

Report on Norwegian Fishery and Marine Investigations Vol. I 1900 No. 1.

FISHING EXPERIMENTS IN NORWEGIAN FIORDS

BY

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With 3 Plates.

KRISTIANIA

OSCAR ANDERSENS BOGTRYKKERI

1900

Preface.

The Investigations, referred to in this Work, were carried out in the south of Norway, from August, 1897, until now, by Dr. Johan Hjort, the expenses being defrayed by the Home Office, the Municipal Council of Christiania, and the Biological Station at Drøbak. Student A. Wollebæk assisted in the work during 1899. From the 1st January, 1898, until the present time, investigations were carried out in the Trondhjem Fiord by Mr. Knut Dahl, the expenses being defrayed by Det kongelig norske Videnskabs Selskab at Trondhjem, with assistance from the Home Office and local institutions.

Most of the results obtained have been published, in Norwegian, in a more popular form, in a book called «Fiskeforsøg i norske Fjorde», which was issued in March 1899.

Christiania. March 1900.

Johan Hjort.

Knut Dahl.

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Introduction.

In this country the fisheries are generally divided into two groups, the one including the periodical fisheries, which, during a short period, carry on the fishing of migratory fish, the other embracing the so-called «daily fishing» which is carried on throughout the entire year along the coast in small open boats, as a rule in the vicinity of the fisherman's home, and whose take chiefly consists of those species of fish which, it is assumed, are stationary all the year round.

In Norway the periodical fisheries are of the greatest importance. Our Official Statistics, do even not contain any column devoted to the daily fishing, concerning which information is only given in respect to some districts, for instance, the Christiania Fiord.

In most other countries bordering the North Sea, the conditions are quite different. The periodical fisheries, doubtless, yield often great returns, such as the Herring fisheries of Scotland and Denmark, but the daily fishing in such countries plays, by far, the greatest part.

A hundred years ago, the daily fishing in those countries, as is the case now with us, was exclusively confined to the coasts. At that time, for instance in England, there were a number of small fishing villages whose inhabitants in small sailing vessels, some being open, others decked boats, fished the adjacent waters, and sold their fish in the surrounding neighbourhood.

The rise of the present daily North Sea Fishery from such a primitive base, has been due to numerous factors, such as the development of railways in England and on the Continent, the advance of steamship construction, and the rapid increase of population. But few branches of industry have witnessed so rapid a growth as this North Sea Fishery.

The catch of vast quantities of fish as in latter years has, however, as is well known, given rise to the fear that too much fishing now takes place, that the stock of fish in the ocean may decrease to such an extent as to render the fisheries no longer remunerative. It is evident that this dread has been most felt in England, where the fishery has been carried on with the greatest energy, and the most perfect apparatus. In view of the importance attached to this subject, a committee was appointed by the House of Commons, which, in 1893, published the results of its investigations and the conclusions it had arrived at. The main result of its deliberations has been given in the following words: «No decrease of herring and round fish (Mackerel, Cod, Haddock and the like) has taken place in the North Sea. On the other hand, it must be assumed that there has been an appreciable decrease of flat fish, especially of Plaice and Soles, on the fishing banks of the North Sea proper».

In proof of this conclusion, the Committee states that, the fishing cutters, which have been employed for a long period, made a larger annual catch in former days than at the present time; that, on the great banks they cannot get so many in each haul as they did formerly, and that the flat fish do not attain the same size as in earlier days. They are not, in fact, allowed time to become big before they are caught.

A similar state of affairs has also been reported from other places. We have thus been informed that, at the commencement of the fishery in the Cattegat, it not infrequently happened that Plaice, as large as our Nordland «Golden Plaice», were taken, a thing that never occurs now.

It is, consequently, generally believed in countries such as Germany and Denmark, that flat fish are decreasing both in numbers, and size, at those spots where the fishing is carried on with engines of such capabilities as trawls, the Danish Plaice Seine and the like.

At the same time that experienced views and evidence were being gathered from practical sources, a great number of scientific investigations were carried on in Great Britain and Denmark, with the object of studying the habits and life of edible fishes from the moment they are spawned as ova, until they, in their turn, are capable of procreation; of finding out where they live at various stages of their existence; of discovering the dangers that threaten them at various times, and the age at which they are mostly sought for by man. Concerning these questions there is

a mass of information to hand from expert foreign scientists who have added to the first investigations, employing the method inaugurated, which, as is known, was in the sixties by Professor G. O. Sars.

The great experience that has been gained concerning overfishing, and the taking of undersized fish, has produced many reflections respecting the manner in which such as state of affairs can be regulated by legal measures; and rules respecting the size of the mesh in fishing appliances, prohibition of the sale of undersized fish, the hatching of ova of sea fishes, etc. etc. has been discussed.

Even in this country complaints are, and have been for long, made, that the fisheries are on the decline. The Commission appointed by an Order in Council of 28th May, 1852, states in its report (p. 38), «But notwithstanding the large quantities of fish, which, owing to the development of the industry, year by year, have been taken of late, the Commission, nevertheless, concludes that the most important species of fish, which are the objects of daily fishing, have been decreasing, perceptibly, for some length of time. In respect to this, the Commission may confine itself to referring to the almost unanimous statements concerning the question — supported by the daily experience of very many years — made at most of the meetings, at which fishermen were present. This decrease in the quantity of fish, which, it is said, was already noticed about 30 years ago «(about the year 1820)», but which has, become more and more perceptible during the past 10 years, appears to have first shewn itself, principally, in the inner part of the Christiania Fiord, etc. etc.». The Commission was in doubt as to the origin of the decrease. It studied, minutely, the various reasons advanced by the witnesses who were examined — whose evidence was based on daily experience throughout a course of years — reasons, as for instance steamship traffic on the fiord, which, however, is of too great importance to be stopped, an ever increasing number of «Haabrand» (*Isurus cornubicus*), and the introduction of long-lines, which then appear to have been a comparatively new invention; but the attention of the Commission was specially drawn to the seines which, «over great areas, are hauled along the bottom of the sea», and that «it follows, as a matter of course, that they not only destroy the ova which lie there, but also disturb the vegetation which is, in part, necessary for the breeding of fishes and the development of their fry».

«The seines do an equal amount of damage in capturing a great quantity of those worms, mollusks, and crustaceans on which the fish are accustomed to feed, while they also take all kinds of fish, both servicable and non-servicable, as even the smallest fry can, only with difficulty, escape through the small meshes».

•According to the fishermen's own reports, one haul of the seine, alone, will often bring up barrels of inch-long fry; and the immense destruction that takes place can well be imagined when, night after night, many hauls are made with each of the, *about 50 seines*, which, according to what has been stated above, are in constant use in the Christiania and Langesund Fiords».

These, and similar accounts, led to the adoption of the Law of 5th June, 1869, which, subsequently, was replaced by the Law of 18th April, 1888. The following is the most important point in that Law: «The King may, after a resolution on the subject has been passed by the Municipal Authorities in the District, or the adjoining Districts — Town or Parish — until further notice, or for a fixed period, prohibit the employment of certain engines for taking fish, or methods of fishing in the sea, in order to prevent the destruction of, or decrease in the stock of fish».

In consequence of this Law, which it will be seen lays the chief decision in the hands of the administrators, a great number of applications have been sent in to them, requesting that measures may be taken to ensure an improvement of the fisheries. Endeavours have, too, been made to prohibit the use of many kinds of appliances, nets of various sorts, and, especially, seines, and several Orders in Council have been promulgated, the most important regulations being those which prohibit the use of small seines, especially in the eastern part of the country. Energetic demands have been made for the prohibition of seining in the Christiania Fiord and the waters about Arendal. Men living in those parts have also published pamphlets *) in which they point out «how, during the course of the last few years, the one well stocked fiord after the other has become unproductive» so «that we, sooner or later, will find our coasts comparatively devoid of fish, and mourn the loss of one of the greatest blessings conferred on us by Nature».

*) G. M. Dannevig: Vore Kystfiskerier 1883.

In the latter mentioned pamphlet one can read of how «during a ovely summer night, 10 or 12 hauls of the Eel Seine were made, or as many as could be made throughout the night. After the work was ended, we examined our take, and found it to consist of one or more stones weight of eels, and about half a barrel of fry, the specimens from 1 to 3 inches in length, consisting of cod, whiting, wrasse, flounders, and a number of bull-heads and sand crabs». It is, moreover, stated that «fishing with fish-traps for cod, which, of late, has increased to an alarming extent, has also had a great share in causing a decrease in the stock of fish, for, as it is known, such appliances are placed in shallow bays, and prove to be one of the deadliest traps for cod, when they, during early spring, proceed to the shallows for the purpose of spawning. It is certain that thousands upon thousands of spawning cod are thus prevented from increasing the stock by natural production, and when the stock of fish is, already, considerably reduced, this cannot occur except at an irreparable loss.»

Under the pressure of these, and similar statements, great measures have been taken in our land (measures which far surpass those undertaken in any other country), to prevent the decrease of fish. Throughout a great part of the kingdom hauling seines in shallow water, has, as before mentioned, been prohibited, by which, certainly, one sort of fishing industry has been put down in some districts. In other parts it still flourishes illegally.

At the instigation of those men, who, with so much energy, pointed out the decrease in the stock of fish, hatching of cod has been carried on since 1884. In the Report of October, 1897, issued by the Fish Hatchery at Flødevigen, it is stated, in respect to the hatching, that, during the year, 227.000.000 of cod fry were let out, which is 100.000.000 less than the previous year, but 128.000.000 more than the average since the work was commenced in 1884. This fry was placed in the sea between Christianssand in the West, and Christiania and Fredrikshald in the East.

Opinions have been differring as to the results of these protective measures, and hatching labours. From one quarter some evidence has been brought forward shewing that the quantity of fish, especially that of cod is now on the increase to the east of Lindesnes. In support of this statement declarations, signed by many fishermen, have been produced, while the Statistical Tables, giving the numbers of fish caught in the Christiania Fiord, north of Drøbak, where fry were let loose, are also

referred to. On the other hand, however, many maintain that the *fisheries are still on the decline*.

Everyone who endeavours to obtain an independent judgment of all these «experienced» declarations and statements concerning the decline, or otherwise, of the fisheries, will soon regret that, amongst the mass of papers, and documents, to hand, there is hardly any information which can be grasped and depended on. Opinions, not facts have been gathered together.

The Report of the Commission of 1852, which contains much of interest and sound judgment, does not record even one haul of the nets before the eyes of the Commissioners. The Commission confined its labours to holding meetings with the fishermen at different places on the Christiania and Langesund Fiords, to whom eight questions, were addressed, amongst others such as «Do you assume that the quantity of fish in the fiord has decreased of late years, and if so, does it apply to certain species, or to the entire stock». Neither in the Minutes of the Commission, nor in the other documents or writings, can we find anything but such general questions or opinions. There is not one single *figure* given as to the numbers there were formerly, or in respect to the quantity existing at present, or as to how many fry of one or another kind of fish have been destroyed by destructive fishing engines. It is stated that there were «many» fish formerly, there are «almost none» now (in 1852); stones weight, and barrels of «all kinds of fry and small fish» are destroyed.

