows: St. 1207: 54° 17′ N. 11° 28′ E. St. 1225: 55° 52′ N. 12° 46′ E.
** The figures in brackets were found by calculation.

Temperature at determination of Sp. Gr.	Salinity of water where the egg was placed	Time in which the egg has remained in water of the salinity stated in the previous column	Species of Egg	Remarks.
18	20·5	1/5 ca. 10^{30} a. m.—1/5 6^{00} p. m.	Pleuronectes platessa	
15	20·5	1/5 ca. 6^{30} p. m.—2/5 10^{30} a. m.	..	1/5 6^{15} p. m. Observed that eggs No. 5 and No. 6 were alive, pulsation of the heart in the embryo.
18	20·5	2/5 11^{00} a. m.—2/5 8^{40} p. m.	..	2/5 10^{30} a. m. Observed that egg No. 5 was alive, pulsation of the heart in the embryo, Egg No. 6 was hatched.
..	15·0	2/5 8^{40} p. m.—	..	2/5 8^{40} p. m. Observed that egg No. 5 was alive.
				3/5 9^{40} a. m. Egg No. 5 hatched, young of plaice alive.
ca. 18	12·5	1/5 ca. 10^{30} a. m.—1/5 6^{00} p. m.	Pleuronectes platessa	
ca. 15	12·5	1/5 ca. 6^{30} p. m.—	..	1/5 ca. 5^{45} p. m. Observed that eggs No. 7 and 8 were alive and apparently vigorous; in one of the eggs the embryo moved vivaciously.
..	..	...	..	2/5 9^{45} a. m. Eggs No. 7 and 8 hatched, continuously in water of 12·5 ‰. The young alive.
ca. 18	20·4 [1]	1/5 ca. 10^{30} a. m.—2/5 11^{30} a. m.	Pleuronectes platessa	[1] 1/5 ca. 10^{30} a. m. Placed the glass containing the egg at the pilot-house, i. e. in the temperature of the atmosphere.
ca. 18	20·4 [1]	2/5 ca. 12 m. —2/5 8^{40} p. m.	..	
..	15·0	2/5 8^{40} p. m.—	..	2/5 8^{40} p. m. Observed that egg No. 9 was alive, the embryo moved.
				3/5 9^{40} a. m. Egg No. 9 hatched, young of plaice alive.
19	20·5	1/5 ca. 2^{15} p. m.—2/5 12^{50} p m.	Pleuronectes platessa	
19	20·5	2/5 ca. 1^{20} p. m.—2/5 8^{40} p. m.	..	2/5 8^{40} p. m. Egg No. 10 was lost.
..	..	...	..	
19	20·5	1/5 ca. 2^{15} p. m.—2/5 1^{00} p. m.	Pleuronectes platessa	
19	20·5	2/5 ca. 1^{30} p. m.—2/5 8^{40} p m.	..	2/5 1^{30} p. m. Egg No. 11 clear and transparent.
..	..	...	..	2/5 8^{40} p. m. Egg No. 11 was lost.
19	20·5 [2]	1/5 ca. 2^{15} p. m.—2/5 2^{30} p. m.	Pleuronectes platessa	[2] 1/5 ca. 2^{15} p. m. Placed the glass containing the egg at the pilot-house (Temp. of the atmosph.).
10·5	..	...	..	[3] The determination of the specific gravity was undertaken at the pilot-house.
19	20·5 [5]	2/5 ca. 3^{45} p. m.—2/5 8^{40} p. m.	..	[4] one egg suspended. [5] 2/5 ca. 3^{45} p. m. Placed the glass again at the pilot-house.
..	..		..	3/5 9^{40} a. m. Eggs No. 12 and 13 both hatched, the two young of plaice both alive.
16	12·0	8/5 5^{45} p. m.—9/5 1^{00} p. m.	Gadus callarias	9/5 1^{00} p. m. Observed that the embryo in egg No. 14 moved twice. The egg looked somewhat unclear, and the embryo was abnormally bent. After being observed under microscope the egg was placed in 34 ‰ water, in which it sank to the bottom, it was probably dying.
ca. 15	..	...	..	

Table 3. Showing main results of the investigations in 1906 and 1908 concerning changes in the specific gravity of pelagic fish-eggs.