An acquaintance with these statements, induced one of us, Hjort, to think that if one was to study, more deeply, this important problem of the fisheries, such must be done, not by travelling about, note-book in hand, but by personal observations, and personal fishing. As all good appliances for collecting fry were prohibited here, and it was known that such were employed both by fishermen and scientists abroad, Hjort, in 1896, travelled about in Northern Europe in order to become acquainted with various practical and scientific fishing apparatus, and through the unflinching kindness of the prominent Danish Zoologist, Dr. C. G. J. Petersen, he succeeded in finding a number of appliances which have proved to be exceedingly suitable for use in the study of the question treated of here. Several thousand fishing trials have been undertaken with these appliances during the years 1897, 1898 and 1899, all with the object of

finding out what numbers of fish, and fry, of various species, were to be found in the waters investigated at various seasons, and the extent of the damage that may be inflicted on the stock of fish by the most effective fishing appliances.

In the following pages we shall, first, give an account of the investigations that have been carried out, and thereafter report the results and the conclusions we have drawn from them.

Chapter I.

The Waters Investigated.

I. The Skagerrak.

(See Map. I.)

The area of water between the North of Jutland, Bohuslæn and the South Eastern Coast of Norway, called the Skagerrak, is, as is known, a vast deep water basin, which attains its greatest depth, above 300 fathoms, about mid-way between Arendal and Skagen (The Scaw). It will be seen from the Chart of Depths, No. I, that this depression approaches very close to the coast of Norway. There the slope towards the deep is very steep and short, the incline on the Bohuslæn coast being somewhat less precipitous, where it forms, as it were, a sort of bank in front of the shore, and off Jutland there is a long smooth acclivity.

While on the Norwegian coast and even in the fiords the 100 fathom line may be reached at a distance of not more than one geographical mile from the shore, one has, at many spots off the north coast of Jutland to proceed 20 miles to sea in order to find 20 fathoms, and 40 miles before reaching depths of 100 fathoms.

To the west, the Skagerrak depression shelves upwards to the North Sea banks, which, as is known, extend, at an average depth of 30 to 40 fathoms, to the English coast.

The Skagerak depression then continues only in a north westerly direction along the Norwegian coast, as the so-called «Norwegian Channel»,

which is bounded by the North Sea banks to the west and south, and by the Norwegian coast to the eastward and northward.

From this brief description it will be seen that the Norwegian coast is vastly different to the shores of other countries bordering on the North Sea. From them, the shores slope gently outward, in England, for instance, in some places so evenly as 1 fathom per English mile. The bottom of these even declivities consists of white, fine sand, which houses innumerable species of the lower organisms. Nearly everywhere the Norwegian coast plunges abruptly down towards the great deep.

The sea-bottom of these deep declivities generally consists of walls of rock which, down to the 20 fathom line are, as a rule, covered with luxurious vegetation, uppermost being the well known wrack, and, deeper down, the large, lengthy tangle, of which great quantities drift ashore and are burnt for the sake of the ashes. The sandy bays, and beaches to be met with in all the other countries adjoining the North Sea, are but rarely found along our coast.

Out towards the open sea, off Lister and Jederen, there are a few somewhat extensive (miles in length), sandy beaches, but even they are of narrow width, rarely extending more than 1, or 2 miles. Even beyond the level sands of Lister, it is only 2 miles to the 100 fathom line; while, in Jederen, it appears from the investigations, that the great forests of tangle, reposing on a partly hard bottom, commence very close to land. Sheltered by the belt of islands, which are so characteristic of the Norwegian coast, there are in sounds, bays, and creeks, small flat stretches which are generally covered with *zostera*, the green, flat, wrack grass, but the area occupied by this bottom is small compared with that of the hard bottom, while in countries like Denmark, the sea-bottom, for many square miles is clothed with undulating fields of *zostera*.

The great deep outside the belt of islands, from 50—400 fathoms is covered with soft, light-blue coloured clay (mud-bottom), formed of the finest particles derived from the drainage of land, by the rivers.

This is so soft as to cause the otter boards to sink far into it, and if the fine-meshed trawl enters it but for a moment, it becomes filled with tons of mud, which, as it partly emerges, surrounds the net like a white cloud when it is brought to the surface.

The Skagerrak is the battle field of many oceanic currents in their strife with each other.

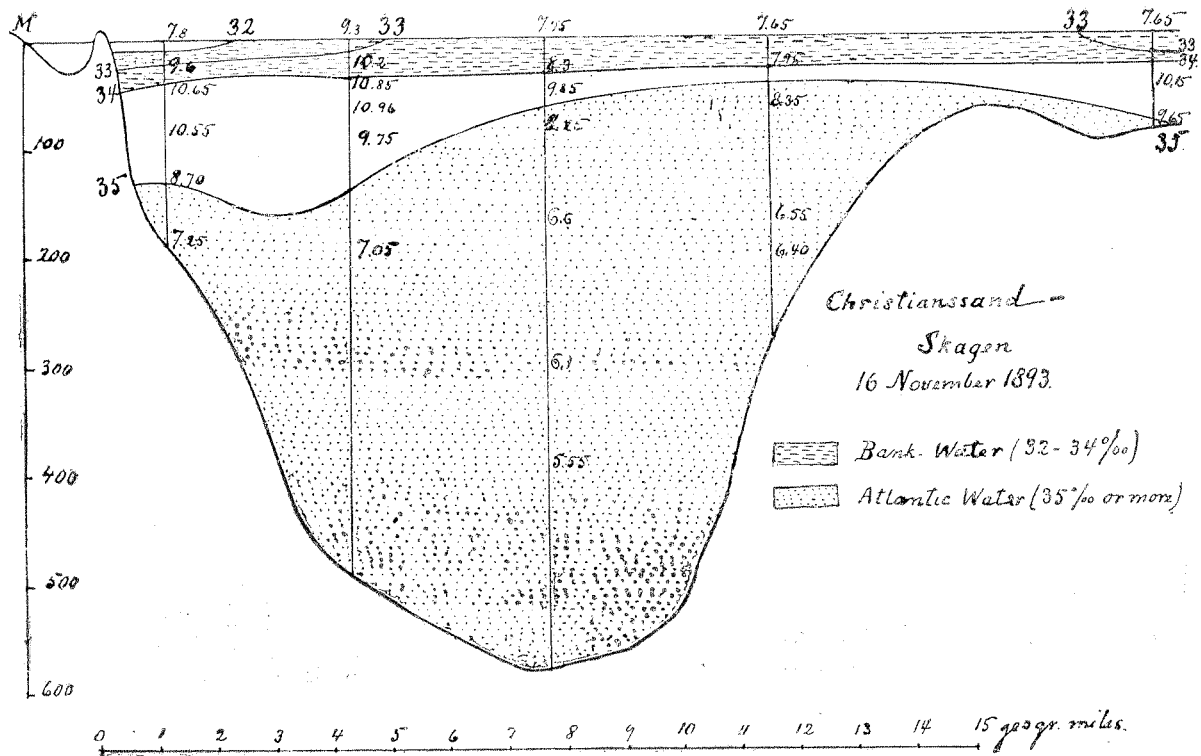


Fig 1. Copy of Pettersson and Ekman's chart.*

The accompanying Fig. 1*, presents a hydrographical section of the Skagerrak's waters in the autumn. From this section it will be seen, firstly, from the character of the bottom, that this is much steeper along the Norwegian coast, where, after first forming the belt of islands, it plunges down to a depth of about 600 metres; while on the Danish side, towards Skagen, it forms a huge rampart in front of the coast.

The bulk of the layer of water that fills the deep hollow of the Skagerrak is, as one sees, composed of the so-called Atlantic water (represented by dots) which forms a mighty layer from the very bottom to some 100 metres from the surface. It is of the same high salinity as the Atlantic water, 35 *per mille* (‰). Over and above this layer, there are, as will be seen, several other layers, one of a salinity between 35 and 34 ‰, then an intervening layer between 34 and 32 ‰, and finally, nearest the Norwegian coast, a layer whose salinity is less than 32 ‰.

If one investigates the Skagerrak at various seasons, and if one draws a similar graphic account of the results obtained, it will be seen that the thickness of the layers vary very considerably with the seasons.

The deepest layer, the «Atlantic Water» flows in the deep to the eastward towards the coast of the Bohuslæn and up its fiords, and in the Christianiafiord so far up as to Drøbak. In a contrary direction, and with very great speed, there flows in the Skagerrak the here well known «West running current», a surface current which rises mainly in the Baltic, and is nourished by all the great quantity of fresh water which flows from the rivers of northern Europe.

The current flows through the Cattegat, along the Bohuslæn and on in a great curve, westward, along the south coast of Norway, past Lindesnæs, and on to the westward and northward along the west coast of Norway. The strength is especially great from the spring — March and April — till the close of September, during which period it covers the whole surface of the Skagerrak with its fresher water [less than 30 ‰].

In the Autumn [October—December] it becomes weaker, and the Skagerrak surface then becomes wholly or partly covered with salter layers formed either on the Danish or Norwegian coasts.

*) Taken from Pettersson and Ekman's investigations.

II. The Christiania Fiord.

(See Map. No II.)

From the Northern part of the Skagerrak a succession of parallel fiords run in a Northerly direction into the land.

These are the Langesund Fiord, the Larvik Fiord, the Sande Fiord and the largest of them all, the Christiania Fiord. The outer portion of the latter is a funnel shaped sound, running 60 miles up the country. One can discern 4 natural sections of this fiord:

1) *The outer part to Slagenstangen and Larkollen in the North*, which, to the eastward and westward, is bounded by belts of islands and inlets, and which is so broad that it might be said to be a continuation of the Northern Skagerrak. The Depth is, also, exceedingly great, up to between 150—200 fathoms, while the sea bottom, in every respect, resembles that of the deep depression of the Skagerrak, there being only off Hvaler a shallow ridge or barrier which crosses the fiord at a depth of 30—50 fathoms.

2) *The basin from Slagenstangen to Filtvedt*. Also in this basin great depths may be found, mainly on the eastern side, between Bastø and Moss. Both there, and in the outer part, the shores are much less precipitious than in the Skagerrak. A tendency is shown towards the formation of shallow stretches (as at Aasgaardstrand, see Map.) and creeks, as, for instance, the Kure Fiord near Moss. There smaller, and quite shallow areas of water are to be met with of less than 10, and even under 3 fathoms in depth, in which *zostera* abounds, and which resemble small Danish fiords.

3) From Filtvedt to the northern point of Haaøen, the fiord forms quite a narrow channel, about one mile across, with a depth of 100 fathoms, with very steep sides which descend abruptly to the clay covered bottom.

To the north of Drøbak another barrier of 30 fathoms crosses the fiord, and the water of the inner basin is therefore only connected with that of the outer part of the fiord down to the depth of barrier.

Near Drøbak there are a number of small bays and inlets of no great depth, and partly filled with *zostera*, such as Sandspollen, Hallangspollen etc. etc.

4) The inner portion of the fiord forms a fairly wide basin, whose only connection with the sea is through the narrow Drøbak Sound.