Experiment	No. of egg	Species	Specific gravity of the egg at the beginning	Salinity of water, where the egg was placed	Time in which the egg has remained in water of the salinity stated before (hours)	Increase in specific gravity	Remarks
I 1906	No. 1 No. 2	Pleuron. limanda or flesus »	< 24·3	24·3 32·3 35·0 27·8	½ 1 17¾ ½	> 2·2	
	No. 3	Gadus call.	< 24·3	24·3 32·3 35·0 27·8	½ 1 17¾ ½	> 2·2	
	No. 3	Gadus call.	26·5	26·5 21·2 31·1	½ ¾ 24½	4·6	
	No. 4	Gadus call.	< 24·3	24·3 32·3 35·0 32·8 27·3	½ 1 17¾ 6½ 20¼	> 3·0	
	No. 5	Pleuron. platessa	< 24·3	24·3 32·3 35·0 32·8	½ 1 18 6½	> 3·0	
II 1906	6 eggs	Gadus call.	34·9	34·9	20¾	0·0	
	4 eggs	»	34·9	34·9	45¼	0·0	
1908	No. 1	. .	32·8	17·8	6	1·0	
	No. 3	Pleuron. platessa	20·5	33·0	7	1·7	
	No. 4	Pleuron. flesus (or limanda)	22·9	33·0	6	4·4	
			27·3	33·0 33·3	2 13	> 6·0	
			> 33·3	33·3 26·0 23·5	4 9 9½	. .	the spec. gr. > 33·3
			> 33·5	23·5 19·3	13 10½	the sp. gravity has decreased more than 1·1	
			32·4	19·3 15·0	12 22	> 1·6	
	No. 5 & 6	Pleuron. platessa	17·0	20·5	7½	1·3	
	No. 5 only	»	18·3	20·5	16	0·0	
	No. 7 & 8	Pleuron. platessa	17·0	12·5	7½	0·6	The glass with the egg placed outside the Laboratory. Temperature in the vessel ca. 7° lower than usual
	No. 9	Pleuron. platessa	17·0	20·4	25	2·3	
	No. 10	Pleuron. platessa	17·5	20·5	22½	3·4	
	No. 11	Pleuron. platessa	17·5	20·5	22¾	3·9	The glass with the egg placed outside the Laboratory. Temperature in the vessel ca. 7° lower than usual
	No. 12 & 13	Pleuron. platessa	17·5	20·5	24¼	2·0	

The results of the experiments accomplished are in strict accordance with the view that there is produced an increase in the specific gravity of the egg by the very development of the embryo, but they do not afford any conclusive proof of the correctness of this opinion. The increase in the specific gravity which has normally been noticed in eggs from our inner waters could, for instance, have been produced in the way that by osmose more and more salt is induced in the egg without regarding that this process may possibly further the development of the embryo. If we now consider that we, a priori, may take it for granted, that a diffusion of salt water takes place through the membrane of the egg, we might for this reason expect an increase in the specific gravity of the egg, if this were placed in relatively salt water, and a decrease in the specific gravity if it were placed in relatively fresh water. If, besides, we make it a starting point that together with the advance in the development of the embryo, an increase in the specific gravity of the egg normally takes place, we may conclude that both effects may have joined each other in certain of the cases which we have investigated, and counteracted each other in other cases. We thus obtained the relatively high increase together with the development of the egg when it remained in water of a greater specific gravity than its own, and the relatively low increase — or even a decrease — when the egg remained in water of a lesser specific gravity than its own. The influence of the temperature may be looked upon as furthering the development of the embryo.

The main results of the present investigation are then as follows:

I. The specific gravity of the pelagic fish eggs is not fixed once for all at the spawning or directly after this has taken place. Changes may take place even when the development of the embryo is far advanced, and these changes depend partly on the temperature and salinity of the water in which the eggs remain.

II. When eggs, which in nature have remained in water of a relatively low salinity, are transferred to water of a higher salinity, they will increase considerably in specific gravity. An increase in the specific gravity corresponding to 2—6 ‰ salinity has thus often been noticed in the course of 24 hours or even in a shorter time.

III. When eggs, which in nature have remained in water of a relatively low salinity, are transferred to water of a still lower salinity, a relatively slight increase only or even a decrease will take place in the specific gravity.

IV. The thermic expansion coefficient of the egg is found to be the same as for sea water of the same specific gravity as that of the egg.

V. For eggs, which in nature have remained in water of a relatively low salinity, and are transferred to a vessel containing salter water, the increase in the specific gravity is furthered when the temperature increases.

B. ON THE TRANSPORTATION OF PELAGIC EGGS AND PELAGIC YOUNG FISHES ORIGINATING FROM PELAGIC EGGS IN THE BELT SEA AND KATTEGAT.

Current observations in the surface water have for a longer series of years been carried out every fourth hour from the Danish light vessels. In order to obtain an idea concerning the average speed of water movements at the surface we have calculated this for the light vessel "Kobbergrunden"[1] for the months for which it is of interest here: January, February, March and April in the years 1897—1907. That the light vessel "Kobbergrunden" was chosen, is owing to the fact that it is lying comparatively free.

[1] The figures that have been used for the purpose are taken from the Nautical-Meteorological Annual published by the Danish Meteorological Institute.

At "Anholt Knob" the adjacent reef thus influences the current in no slight degree. It appears that the current at "Kobbergrunden" occurs in all azimuths. It will, however, be seen that the frequency of the current from E. and ENE. and from W. and WNW. is less than that from other bearings. We have for this reason employed the directions E. by N. and W. by N. as limits for out-going and in-going (or incoming) currents. The out-going and the in-going currents were then separately added geometrically and the mean values calculated for the months mentioned below, by dividing by the whole number of currents observed every fourth hour in the month. The figures we get in that way represent what we will call the out- or in-going water movement. (Comp. Table 5, p. 20.)

Table 4. Showing average speed in miles per hour of out-going and in-going water movement at "Kobbergrunden" Light-vessel.

	January	February	March	April
Out-going water movement (W....S....E.)....	0·25	0·25	0·33	0·28
In-going water movement (ENE....N....WNW.)	0·11	0·11	0·11	0·11
Difference....	0·14	0·14	0·22	0·17

As mean value for all four months we may therefore take 0·17 miles per hour as the resultant for the out-going movement.

How far we get the best expression for the resulting water movement by composing the measured currents, as has been done here, is difficult to say from the knowledge which we possess concerning the currents in the Kattegat, but it is probable that through this method we get nearest to the truth.

A. W. Cronander[1] has undertaken a series of current measurements from "Fladen" light vessel at different depths in the period from November 16th of 1902 till April 30th of 1903. The author has reckoned as out-going currents those coming from the directions W.—SW.—S.—SE.—E. and as in-going currents those coming from WNW.—NW.—N.—ENE. Observations were, as a rule, undertaken twice a day, but not always, and not every day, why the intervals between the measurements are not equidistant, and as it cannot be seen from the paper whether the moments of measurements were chosen quite spontaneously, we dare not just take it for granted that the calculated mean represents the mean values for the currents in the period mentioned. The number of the measurements is however rather large: 111 series by out-going current from the surface to the bottom, 86 series by in-going currents from the surface to the bottom, and 9 series where the current had a different direction at different depths. By the calculation of the mean all the numerical values of the in-going currents have, as far as can be seen, been added up without taking the direction into consideration. Cronander has stated the mean for the respective out-going and in-going currents to be as follows:

Depth (Meters)....	0	5	10	15	20	25	30	35	40
Out-going.......	57·8	53·7	42·9	33·4	29·0	24·5	19·9	19·6	17·1
In-going........	58·8	61·5	54·9	44·2	32·8	26·5	23·1	20·2	17·4

The speeds are given in centimeters per second.

If we now take it for granted that these observations were carried on without regard to the currents occurring at the period mentioned, or the causes of these (the weather), we may find the resulting water movement by calculating means of the before mentioned mean values, the out-going being calculated as positive, the in-going as negative, and giving the out-going the weight of 111, the in-going the weight of 86, and taking besides the 9 series of observations into consideration, where the directions of the currents are different at different depths. We find then the following out-going water movement.

[1] A. W. Cronander: Om Ytström och Bottenström i Kattegatt. Stockholm 1904.

Depth (Meters)	0	5	10	15	20	25	30	35	40
Out-going water movement (cm./scd.)	6·6	2·9	— 0·3	— 0·9	1·6	1·7	1·0	1·9	1·9
» » » (miles per hour)	0·13	0·06	—0·01	—0·02	0·03	0·03	0·02	0·04	0·04

It will thus be seen that according to this calculation we should in the surface find an out-going water movement of 0·13 miles per hour. The water movement decreases with the depth and becomes at 10—15 meters slightly in-going to become out-going again at a greater depth. This last can hardly be right.

By the mean values which Cronander gives we see that the out- and in-going currents at the bottom, are about equal, while the out-going currents at several of the intermediate depths are considerably less than the in-going currents. Even if we doubt the correctness of interpreting the difference mentioned as being an expression of the resulting movement, it may however be said with certainty that the resulting water movement is considerably less at the bottom than at the surface.