The bottom, between Asker and Næsodland, is a level plain, lying at a depth of 50 fathoms below the surface, which, to the north, is bounded by numerous islands and holms in the neighbourhood of Christiania, as well as by a 30 fathom transverse ledge, which extends from the islands towards Næsodland, and thereby isolates the 80 to 90 fathom deep sound called the Bunde Fiord.

In between the islands near Christiania, there are many small sounds and bays, filled with *zostera*, and very shallow [2—5 fathoms].

The salt, bottom-current of the Skagerrak, flows along the deep depression into the Christiania Fiord, and right up to Drøbak the bottom is covered with a layer of water of 34—35 ‰ salinity. Inside Drøbak the water is more mixed with fresh water, the salinity along the bottom there being 32 to 33 ‰. On the surface, there runs, as a rule, a very strong, but frequently fluctuating current out of the fiord. This consists of water of low salinity (in the summer about 20 ‰), which varies, greatly, from day to day. It is strongest during the period March or April to September; towards Christmas it becomes gradually weaker, and, consequently, in December—January, a much higher salinity is met with on the surface than at any other time of the year; the fresh surface water flows away, and the salt water rises up in its place.

This variation of the current partly depends on the fresh-water supply from the rivers, and, partly, on the winds.

With a strong southerly wind, the entire body of water is forced into the fiord, and a rise of the water takes place in consequence, while, on the other hand, with a strong northerly wind, the surface water is driven out, and, in by Christiania, the salt water then rises from the deep*).

III. The Trondhjem Fiord.

(See Map. III).

Like the Christiania Fiord, the Trondhjems Fiord is a long, and very deep cleft, running 60 miles into the country. Its form exhibits many channels, which alternate with more open and larger basins.

*). See the following paper in this Report.

Thus we have:

1) The outer channel, which, with many sharp turns, runs from the sea up to Rødbjerg. The coast on this stretch, as is shewn in the Chart of depths No. 3, is very steep. Even the 100 fathom curve (200 metres) runs almost close to land, and those who have used the dredge in that part of the fiord will know how this can actually drop down the rocky walls on either side of the fiord. The area of the bottom below 5 fathoms is, therefore, as small as is possible, and only in some small bays can little patches of sand be met with. The channel itself, is about 250 fathoms (500 metres) in depth in the centre.

Like in all the deep water regions of the fiord, the sea-bottom there is covered with fine mud, while, on the solid rocky bottom on the sides of the fiord, whole forests of all sorts of corals and lower organisms are to be found, owing to which those localities are noted for their abundance of rare organisms.

2) *The Basin between Rødbjerg and Frosten* forms, with its ramification the Kors Fiord, a continuation and extension of the deep channel. Almost the entire fareway exceeds 100 fathoms, and the greater portion of it is about 250 fathoms in depth.

Only at the mouths of the large rivers Orkla and Gula in the Kors Fiord, and the Størdals river on the eastern side of the basin, are flats below 30 fathoms (60 metres) to be met with. Thus one shoal is found round the isle of Tautra, where, perfectly level sandy beaches are to be met with.

3) A deep water channel, from Tautra to Levanger, forms a continuation of the deep depression in the fiord.

4) A basin between Levanger to the south, and Inderøen to the north. This is also a continuation of the great deep depression of the fiord; which, as will be seen, also continues as a very narrow channel along the west coast of Ytterøen and through

5) the narrow sound, *Skarnsund*, terminating in the innermost basin of the fiord.

6) The Beistad fiord.

From the course of the 60 metre curve it will be seen, that in the Levanger basin and the Beistad Fiord, especially towards the east, where the rivers of Værdalen and Stenkjær debouch, small flats are met with, under the 30 fathom line, which have smaller bays partly owning sandy beaches, and, partly, owning a bottom covered with *zostera*.

It will be seen, from the above, that the Trondhjem Fiord is, distinctly, a deep-water fiord, being, in parts, of a very great depth (250 fathoms). Along the shore there is a short ledge, or border of shallow water, which only in some places expands into wide bays or flats.

Finally, we shall very briefly refer to the smaller basins or creeks existing in various parts of the fiord, and which are only connected with the main fiord by very narrow and shallow inlets.

These basins, like the Borgen Fiord in the Inderøen, and Eidsbotten, near Levanger, are shallow, in as much as their depth does not exceed 30 fathoms. They are mostly surrounded by a belt of fairly short zosteræ, while the bottom which, in many places is very stony, slopes abruptly towards the deep, which, generally, is covered with a layer of mud.

The water in the deep regions of the fiord, consists of salt Atlantic and North Sea water, which flows in like a wedge below a fresher, mixed layer of 33—32 ‰ salinity, on the top of which there lies a still fresher layer, whose thickness and salinity vary with the seasons. The accompanying section of the fiord during summer (Fig. 2) shows how the Atlantic 35 ‰ water forces itself in as far as the Tautra bar, and right up to a depth of 200 metres.

Above this comes the North Sea 34 ‰ water, which, at the entrance to the fiord, rises to 30 metres, and then, as it continues on up the fiord, sinks, until, in the Beistad Fiord, it reappears at a depth of 150 metres, while the fresher layers of 33 ‰, to 32 ‰, salinity which lie above it, are thickest at the head of the fiord, and steadily decrease in thickness towards the entrance.

Above these layers, there lies a thin layer of still fresher water (less than 32 ‰), 10 to 20 metres in thickness, which is due to the water proceeding from the many rivers.

During winter, when the addition of fresh water is very slight, this fresh surface layer is considerably reduced, and salter, layers, of about 33 ‰ salinity, mount to the surface.

The conditions there, are, in the main, the same as those of the Christiania Fiord and the Skagerrak.

The fresh-water layers of the surface flow outwards, in the spring and summer, with considerable force, a force which cannot solely arise from the difference in level between the fiord and the sea, caused by

the river water, but must be also due to the easterly winds which, as a rule, prevail during that period. As the thickness of the fresh layers decreases, so, during winter, does the strength of the out flowing current diminish. Attempts have been made to ascertain the force of this current at different periods of the year by means of floats (bottles containing post cards) which have been set adrift, and these endeavours fully confirm the above statement.

Thus, while bottles thrown out in the upper part of the fiord (near Tautra) during spring and summer were found out side the fjord after the lapse of a *couple of days*, bottles set adrift in the autumn (November) were picked up almost at the spot where they were thrown out.

Chapter II.

Fishing Gear employed in the Investigations.

Before entering upon a description of our fishing experiments, we will give an account of the appliances we have used.

The Eel-Drift Net or the Otter Trawl.

(Dr. Petersen's Trawl).

This engine which was, originally, used in North Germany, was introduced into Denmark towards the end of the seventies, and was used, and is still employed exclusively for catching eels in the sea. It is only used in shallow waters.

The appliance itself is a small seine, with a large bag, or sack, in its central part. Within this sack there is fastened a so-called pocket, which prevents the escape of the fish when once they have entered the bag. The accompanying sketch, Fig. 3 (after Drechsel), gives a very good idea of the original appliance and its employment.

The different parts of the apparatus are:

- A. The bag or sack.
- B. The pocket (attached to the inside of the bag).
- C. The arms, which are prolongations of the sides of the bag, [these, as well as the upper and lower rims of the bag, are furnished with a rope to which they are laced].
- D. Drag-lines.
- E. Stilts or supports.

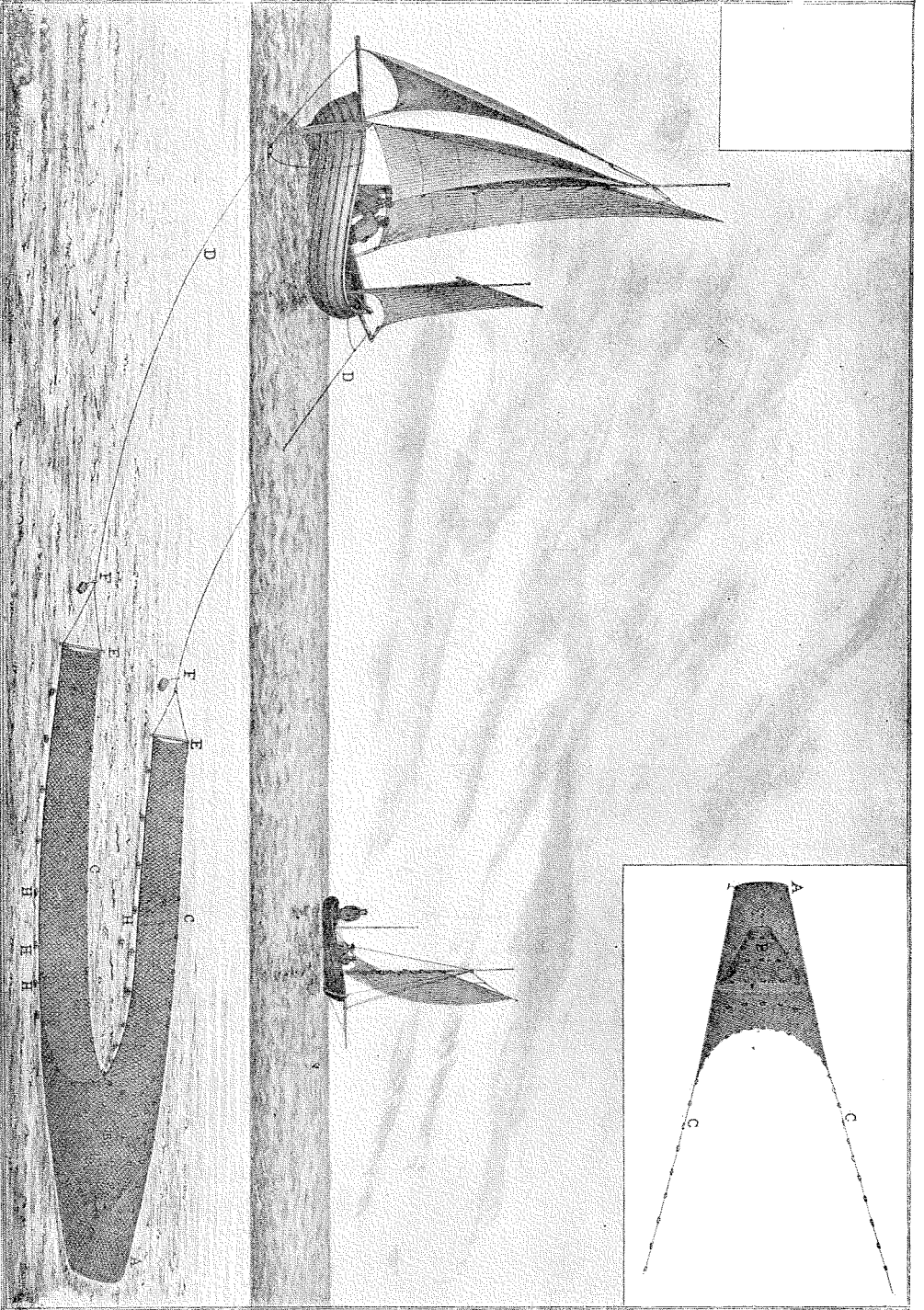


Fig. 3.