For the outflow at the surface at Gjedser Reef, Drogden, and Lappegrunden, Martin Knudsen[1] has formerly found the resulting water movement to be respectively 0·15, 0·15 and 0·70 miles per hour for the three months December, January and February, and 0·16, 0·25 and 0·81 miles per hour for March, April and May. Without regarding the great speed at Lappegrunden, which without doubt is owing to the narrow water, we see that the values calculated by Martin Knudsen lie on an average between the speeds stated for "Kobbergrunden" and „Fladen", the somewhat greater speed of 0·25 miles at „Drogden" excepted, for the months of March, April and May.

According to what has been stated here, we assume that the resulting out-going water movement for the part of the year under consideration at the surface in mean value lies between 0·1 and 0·2 miles per hour, where the sea is somewhat free.

For the Great Belt it may possibly be greater.

With regard to the speed of the resulting in-going water movement in the depth we assumed, according to the measurements at Fladen, that it was considerably less than for the surface, and we arrive also at a similar result in other ways. By regarding the time elapsing between the occurrence of a temperature maximum at Skagen, and the occurrence of a similar temperature maximum at Schultz' Grund or Lappegrunden, Martin Knudsen[2] has found that the difference in the summer of 1897 was c. 7 weeks.

On the basis of the mean values for a longer series of years it has likewise been found that the temterature maximum for the summer at Schultz' Grund at 20 meters depth appears ca. 6 weeks later than at the surface at Skagen.[3]

This difference is in winter considerably less, only ca. 14 days, but the mixing up is considerably stronger, for which reason we cannot in this way determine the speed of the inflow in the winter-time.

The time which the maximum in summer takes to reach Schultz' Grund is still longer for the deeper layers. For the depth at which the light vessel is situated, 26 meters, it lasts just ca. 2 months, and even if the conditions in winter are otherwise than in summer we may presumably reckon upon a similar order of size. The distance between Skagen and Schultz' Grund at ca. 26 meters depth is ca. 120 miles, and the bottom water must thus move 120 miles in 2 months, i. e. with an average speed of ca. 0·08 miles per hour, which is about half the average speed which we have reckoned for the surface layer.

In this connection we may refer to the Diatomaceæ *Biddulphia sinensis,* which, according to Ostenfeld[4]), was introduced into the North Sea by chance in the autumn of 1903 and began to propagate off the mouth of the Elbe. The current carried it North, partly round the Skagen, and it is shown by

[1] Beretning fra Kommissionen for vid. Undersøgelser af danske Farvande Bd. II, Hefte 2, 1899, p. 54.
[2] l. c. p. 48.
[3] Medd. fra Komm. for Havundersøgelser. Serie Hydrografi. Bd. I, No. 10. 1908. Taf. VI og VII.
[4] Skrifter udgivne af Komm. for Havunders. No. 4. København 1908 p. 25.

various Plankton-collections, that the time it took to pass in the under current from Anholt Knob to Schultz' Grund was between 15 and 45 days. The distance between Anholt Knob and Schultz' Grund is 43 miles and the speed of the water movement in the depth between these light-vessels may thus be calculated to be between 0·04 and 0·12 miles per hour. It is in accordance with what may be seen from the movement of the temperature maxima, that this is the area in which the current runs slowest in the Kattegat.

It is therefore to be supposed that we arrive nearest to the truth if we estimate the time which the surface water takes in mean value at the mentioned time of the year to move through the Kattegat from the Great Belt to Skagen to lie between 25 and 50 days, and that the bottom layer takes on an average double the time to move the opposite way.

These figures naturally need closer verification, but for the present we must, for want of better, regard them as the most probable.

If we regard the resulting water movement for one single month only, we shall usually get a value somewhat differing from the afore mentioned mean values. In Table 5 we have stated the out- and in-going water movements for each of the four months January, February, March and April for the years 1897—1907 giving below their mean values. It will be seen that the values for the single months do not differ very much from the mean values of the water movement for the whole series of years. On the other hand it is a fact, that for a shorter period an outflow can occur which in a few days (c. 5—10 days) can carry a water particle from the northern Belt Sea into the Skagerak.

It is not improbable that in some cases such a strong out-going current may play a rôle in carrying pelagic eggs and young of fishes away from the Kattegat and Belt Sea, but it should be remembered, that, even if the direction of the current is the same at the bottom as at the surface, the speed decreases normally with the depth, and when the current changes a part of the eggs and young of fishes will be carried back again.

Table 5. Showing the out- and in-going water movement at Kobbergrunden light-vessel for the months of January, February, March and April, from 1897 to 1907 (the figures indicate miles per hour).

	In-going water movement				Out-going water movement			
	January	February	March	April	January	February	March	April
1897	0·11	0·22	0·16	0·09	0·29	0·06	0·55	0·34
1898	0·12	0·15	0·16	0·09	0·19	0·32	0·41	0·46
1899	0·17	0·09	0·15	0·14	0·35	0·26	0·24	0·24
1900	0·17	—	—	0·15	0·28	—	—	0·27
1901	0·06	—	—	0·12	0·25	—	—	0·26
1902	0·12	0·08	0·13	0·14	0·15	0·28	0·25	0·36
1903	0·07	0·11	0·05	0·13	0·21	0·17	0·34	0·18
1904	0·11	0·09	0·03	0·14	0·43	0·44	0·38	0·21
1905	0·08	0·07	0·12	0·12	0·22	0·23	0·40	0·25
1906	0·06	0·08	0·10	0·07	0·23	0·25	0·23	0·19
1907	0·12	0·10	0·09	0·07	0·18	0·28	0·16	0·31
Mean values	0·11	0·11	0·11	0·11	0·25	0·25	0·33	0·28

In "De danske Farvandes Plankton i Aarene 1898—1901"[1] Petersen sets forth the view that the currents show an inclination to remove the pelagic eggs and young of the earliest spawning fishes from our waters inside the Skagen, while the eggs of the fishes spawning later on in the year frequently develop in the Kattegat. Dr. Petersen thinks he has noticed that while numerous eggs of plaice, flounders, dabs and cod are present in our inner waters, only very few young of these species occur there. He

[1] D. Kgl. Danske Vidensk. Selsk. Skrifter 6. R., naturv. og math. Afd. XII, 3. København 1903.

found on the contrary proportionately more larvæ of fishes spawning in summer, such as *Rhombus maximus*, *Rhombus laevis*, *Arnoglossus laterna*, *Zeugopterus norvegicus*, and he explained this in the way that, as the salinity in the upper layers of our inner waters is greater in winter than in summer, the eggs and young of the winter spawning fishes would more easily be removed from the Belt Sea and Kattegat than the eggs and the young of the summer spawning fishes. Dr. Petersen starts from the point of view that no changes take place in the specific gravity of pelagic fish eggs. He supposes for instance that the plaice eggs have a continuous specific gravity as sea water between 14·4 and 18·5 ‰ S. (comp. p. 4). From this consideration it is hardly possible to draw any other conclusion than the one Dr. Petersen draws, namely, that eggs of a specific gravity similar to those of the plaice as stated above are on the whole transported in a northern direction towards the Skagerak, in the upper layers of the Kattegat and the Belt Sea, while the under layer does not compensate by carrying such eggs in a southern direction.

In "Eggs and Young of Fishes in the Danish Waters"[1], Otterstrøm expresses himself in a similar way to Petersen, but emphazises still more the rôle which the currents play in removing eggs and young from our waters. He writes i. a. as follows (p. 21): "It may be given as a rule, that the bottom-stages are few in numbers in Danish waters within the Skaw. If we have therefore a relatively rich stock of fish in our inner waters, even of the species the bottom-stages of which are wanting or occur there seldom, this is due to the fact that these as soon as the bottom-stage is reached, begin to wander into the waters from which the currents have carried them during development." He lays, however, stress upon the fact, that the eggs and young are kept back in certain basins in the waters. "The eggs are carried from the Danish waters, according as they float in the surface or bottom-waters, sometimes in the direction of the North Sea, sometimes in the direction of the true Baltic. When the eggs are confined to the bottom-water, they are often retained where the bottom forms basins or depressions; especially is this the case in the western part of the western Baltic." (p. 14).

If we start from the information now to hand concerning the great range of variation in the specific gravity of eggs of cod, plaice etc. and the inclination which the eggs generally show to increase in specific gravity during development, so that they can easily sink from the surface current into the under current, it cannot be doubted, that many of the eggs, which do not immediately stay in the deeper and more saline layers, will come there later on. The under current thus plays a rôle partly by transporting eggs from outwards inwards (e. g. from the Skagerak to the Kattegat and from the Kattegat to the Belt Sea) partly by retaining the eggs spawned in our inner waters. It is also in accordance with this view that the majority of the pelagic fish eggs in the Belt Sea and the southern Kattegat are present in the lower layers, and the same seems also to hold good for the pelagic young of species such as cod and plaice (see p. 22 and Fig. 2). To this we must add moreover, that even if some of the eggs spawned in our inner waters, for instance in the Belt Sea, were to remain continuonsly in the layers whose main movement is out-going, the transportation to the Skagerak would generally take such a long time, that the eggs would be hatched before the reached out, and a great deal of the tiny young ones already go down to deeper layers than the eggs.