F. Front weights.

H. Sinkers (stones).

The meshes in the different parts of the net are of various sizes. The usual dimensions are (according to Drechsel):

Length of bag 15 to 20 feet.

» » arms 24 to 18 »

Height [the distance between the upper and lower rope at the mouth of the bag] 8 to 9 feet.

Depth of arms at the mouth of the bag, 8 feet.

» » » » the fore end 6 feet.

Number of knots in the forepart of the bag = 20 to 21 per foot.

» » » » » afterpart » » » = 22 to 23 » »

» » » » » arms » » » = 19 » »

Cost of net = abt. £ 4:10:0.

Materials, Cotton twist.

When the appliance is in the water, the bag is kept expanded or circular by several rows of cork attached to the upper side (the corks counterbalancing the weight of the bag in the water). The arms are kept vertical by buoys or floats of cork.

The drag-lines by which the appliance is hauled along, are fastened by towing bridles to the head, as well as the ground rope and, in order that the upper and lower portions shall not close upon each other when the strain of towing is brought to bear on them, stilts or supports are placed between them.

The appliance is shot from a large or small vessel, in such a manner that, first the bag, then the arms, and, finally, the drag ropes, of equal length, are lowered into the sea on the weather side of the vessel.

The drag-lines are fastened fore and aft to booms projecting, fore and aft from the ends of the vessel, the sails are backed, and, thus, while the vessel drifts with the wind, the net is spread and opened out as it drags along the bottom.

It will be seen that the first condition necessary, when fishing with such an appliance, is to see that it goes down correctly in a vertical position viz., that the one arm does not sink quicker, or juts out ahead of the other.

In order to do this the drag-lines must be of an equal length, and the vessel, while drifting, must retain its original position to the net.

In order that the trawl may prove effective, the arms must also spread out, and this is occasioned by keeping the ends of the drag ropes as wide apart as possible (see the previous page, how they are rigged out on booms fore and aft).

It is evident that this arrangement is only suited for very shallow water, for if the drag-lines be lengthened the position of the appliance cannot be easily controlled. Again the appliance can only be employed under certain conditions of wind, in as much as the vessel, as already mentioned, may only drift, and not sail with it.

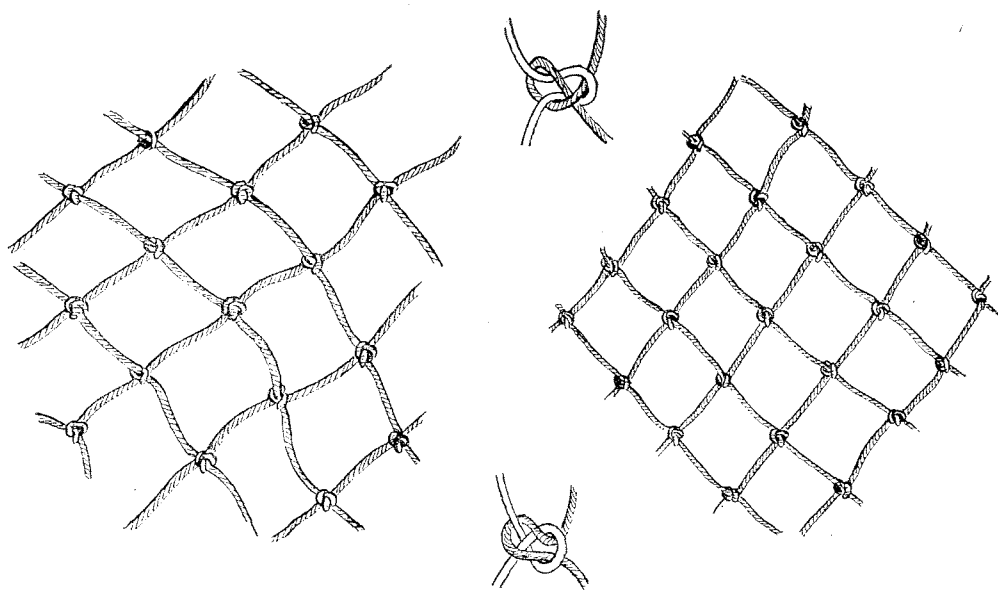


Fig. 4. Meshes in the eel-drift-net and the eel-ground-seine.

Danish fishermen therefore commenced handling this instrument in rather a different manner, shortening the drag-lines to only a couple of fathoms, and fastening them to the ends of a beam, the length of which corresponded to the spread they desired to give to the appliance.

From this beam there ran a bridle, to which was attached a *single tow-rope* which was made fast to the boat or vessel. The beam thus prevents the arms from approaching each other whilst the short tow-ropes by which it is attached to the arms, allow of its *floating* on the surface. Thus it does not go in front of the appliance and frighten the fish. By

using the beam, one can, therefore, keep the appliance extended and tow it by means of a rope. And, consequently, far greater benefit can be derived from the wind, as one can then sail with the net.

But even when used in this manner the apparatus is only adapted for shallow water.

Out in the deep, one can not have the beam floating on the surface, and if it were fastened just in front of the net, it would frighten a number of fish. In order that it might be advantageously used in deep-water, the apparatus would need to be still further improved. Another method of keeping the net open would have to be invented.

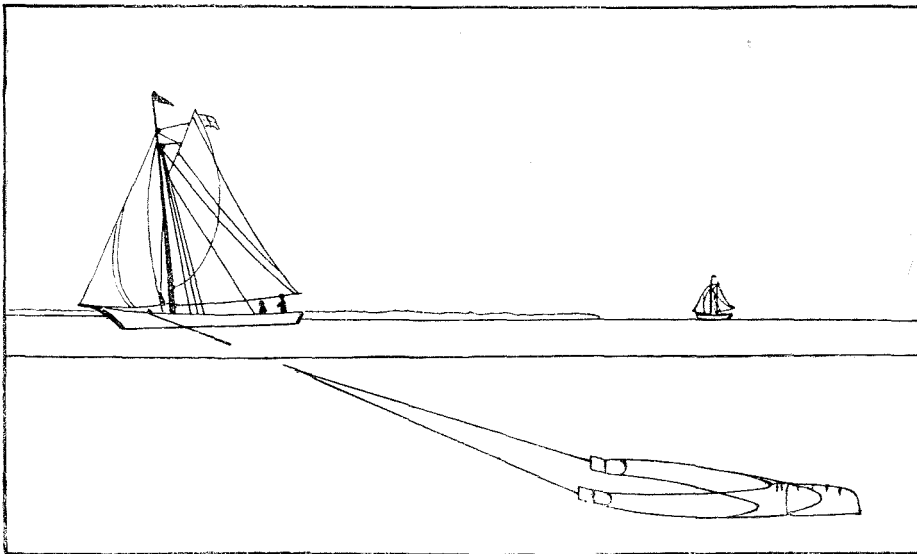


Fig. 5. Eel-drift-net with otterboards. From Dr. Petersen.

It was Dr. Petersen, the Director of the Danish Biological station, who first conceived the idea of modifying and employing the eel drift net for deep-sea investigations.

After having made several attempts, he decided upon adopting the principle of expansion, on which the construction of the English Otter-trawls, was based. viz., by making use of otter boards.

The principle of the Otter-trawl is also in this country so well known, that we regard it as superfluous to give any detailed description. To each arm of the apparatus, an Otterboard, is fastened, and from each of these there runs a tow rope, both of which are fastened close together on the vessel. Thus when the net is hauled through the water, the

Otterboards move outwards, each to its own side, and thus keep the net sufficiently extended, and thereby, make it admirably suited for fishing purposes.

Dr. Petersen soon found, however, that a single line would answer the purpose, provided that the portion of it nearest the appliance were forked, or in other words by using a bridle. This bridle is fastened by a swivel to the single tow rope, and the net is equally good for fishing purposes, provided the branches of the bridle are of sufficient length to allow the boards to diverge sufficiently (see Fig. 5). We here print Dr. Petersens own description of the apparatus, as given in »Beretning fra Dansk biol. station 1898«:

»The trawl net which I have employed, consists, so far as the net is concerned, of 2 *arms*, each from 300 to 340 meshes in length, and

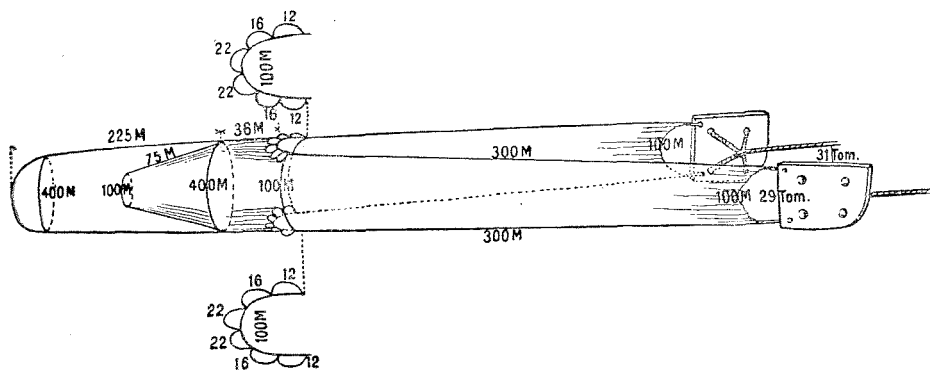


Fig. 6. Dr. Petersens trawl.

100 meshes deep throughout, which are attached to the bag (at the mouth of the net).

The bag consists of a front and back part, as well as a pocket, which is attached to the hindermost margin of the front portion. The front portion of the bag is 36 meshes in length, and in circumference 400 meshes (100 on the top and 100 on the bottom), 100 meshes being carried to two feet of the head and ground ropes respectively, and, as indicated on the drawing, with 6 loops (12, 16, 22, 22, 16, 12 = 100 meshes). Thus the bag is much creased above and below, but is straight in the arms.

The pocket which, in front, is 400 meshes in circumference, is attached to the hinder margin of the front portion of the bag (also 400 meshes); it is funnel shaped, 75 meshes long and 100 meshes in circumference at the free opening.

The hindermost portion of the bag is about 225 meshes in length, and 400 meshes in circumference throughout; one may, however, when desired, attach a closer meshed terminal part (see Fig. 6).

The bag is only open at one corner, and can be closed by a cord lashing.

The pocket may be composed of two machine made pieces, but is, usually made by hand of light, strong, fine cotton twine, as it must move with great ease in the water.

If it be hand made, it must be »drawn in«, but, *otherwise, there is nothing to be drawn in or narrowed in the whole net*; and it may thus very easily be made from rectangular machine made pieces of net.

The meshes of the arms and foremost part of the bag, when stretched, measure about 20 mm, in length (40 mm. in circumference); the meshes of the pocket and hindermost portion of the bag measure about 16 mm. in length (32 mm. in circumference); the twine throughout (except in the pocket) being of a 9 strand cotton twine, No. 12.

A still closer meshed portion may, as already mentioned, be attached to the bag, for instance one of meshes of 11 mm. in length (22 mm. in circumference), but this will depend upon the use to which the trawl is to be put.

The meshes of the arms are thus attached to the upper and lower ropes of the net, so that 6 meshes hang on each loop of a length of 4 meshes, that is to say 80 mm., and, on the outer half, 6 meshes on each loop of 86 mm. in length. The length of the bag is about 16 to 18 feet.

Both ropes are equally long, about 24 to 28 feet; but the lower, or ground rope must be much thicker than the upper one for instance 3—3½ inches in circumference, and, both ought to be of loosely twined and somewhat used rope that wont kink.

When in the water, the entire apparatus, especially the arms near the mouth, must be perfectly smooth, without any creases from the top to the bottom. On the other hand, there will be a number of longitudinal creases near the mouth of the bag.

Accuracy in joining it to the ropes is highly necessary, and if the ropes stretch from use, the net must be removed, and replaced, especially if the ropes do not stretch equally,

In order that the net may obtain the proper position in the water, weights are fastened to the ground rope, and floats to the upper.

The greater the weight the more does the rope scrape on or dig into the bottom; the greater the number of weights, the more evenly distributed will the weight be. I have found some 39 small sinkers, strung in loops of 2—4 inches length, suitable; the sinkers at the mouth must be rather less apart than elsewhere.

Floats were first made of pieces of wood, about 40 small pieces being used. Floats must lie close to the mouth, so that this can be lifted well up in the water; subsequently I have only used glass balls (the Norwegian floats) and it is undoubtedly right to use *glass floats only*, as these can stand the pressure of water right down to 3000 fathoms (see Tanner loc. cit. pg. 355) and cannot change their weight as do wood and cork, which even at the depth of a few fathoms become saturated with water, and thus lose their power of raising the net.

Each glass ball will support about $\frac{1}{2}$ lb. of lead in the water, and I have found it suitable to attach just as many glass balls as may be required to float the attached *weights in the water*. The net sinks then by its own weight, and that of the Otterboards only.

It is a matter of great importance that the net is properly balanced, and balanced so as to be able to fish on the bottom on which one desires to use it.

It is easy to make it so heavy, that it will scrape the bottom and become filled with mud. With glass balls tied up in netting, the balancing may be easily effected in shallow water, and the whole appliance be properly adjusted. Its weight in deep waters will then not alter to any appreciable extent, as is the case with wood and cork.

About 30 glass balls to 14—16 lbs. of weights in the water, I have found suitable

The Otter boards are made from $\frac{3}{4}$ ins. fir planks, through which run two long iron bolts. They measure about 29 ins. in height and 32 ins. in length, or more. At first, small Otter boards were used, but the present ones are, unquestionably, better. They are shod with iron underneath, so that they sink as quickly as is desired.

On account of the distribution of weight (the iron keel) they will, on reaching the bottom, as well as in sinking through the water, always remain in an upright position, just as the arms of the net.

When suspended by the bight of their 4 branched bridles the fore part should drop slightly. The ropes of the arms are fastened to the hind

margins of the boards through two holes, so that the arms lie *on the outside of the boards*. From a little in front of the centre of the Otter boards proceed the branches of the bridle (see Figs 5—6). The bridle is of wire, and each branch is about 8 fathoms long. At first, short bridles were used, but it is a great question whether *they ought not to be still longer* (this will be referred to later on). At the end of the loop of the bridle is the swivel, and to one of its eyes the tow rope is fastened. To prevent the branches of the bridle from becoming twisted together which they are apt to be, a weight (about 5 lbs.) is fastened to the lower revolving eye of the swivel, in such a way that it hangs from it by a short loop which prevents the twisting.

As soon as the bag and arms are in the water, and the boards let down, while the vessel moves on quite slowly, the whole apparatus immediately assumes its right position, with the boards some 12 to 16 feet apart, so that one can see on the surface that the whole gear is clear and in order.

On lowering, which must be done in such a way that the tow rope is not let out too freely, the apparatus will always reach the bottom aright, but, if otherwise the bag may, when the arms are lowered over it, twist itself round them, or the one board may fall atop of the other. This only occurred in the beginning.

As already mentioned, I presume that the Otters, when proceeding at ordinary, suitable speed (about 1 knot) are from 12 to 16 feet apart.

The apparatus thus opens as much as the ordinary trawl adopted for scientific purposes even on the largest vessels.

The height of the mouth is about 3 to 4 feet in the water, thus considerably higher than in the trawl referred to (about 2 feet). The length from the Otters to the end of the bag is about 40 feet, as compared with a total length of 17 to 20 feet in the trawl, yet, nevertheless, this apparatus is easily managed from the smallest steam boat capable of towing it, or from a small five ton sailing boat.*

We have used this apparatus chiefly from a steamer; on a few occasions from a sailing-boat (Pilot-boat), and it appears that, in some instances, it may fish exceedingly well down to a depth of 400 to 500 metres.

Practically all local organisms, and all the bottom animals, as well as the sluggish kinds of fish are obtained, occasionally, in great quantities; and the chief advantage of this apparatus lies, in our opinion, in the

fact that it gives a quantitative idea of the sea-bottom fauna, better than any other apparatus hitherto employed in this country.

While the apparatus formerly employed (as for instance the Bottom-dredge and the Beam-trawl) only enabled us to ascertain the species existing in one or the other spot, so the Otter-trawl tells us, in many instances, the quantity in which they occur.

One is inclined to think, that our fiords with their precipitous rocky-shores, would create insurmountable obstacles to the employment of such an apparatus.

This is proved, however, not to be the case, and apart from a few technical difficulties which gradually had to be overcome, the apparatus may be said to have worked thoroughly well.

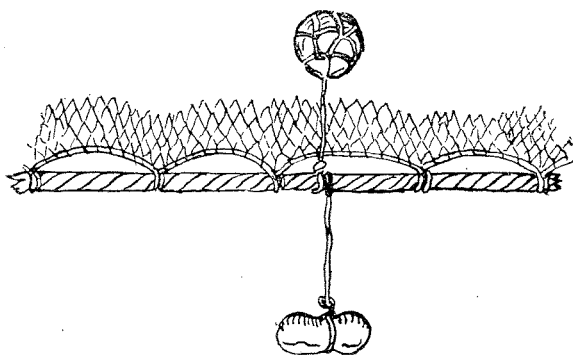


Fig. 7. Ground rope of trawl, with floats and sinkers used for trawling on a rocky or very soft bottom where the trawl must not touch the bottom.

The greatest impediment at the beginning was caused by the net being much inclined to cut into the soft bottom, and become so filled with mud, owing to its ground rope being weighted with lead, that in hauling up the net, the bag would burst, or else one might have to lie at a spot for hours, and back the vessel in order to rid the net of its many tons of mud.

By gradually diminishing the lead on the ground rope, and increasing the number of glass balls on the upper rope so that the net was just kept at the bottom by the weight of the Otters, and, moreover, was just balanced by the weight of the net counteracting the floating power of glass floats on the head rope, we succeeded in getting the trawl to move easily over a soft and even bottom. On the other hand, if the bottom were hilly, or undulating, it frequently happened that the apparatus

would suddenly dig into the bottom and become filled with an equal amount of mud as formerly.

In order to prevent this, however, we fastened light sinkers to cords about 6 inches in length, and attached them to the ground rope. To counterbalance the weight of the sinkers, glassballs were tied beside each lead whose floating powers were equivalent to the weight of the sinkers.

Thus when the apparatus was subjected to sudden changes of the bottom, the lead would receive the first blow, and, when thus forced up, the glass float would instantaneously raise the ground rope. (See Fig. 7.)

In this way, mud was never obtained, and we have good reasons to think, that, even on stony bottoms, it worked better than otherwise.

Owing to the size of the meshes of this net (see Page 27, Fig. 4) it was only capable of catching fish down to a certain size (4—5 cm.), while small fry, and, on the whole, very small organisms could not be taken in this apparatus.

We therefore constructed a smaller appliance of the same type for use in shallow water on beaches, made of bobbinet, silk gauze or embroidery net, and these were capable of catching the most minute organisms. They were not sufficiently strong however, to be used except by hand in shallow water, but were also occasionally used from a steamer for catching organisms in the surface layers.

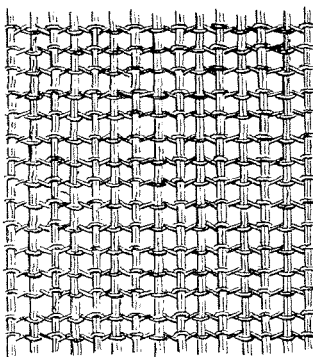


Fig. 8. The finest width of mesh ever used in for a trawl.

For use in deep water, however, they must be larger and stronger; but the closeness of the material would place difficulties in the way, and prevent their employment. When the net is too close, or its meshes too fine, its powers of catching cease at a certain maximum speed. If this be exceeded, the water cannot pass through the net as quickly as it is drawn through the water. There will be dead water before it and its fishing capabilities are destroyed.

Finally, we furnished the hindermost part of the bag of the Otter-trawl with an exterior bag of embroidery net, Fig. 8, terminating in a pointed bag, tied up with a lashing.

While the net itself as usual collected the bigger organisms, the smaller passed through the meshes and remained in the close-meshed bag.

The fishing capability of the apparatus was thus not diminished to any appreciable extent.

The Eel Ground Seine.

This, like the former, is a net with a large bag or pocket in the centre, but without the pocket. Its dimensions are much larger than those of the preceding one, while the various parts of the apparatus are somewhat differently related to each other.

According to Drechsel, the ground seine most frequently used are of the following dimensions:

Length of each arm . . .	70 feet
» » bag	30 »
Depth at the Mouth . . .	20 »
» of arms at Mouth	20 »
Depth at the stilts .	6 to 8 »
Number of knots in arm, about . .	19 to 20 per foot.
—»— in forepart of bag	20 to 22 —»—
—»— » codend » »	23 to 24 —»—

Price complete, about £ 7.50.

Material, Cotton Twine.

The apparatus is generally used from a boat, and may be employed in different ways.

The accompanying drawing shows how it is frequently used at some places in Denmark.

The drag lines are fastened to the net by a bridle and stilts. The net is placed in the boat ready for use. At the fishing place a grapnel attached to a buoyed line is let out, and one of the drag-lines is secured to the same. The apparatus is then shot in a semi circle, as is the case with every seine, and, whilst rowing back to the buoy, the other drag line is let out. The boat is then fastened to the anchor rope, and by gently

hauling on both drag lines the apparatus is towed along the bottom, gradually closing on the fish which have been encircled by it.

The seines used by us, have differed considerably in size.

Some have been larger, and others of smaller dimensions than the one already described. We also found, that they could be used for various purposes.

By varying the number of corks on the top rope it could be made to press heavier, or lighter on the bottom, to open more or less, and by adding a sufficient number of corks to the head rope, we have been able to use it as a floating seine.