According to Earll[2] the average time between fecundation and hatching is for cod eggs:

Temperature. C°	−0°6	0°6	1°1	2°2	3°3	5°0	7°2
No. of days	51	34	31	24	20	16	13

Dannevig found the following average time of evolution for eggs of cod[3]:

Temperature. C°	1°	3°	4°	5°	6°	8°	10°	12°	14°
No. of days	42	23	20·5	17·5	15·5	12·75	10·5	9·67	8·5

[1] Report XIII from the Danish Biological Station 1906.

[2] United States Commission of Fish and Fisheries. Report of the Commissioner 1878. Part VI.

[3] Harald Dannevig: "The influence of temperature on the development of the eggs of fishes". 13. Annual Report of the Fishery Board for Scotland. 1895.

We must thus assume that the hatching of cod eggs spawned in the Belt Sea in January—April will take 15—30 days, as a rule[1], while the surface water, as stated before, on an average takes 25—50 days in reaching the Skagerak from the northern part of the Belt Sea.

The water moving southwards over the submarine ridge between Amager and Skaane, and that moving eastward over the Gedser-Darser ridge, is, as a rule, so fresh that it does not carry great numbers of eggs and young of cod and plaice.

It is in strict accordance with the views stated here, that we have in our investigations found great abundance of young of plaice and cod both in the Kattegat and the Belt Sea.

Concerning the pelagic plaice fry we have usually made far larger captures in the southern Kattegat and the Belt Sea than in the Skagerak and in the true Baltic. In April—May, 1908, the following numbers of pelagic plaice larvæ were caught by Petersen's Young fish trawl:

	per 30 minutes haul Upper layers	per 30 minutes haul Lower layers
The Sound	0	34
SE. of Fornæs	1	47
Langelands Belt	0	23
SW. of Ærø	30	71
SE. of Langeland	0	35
Neustädter Bay	0	63

In comparison with this the captures in the Skagerak have always been extremely scanty, as we have in the spring months found, on an average, less than one plaice larva per 30 minutes haul, and as a rule none.[2]

By such fishing experiments we do not get the impression, that the stock of plaice eggs and pelagic young from the Kattegat and Belt Sea is evacuated in the Skagerak.

In certain years, to be sure, only very slight quantities of young plaice occur in the southern Kattegat and the Belt Sea, but this can be explained by other causes than that, that the eggs and young should be carried out by the currents (A. C. Johansen l. c. 1908).

The southern Kattegat and the Belt Sea have their own indigenous stock of plaice, which is very considerable in proportion to the size of the waters.

The pelagic young of the cod are present in the Kattegat and in the Belt Sea with great frequency. According to the „Thor"s investigations in April and May 1907, the cod fry in the Kattegat was far more frequent than in the Skagerak, and nearly as frequent as in the eastern part of the North Sea. This may be seen from Fig. 1 which indicates the number of pelagic cod larvæ caught per hour by Petersen's Young fish trawl. The figures indicating the captures in May are underlined to make a distinction between them and those indicating the captures in April. Many more cod larvæ were evidently present in the investigated areas in May than in April.

The investigations from the "Thor" between April 28th and May 9th of 1908 gave the result, that far more pelagic larvæ were caught in the southern Kattegat and the Belt Sea than in the northern Kattegat and the true Baltic (Fig. 2). The largest capture in the southern Kattegat in 1908 may compete with the largest of our captures in the North Sea in 1907. It should be remarked that the largest captures in the Kattegat in 1907 and 1908 were not undertaken in localities where the bottom forms basins or depressions.

[1] Concerning the Temperature in the Kattegat and the Belt Sea see: J. P. Jacobsen: Mittelwerte von Temperatur und Salzgehalt in dänischen Gewässern. Medd. fra Kom. for Havunders. Bd. I, No. 10, 1908.

[2] A. C. Johansen: Contributions to the Biology of the Plaice III. 1908. (Table 5 p. 26.)

For the part of the Baltic situated east of Bornholm a comparison with the rest of the region would not be justified, as the cod eggs for the greater part were not hatched there in the beginning of May 1908. (Fig. 2.)