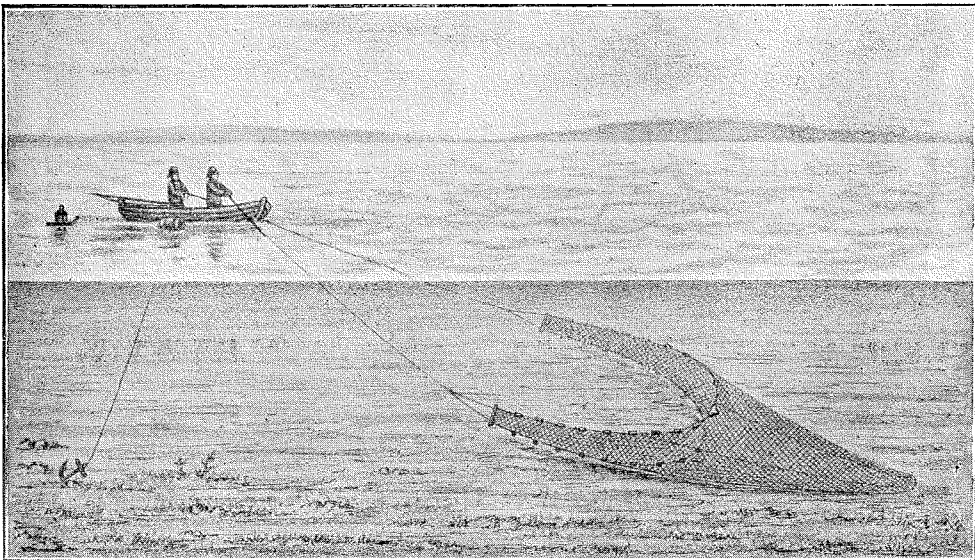


Fig. 9. Eel ground seine hauled from an anchored boat. The net is also often hauled to land (from Drechsel).

Thus the fishing capabilities of this apparatus have been tried in various ways, and the large nets in particular have thus proved capable of being used with advantage in taking even such active fish as trout etc.

We have not only used them in the manner described (with a grapnel), but also largely from the shore as ordinary seines, especially in such fiords and localities where a rapidly descending bottom rendered the use of the grapnel unnecessary or useless.

The fishing capabilities of the apparatus are well known, they may even be said to be famous, and it was entirely due to this that we adopted it as our chief apparatus in shallow waters, it being the

instrument that most likely would furnish us with the information we desired concerning the fry of different species of fish.

Apart from the capital construction of this apparatus, its fishing capabilities are furthermore increased by the small width of its meshes, which with considerably certainly retain the young of ordinary edible fishes, of a length down to 4—5 cms.

At times, when occurring in shoals, even smaller ones were caught down to but a couple of centimetres in length. Young of cod, pollack, coal fish, haddock and whiting have thus been captured, occasionally in astounding quantities, and of the smallest size in which they are known to occur in the neighbourhood of the beach, and as regards flounders, and many other kinds of fish, the apparatus was able to catch young of a size not much exceeding that in which they terminate their pelagic (drifting) existence.

With further information derived from still more finely meshed modifications of the drift net already mentioned, this apparatus, the Eel Ground Seine, must thus, in our opinion, be said to have furnished as complete a view of the occurrence of fry along the shore as was obtainable with the technical means at our disposal.

The Danish Plaice Seine.

This net is also a seine with a bag in the centre. The ground rope is very thin, and loaded with a number of small leaden tubes or sinkers, through which the rope is run. The upper rope is likewise thin, and furnished with comparatively few corks.

The whole apparatus is considerably larger than the preceding one, the length being much greater in comparison to the depth.

The usual dimensions are (according to Drechsel):

Length of each arm 180 feet

—»— bag 20 »

Depth of mouth 6 to 8 »

Number of knots in the net 5 to 6 per foot.

Price complete about £ 4.10.0.

Material, Cotton-twine.

This apparatus is practically intended for the capture of flat-fish only.

Its ground rope, therefore, requires to be well weighted. The apparatus can then thoroughly scrape the bottom, while the width of the meshes prevents any accumulation of stuff from the bottom in the net; and thus allows this somewhat large apparatus to be handled with comparative ease.

They are mostly used from an anchored vessel, from which the net is shot by means of a boat. The drag-lines are generally very long from 60 to 1200 fathoms.

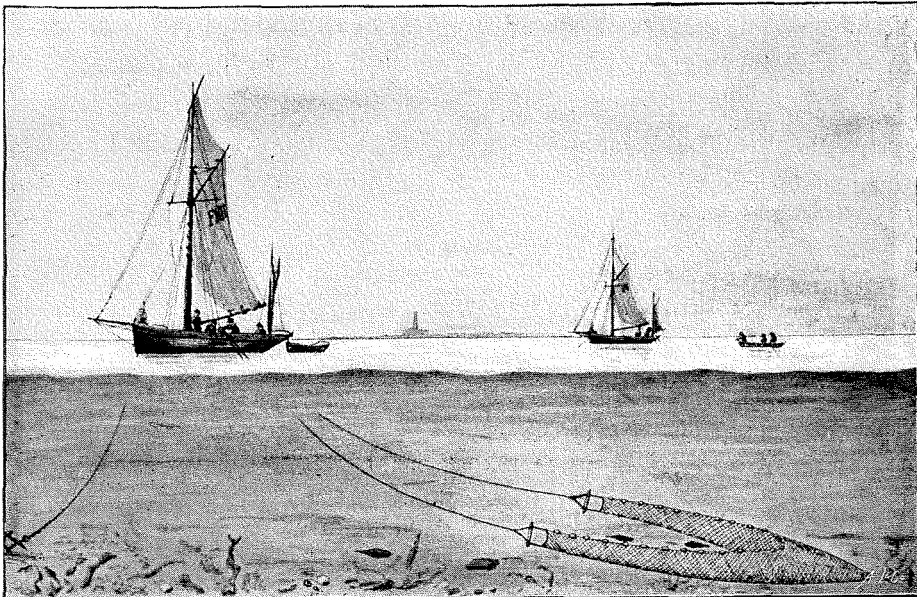


Fig. 10. Danish Plaiice Seine hauled from anchored cutter. The apparatus is only used from an anchored vessel, and is rowed out in a boat (from Drechsel).

They are marked, in order to allow of their being hauled evenly in. Hauling in is performed by means of a steam or hand winch, and the lines, which are generally laid in a semicircle, tend to drive the fish together on that portion of the bottom which will be swept by the net. The apparatus may also be rowed out in a boat from a grapnel, and hauled in a similar manner to that already described respecting the eel ground seine.

It was our intention, with the aid of this apparatus, to investigate the occurrence of adult flatfish in the shallow waters of the coast.

In order to work satisfactorily, large, flat stretches are required, preferably those with an even sandy, or muddy bottom, and as such localities are comparatively scarce along our coast, the apparatus has only been employed with advantage in a few places.

Amongst other apparatus that have been used are the ordinary seines.

Flounder net.

Small nets.

Long lines.

Hand lines with bait or jiggers.

These are, however, but rarely used. On the other hand, Shrimp, Cod, and Eel Pots or Traps of various constructions have been used for special purposes.

We consider that a detailed description of the specially devised scientific instruments employed, would be too lengthy a subject to enter upon here.

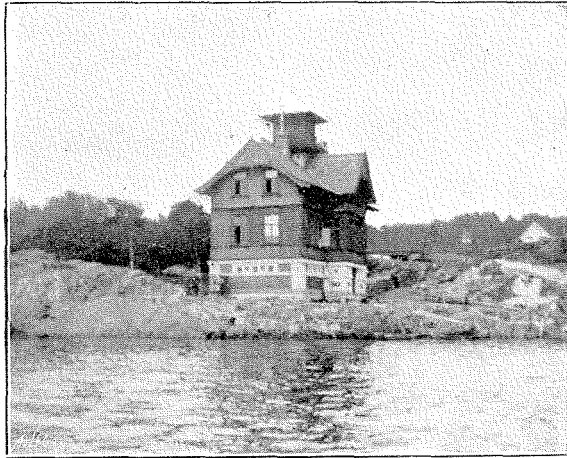


Fig. 11. The Biological Station at Drøbak, from the Sea.

Chapter III.

Our Fishing Experiments.

A. The Christiania Fiord and the Skagerrak.

The Christiania Fiord 1897.

The investigations commenced in August 1897, with the Biological Station at Drøbak as a central station.

From the Naval Shipbuilding Yard at Carljohansværn, the Station had received the loan of a small steam-launch, which towed our fishing-boat round to the various places in which we wished to prosecute our investigations. The neighbourhood of the Station at Drøbak first received our attentions. Fishing with the eel ground seine was pursued in the *zostera* fields found in the small creeks, such as Sandspollen and Hallangspollen.

The fauna there consisted of the following kinds of fishes:

Gold Sinny (Sea Bastard Carp, *Ctenolabrus rupestris*), very numerous.

Goby (Goby. *Gobius niger* and *Ruthensparri*), scarce.

3 spined Stickleback (*Gasterosteus aculeatus*), very numerous.

Burbot (*Zoarces viviparus*), scarce.

Eel (*Anguilla vulgaris*), scarce.

Young Whiting (*Gadus merlangus*), scarce.

Codlings (*Gadus callarias*), very rare.

Garfish (*Belone vulgaris*), scarce.

Herring (*Clupea harengus*), scarce.

And a few Needle Fish (particularly *Siphonostoma typhle*). Of the lower animals, the ordinary Star Fish was particularly common, (*Asterias rubens*) some Sea Urchins (*Echinus droebachiensis*) and a few ascidians.

The above mentioned animal forms, namely the small gold sinney, stickleback, goby, eel, burbot, and the needle fish, may be described as being typical *zostera animals*, which have subsequently been found in all similar localities.

With tales of the great destructiveness of the eel ground seine ringing in our ears, our surprise was aroused during the first days of our research, from the fact that, the net did not capture anything like the thousands we had expected, and it seemed particularly strange, that fry of edible fish were scarcely to be found in the net. In the hauls we made during the first day, there was, at most, 1 codling in each haul, and 3 young whiting in all the hauls we made.

This led to our proceeding to the islands near Christiania, where the stretches and creeks of shallow water are larger, and where, therefore, more hauls might be made on fresh ground.

Partly in the neighbourhood of Drøbak, and partly in between the islands at Christiania, we thus made a great number of hauls from the 11th to the 15th of August, without succeeding in finding any thing of significance beyond the forms alluded to above. Some variations in the occurrence and quantity of the above mentioned *zostera animals* were, certainly, perceived; thus we obtained, further up the fiord, a great many more eels and gobies than at Drøbak, but the scarcity of the fry remained the same.

As an instance, the result of some hauls may be given from the journal: 1897. Kjørbo, at Sandviken (near Christiania), on the night of the 14th of August.

Four hauls with an eel ground seine from a depth of about 2 fathoms. Quantities of jelly fish (*aurelia*) caused some difficulty in hauling the net, but nevertheless we obtained:

The zosteria does not grow at a greater depth than 3 fathoms in the upper part of the fiord. Outside, in the sounds, the bottom consists of soft clay (bare bottom). In such parts, too, many hauls were made with both a hand-seine and an eel drift net, without obtaining edible fish or their fry.

The fish fauna of the bare bottom was very poor, and, with the exception of a few gold sinnies, gobies and flounders (*Pleuronectes flesus*) no fish were to be found.

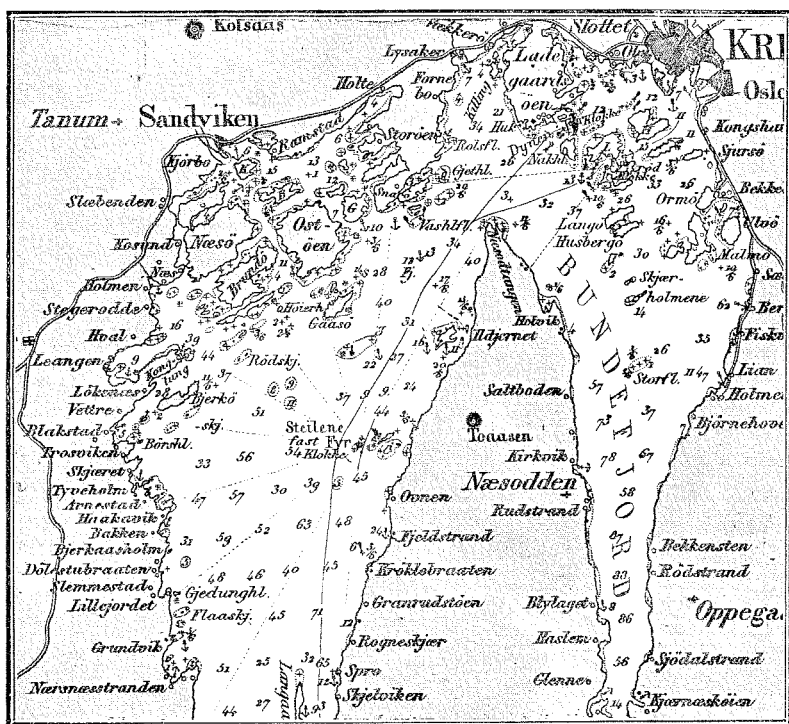


Fig. 13. Chart of the Christiania and Bunde Fiords, between Langaaren and Christiania. The Depths in Fathoms.

Owing to this we decided on adopting the plan of systematically fishing the entire fiord at all depths, in order, if possible, to discover the places inhabited by the fry.

Thus during the summers of 1897 and 1898, hundreds of hauls were made in all places where the eel and drift net could be used, thus by the islands near Christiania, at Drøbak, Horten, Aasgaardstrand the islands between Tønsberg and Færder, Hvaløerne, the Kure Fiord near Moss, and other places.

In the following account, some of the most successful fishing tr in shallow water at those places will be given, so that one may form an opinion as to what may be caught in the nets, and what fish may be met with along the shore during summer.

1. Frognerkilen near Christiania, 31st. August and 1st. September.

a. Two hauls in the zosteria, by *daylight*, 31st. August, close to the place where the Fishing Society let out the fry of codfish, yielded, multitudes of ordinary zosteria animals, especially gold sinny and goby also:

1 Sea Trout.

1 Flounder.

62 Eels.

6 Codling, of which 2 measured 8.5 and 9.5 cm.

4 — 24 to 27 »

b. During the night of the 31th. August, about 35 hauls were made from 8¹/₂ p. m., to about 5 a. m. The hauls were rendered difficult in the dark, owing to our want of acquaintance with the waters, and, towards the morning, the slime from the eels, caused the net to sink.

The catch consisted of:

great quantities of zosteria animals.

probably about half a bushel of *Gubius niger*.

—•— Gold Sinny and

multitudes of Sticklebacks.

500 Eels.

30 Cod Fish, of which seven 7.5—11.5 cm. and the remainder of the following sizes: 19, 5, 28.5, 29, 31, 32, 33, 33, 34, 34.5, 40, 41 and 43 cm.

2. *Drøbak Sound*. August 24th. Two hauls with an eel-seine in the bay at Shiphelle, in 5 to 6 fathoms of water, and gradually upwards to the shore, yielded.

70 Gold Sannies.

30 Gobies.

3 Sea Scorpions (*Cottus scorpius*).

1 (*Agonus cataphractus*).

2 Dragon Fish (*Callionymus lyra*).

1 Burbot

- 12 Eels.
15 Flounders.
4 Plaice (17—21 cm.).
2 Dabs (*Pleuronectus limanda*).
110 Fry of Whiting (11—16 cm.).
3. *The Kure Fiord near Moss.* September 2nd. 2 to 3 fathoms of water with an eel ground seine, several hauls.
numerous Burbots.
— Gobies.
— Gold Sannies.
— Sticklebacks.
a few Flounders.
— Sea Scorpions.
— Needle Fish.
a few young Whiting.
1 Cod Fish.
4. *North East Coast of Eløen, near Larkollen, September 3rd.* Partly *zostera*, and partly a sandy bottom close to the shore. Fine meshed hand seine.
45 Gold Sannies.
26 Gobies.
some smaller species of Goby.
2 Burbot.
2 Dragon Fish.
5 Sea Scorpions.
10 Eels.
1 Cod, fry of that year.
1 do., fry from the preceding year.
14 Flounders.
1 Dab.
14 Plaice, from 18 to 27 cm.
14 do., fra 7 to 11 cm.
4 Brill (1 fry).
3 Trout, 23 to 29 cm.
5. *Thorsøkilen, near Fredrikstad.* September 6th., 2 hauls with Dr. Petersen's trawl, at a depth of 11 to 2 fathoms in the *zostera*, yielded ordinary *zostera* animals (burbot, goby), some flounders, 37 eels,

but no fry of either whiting or cod. Several boats were observed fishing whiting on the bare bottom, with lines.

These examples, chosen amongst the hundreds of similar ones, will give an idea of the conditions *in shallow waters during the summer*. Not once was there a greater quantity of fry obtained than in the above mentioned hauls in shallow water.

These experiences led to our seeking the fry in deep water. We certainly knew, that the fry everywhere, or with but few exceptions, was said to inhabit the shallow waters, but we, nevertheless, found it desirable to become acquainted with the fiord in its entirety in this respect. With the fine meshed trawl, therefore, the various-depths were

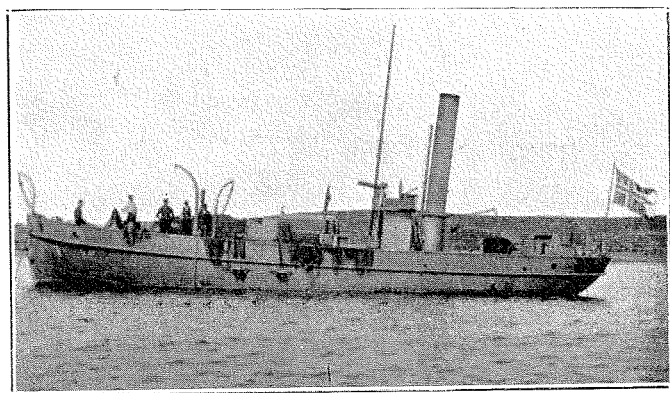


Fig. 14. The Naval Crane Ship, Nr. 3, employed on Hjort's cruise.

examined, viz., at depths of 5, 10, 15, 20, 30, 50, 80, 100 fathoms. During these investigations we used a small 3rd class gun-boat, placed at our disposal by the Ministry of War. In this way hundreds of hauls with a trawl were made at the depths mentioned.

The results of these investigations *of the deep waters of the fiord* were, in respect to the fry, identical with those of the shallow waters. We did not succeed in finding the fry in the fiord, except quite *occasionally*, down to a depth of about 10 fathoms. But neither were the large edible fish obtained in any large quantities during those trials.

We were fortunate in catching numerous kinds which belong to the characteristic deep water-fauna of the fiord; but of such species, as, for instance, the cod, we got but very few. To see if this were owing to the

fishing capacity of the trawl, lines were also set, and the catch of the fishermen was daily noted.

As an instance of the dearth of fish at Drøbak, during the summer, the following catch by lines may be given.

Lines set in 50 to 100 fathoms of water, 23rd to 25th August.

1. 23rd August, 1000 hooks, 100 fathoms.
 - 1 Whiting.
 - 1 Haddock.
 - 3 Argentines (*Argentina silus*).
 - 3 Piked Dog Fish (*Spinax niger*).
2. 23rd August, 1100 hooks, 50 to 60 fathoms.
 - 40 Whiting.
 - 40 Haddock.
 - 1 Ling.
 - 1 Cat Fish.
3. 23rd August, 2000 hooks, 50 to 60 fathoms.
 - 65 Haddock.
 - 15 Whiting.
4. 25th August, 1700 hooks, 50 to 60 fathoms.
 - 18 large Haddock.
 - 16 Whiting.
 - 6 small Haddock.
 - 1 Cod, 2 to 3 years.
 - 1 Ling.
 - 1 Piked Dog Fish.

Everyone acquainted with the fishing at some place or other in the Christiania Fiord, during summer, will also know that it is excessively poor, and that, above all, cod are very scarce.

The results led to our assuming that the fauna of the Christiania Fiord, as is the case in the Danish Fiords, consists of two kinds, the one group belonging to the fiord throughout the year (as the zostera fishes, and the special deep water fishes of the Christiania Fiord, see Chap. IV), the other group consisting of those species which, but now and then, visit the fiord — the migratory fishes.

In order to test this working hypothesis, a number of fishing trials were made during the autumn and winter (1897—98) with the eel ground seine at the same places as those fished during the summer of 1897,

thus in the small creeks near Drøbak. We may here report the results of the hauls at

1. *Drøbak 18th October.* Eel Ground Seine West side of the fiord. Several hauls yielded altogether.
some Flounders.
— Dabs.
— Lemon Dabs (*Pleuronectes microcephalus*).
— Plaice (the largest specimen 50 cms).
quantities of Whiting Fry.
about 150 Cod, from 8 to 32 cms. in length, most from 8 to 13 cms.
2. *Drøbak, 24th October.* One haul of the hand seine.
5 Flounders (23 to 31 cms.)
2 Whiting (16 to 17 cms.)
147 Cod (6¹/₂ to 11 cms.)
3. *Drøbak, 17th February.* Five hauls of the hand seine.
2 Plaice (22 and 33 cms.)
26 Flounders (from 9 to 32 cms.)
1 Turbot (10 cms. *Bothus maximus*).
50 Cod (9 to 12 cms.)

From October, on to the spring, fry were thus met with in the fiord, although not in such enormous quantities as was formerly supposed. From the statistics concerning fishing in the fiord, and noting the take of the fishermen, it therefore appeared that, the large round fish (cod, whiting, haddock) were then present in far greater numbers than during the summer.

This naturally raised the question: «Where does this fry come from during the autumn, and what becomes of it during the summer?»

The object of Hjort's cruise from Utsire to the Christiania Fiord in 1898, and Dahl's researches in the Trondhjem Fiord, was to set this question at rest.