The young bottom stages of the cod appear to be continuously present with greater frequency in the Belt Sea than off the west coast of Jutland, in the Kattegat, and in the true Baltic. In the

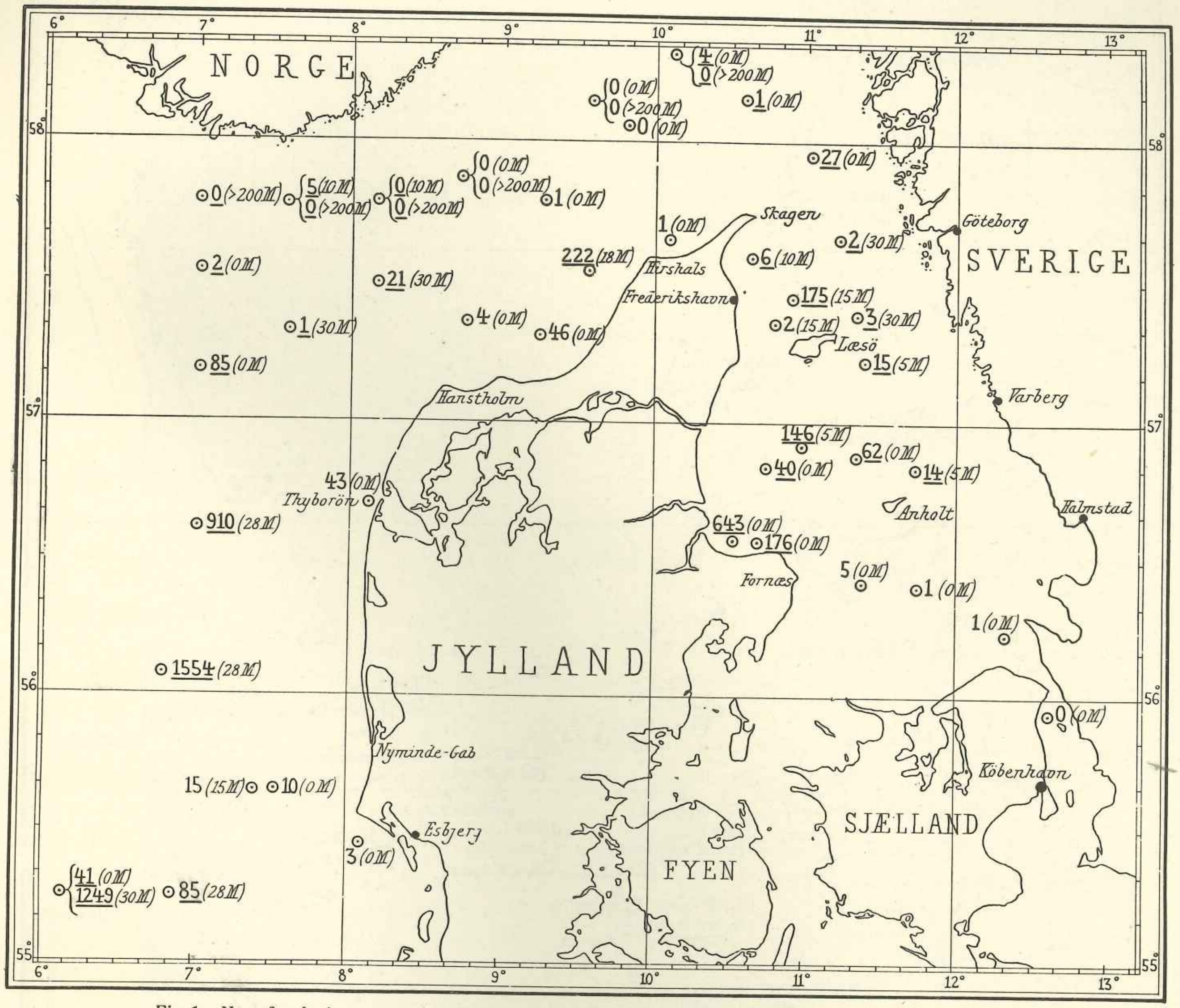

Fig. 1. No. of pelagic young of cod captured per hour by Young fish trawl. April and May 1907.
Figures denoting captures in April not underlined.
— — — - May underlined.
Depth of fishing stated in brackets.

"Thor"s investigations we have never found so numerous bottom stages of the cod's 0 Gr. in the shore belt off the west coast of Jutland as Strodtmann has found in the western Baltic (l. c. 1906).

It is beyond doubt that the Kattegat, the Belt Sea and the true Baltic have their own indigenous stock of cod, besides the stock immigrating from the Skagerak in the winter months.

It has not been elucidated whether the 0-Gr. of the cod like the 0-Gr. of the plaice in certain years is present with a slight frequency in the southern Kattegat and in the Belt Sea, but it deserves at any rate to be mentioned, that Otterström in 1904 found far smaller quantities of pelagic young of cod in these waters[1] than we found from the "Thor" in 1907 and 1908, not only seen absolutely, but also if we take the amount of fishing into consideration.

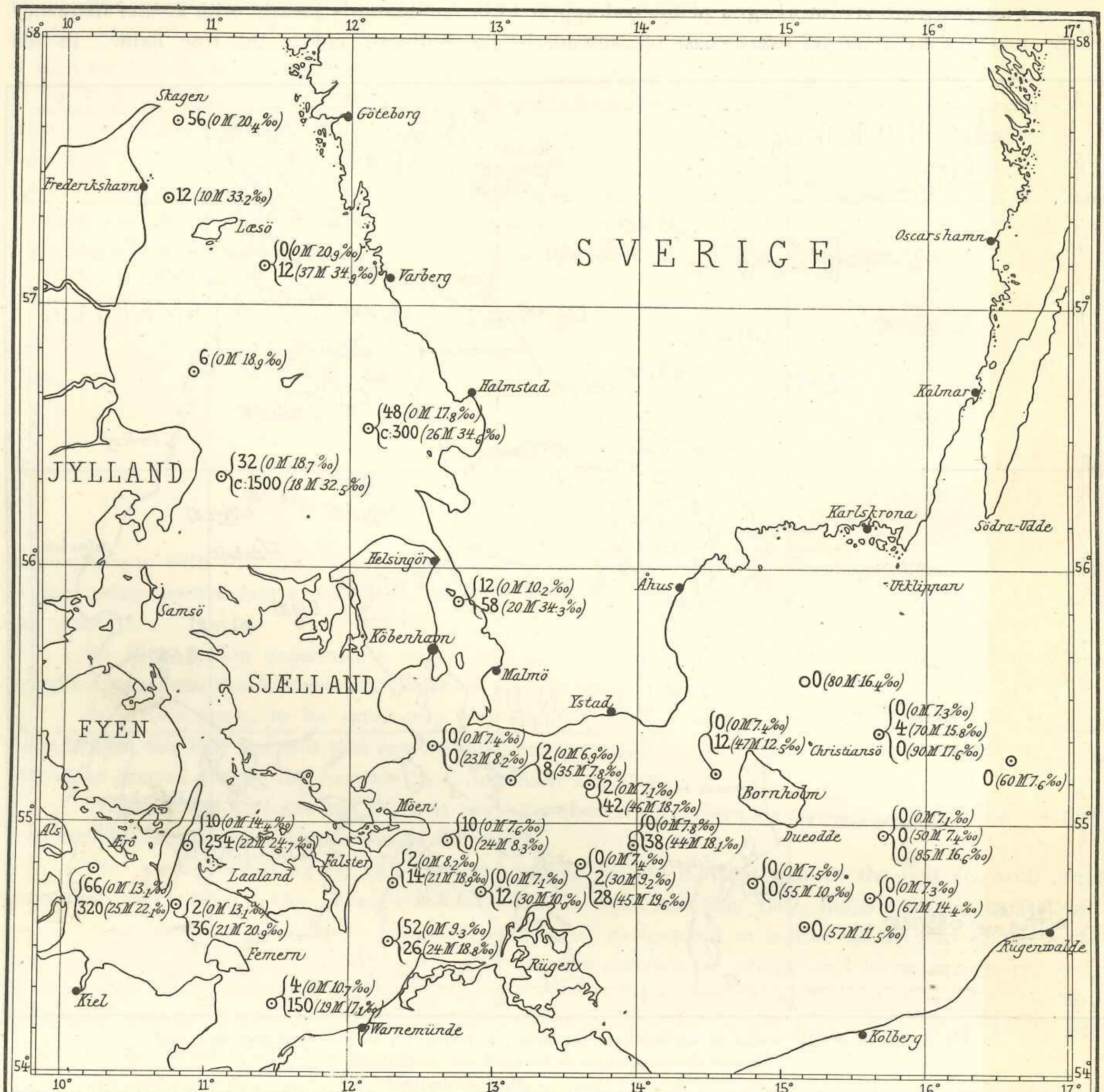

Fig. 2. No. of pelagic young of cod captured per hour by Young fish trawl 28. April—8. May 1908. Depth and salinity stated in brackets.

Thus it is our opinion, that the water movements in the Kattegat and Belt Sea are not unfavourable for an abundant presence of the pelagic eggs and pelagic young of fishes in these waters.

[1] Otterström l. c. 1905.

600. 24/x 1908.