II. The Skagerrak and the West Coast 1898.

The cruise made during the summer of 1898, commenced in Jæderen. See Pl. I. The shallow waters on the shores of that district were systematically

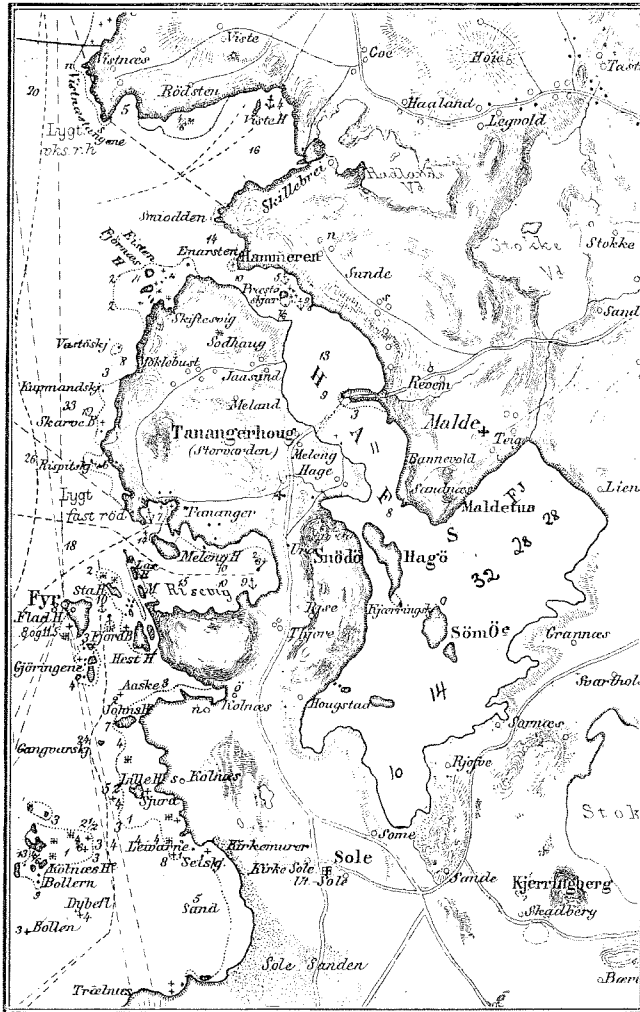


Fig. 15. Chart of the Hafslund Fjord, and the coast beyond it.

investigated, as well as some of the flat sandy bays, for instance at Sole (Solesanden), and some of the spots, such as Risevigen, and the bays in Hafslund Fjord, which were covered with zosteræ. From the accompanying chart (Fig. 15) of Hafslund Fjord, with the adjacent coast, it will be seen that beaches are to be found in Jæderen, as at Sole, but the quite shallow

water does not extend far seawards. Even at Solesanden, 5 fathoms of water will be found three quarters of a mile from the shore, and the grounds suitable for fry, so far as flat fish are concerned, are, therefore, not extensive. With the fine meshed eel ground seine and the silk net, Hjort obtained the youngest yearlings of the plaice in the bays at Sole, Viste, Vigdel and other places, but invariably in small numbers, for instance, in two or three hauls, 8 to 10 only. The fry of round fish, of Gadoids was met with, however, in far greater quantities, and it appeared that the coast there was the true home of the fry of the Gadoids. Some accounts of the yield of the hauls will shew this.

Three hauls of the eel ground seine were made at *Risevigen* and *Tananger*, up to land, on the *2nd August*. *Risevigen* is, as will be seen from the chart, a bay on the coast of *Jæderen*. The depth of water in the middle of the bay is 10 fathoms. Along the north side there is an even, sloping, extensive sandy bottom, covered, in shore, with fucus, and beyond it with *zostera* (a belt but 5 boat lengths wide), and beyond this again, a broad belt covered with an alga called fiddle strings (*Chorda filum*)

The three hauls yielded the following fish:

300 Cod fry, . . . 4 to 13 cms. in length.

9 » 17 » 24 » » »

600 Green Cod fry 5 » 12.5 » » »

27 Whiting fry . 4.2 » 21 » » »

Sticklebacks }
Golden Sannies } in numbers.

3 Wrasse (*Labrus berggylta*).

2 » (*Labrus exoletus*).

1 Dragon Fish (*Callionymus lyra*).

1 Burbot.

6 Plaice (3 cms. long, caught with the silk net).

3 Flounders.

1 Dab.

The result of two hauls with the eel ground seine in *Hafvs Fiord* *30th July*, may be given.

34 Golden Sannies.

47 Sticklebacks.

3 Gobies.

2 Burbots.

- 1 Cat Fish (*Anarrhichas lupus*).
- 26 Green Cod Fry (from 4.5 to 10.8 cms. in length).
- 32 cod » (from 4.2 to 9.5 cms. in length).
- 6 Flounders (20.5 to 40 cms.).
- 15 Plaice (12.5 to 28.5 cms.).
- 23 Dabs (12 to 24.5 cms.).

Similar conditions were observed, during the first half of August, wherever investigations were made on the entire stretch *Utsire* to *Ekersund*. Both in an open fiord, as for instance at *Hinna* (Gands Fiord, near Stavanger) and at *Ekersund*, and especially out by the open sea, for instance at *Fæøen* off Haugesund, vast quantities of fry of the various species of cod were observed (chiefly cod, pollack and Green Cod). The fry was found both in the tangle in the sounds, and in the bays out by the sea, as well as in the small bays with clay bottom covered with *zostera*. The fry was invariably met with only close to the shore.

Much labour was also spent in endeavouring to obtain the large yearlings further out from the land, but this work met with great difficulties. There were but few opportunities of putting out far from shore with the little boat at our disposal, while but small nets (Dr. Petersen's net) and seines could be used from it.

On the coast of *Jæderen* various annual classes of plaice, up to 60 cms. in length, were met with, but it was very difficult to use the nets owing to the seaweed commencing so close to the shore, while it was impossible to haul the seine where the thick stalks of the tangle were growing. In one lucky haul of the Danish seine off *Jæderen* (1 mile to sea) 17 plaice (28 to 36 cms. in length) as well as some large turbot and brill were taken. From the numerous, but resultless attempts at trawling, it appeared that the bottom off *Jæderen* consisted of, first, a belt of sand one to two miles wide, beyond which the tangle, with its thick stalks and fathom long leaves, commenced to grow on the sand, while still further out the bottom was hard, but still covered with tangle at a depth of some 18 fathoms. This shoal, below 20 fathoms, is, in some parts, about 8 miles wide, and there, also, was a perfect forest of tangle. Beyond this the bottom falls towards the clayey depths which are found at 150 fathoms, and which have branches stretching towards land.

The great tangle region is the resort of older annual classes of round fish, especially cod. There the cod fishing is carried on throughout

the entire year (also during summer) from small, open boats, which are rowed, or sailed 4 to 8 miles to sea, and fish, some with long lines, some with hand lines and crab (*Cancer pagurus*) as bait.

On the 8th August, some such fishermen were met with, and their proceedings, and catch, noted. They broke open the crab and rubbed its contents on hooks covered with woollen thread. In the course of some hours, at distances varying from 4 to 8 miles off the land, they caught 30 cod, 40 to 90 cms. in length. Quantities of various kinds of



Fig. 16. Hand line fishing, 6 miles west of Jæderen.

crustaceans, shrimps, crabs and other animals (*Pandalus borealis*, *annulicornis*, *Galathea*, *Hyas*, *Ophiuroids* and remains of *Sandeels* were found in the stomachs of these fish.)

Similar observations were made one day at *Orre* (Jæderen), where some boats, 2 miles from the shore, caught 35 cod in the tangle (15 to 20 fathoms of water). The size of the fish varied from 33 to 82 cms., most 40 to 60 cms. The colour of each fish was carmine, like that of the Norway Haddock. At Fæøen, off Haugesund, we saw some long line fishing, the yield of which consisted of haddock, cod, ling, tusk, Norway Haddock, with an occasional halibut.

After thus succeeding in finding a part of the coast where fry occurred in great quantities, and after having studied the conditions under which it exists there, it became necessary to discover the eastern limits of its distribution in mass, as it, as previously mentioned, is not met with in the Christiania Fiord during the summer. In the district of Jæderen, the cod fry was most numerous in Risevigen, near Tananger, and somewhat less numerous at Ekersund. *Lister*, to the eastward was first tried for some days, 20th to 22 August (the sandy bays and the *zostera* near *Lodshavn*). A few hauls of the hand seine, on the 22nd August, between Havig and Lodshavn yielded;

17 Cod from 21 to 43 cms. in length.

about 100 » » 5 » 11 » » »

Arendal was our next station (24 to 26 August). On these three days a number of hauls were made with the eel ground seines (about 50 or 60) round about in the neighbourhood of Arendal, partly near the open sea, as, for instance, at *Alvekilen* and *Fevigen*, also in the sheltered creeks at the entrance to Arendal, such as *Sømskilen*, *Hovekilen*, as well as inside Tromøen in the coves on both sides of *Tromøsund*.

At none of those places did we find any great quantity of round fish fry. The best hauls, so far as cod fry was concerned, were the following:

Fevig, 25th August. At the head of the creek, several hauls yielded 7 Cod (9.5 to 12 cms. in length).

Flødevig, 26th August. One haul of the eel ground seine yielded a number of small fish, mostly small Whiting, and 3 Cod, of which 2 were possibly of the fry of the year (9, 9.5 and 13 cms.).

Sømskilen, 25th August. Several hauls yielded;

1 Cod, 10 cms. in length.

5 » 24 » to 30 cms. in length.

The conditions at places like the shallow *Hovekile*, were quite similar to those of the Christiania Fiord. In the shallow sounds there were masses of *zostera*, this, in the bays especially, being very luxuriant. On the 24th and 25th, many hauls were made, both with the hand seine, and drift net, without obtaining any fry of other fish than small gobies. On the 25th five hauls yielded:

The ordinary *Zostera* Animals,

25 large Eels (from 32 to 72 cms.),

5 Cod (20 to 27 cms.).

On the 25th and 26th we observed the fishermen off Tromøen. They were met with but a short distance from land, where the charts give 20 to 40 metres of water, and where the bottom consists of tangle and rock. Some used hand lines, with crab as bait, others long lines (1000 hooks, glass balls and sinkers). The catch consisted, chiefly, of whiting and haddock, and a few cod, 20 to 30 cms. in length, of a distinctly red colour. The fishery was, on the whole, very poor. One fisherman said he could earn, on an average, 2 to 3 kroner between 3 a. m. till 9 a. m.

On the 25th, the take of five boats yielded 16 Cod, 19 to 30 cms. in length. On the 26th, that of 6 boats yielded 7 Cod from 23 to 62 cms. in length.

As it appeared, from these observations and investigations, that the conditions at Arendal are clearly the same as those observed at the mouth of the Christiania Fiord, the remainder of the cruise was devoted to checking the results of our researches during the previous year in the Christiania Fiord, especially at its entrance. First we went into localities such as Frognerkilen, Drøbak, Kure Fiord near Moss; then to the waters between the islands on each side of the fiord (Tønsbergøerne and Hvalerøerne), and, finally, to the Larvik and Langesund Fiords. The conditions in 1898, were the same as those met with in 1897. They shewed that the well known zostera fauna was found in shallow waters, and no young fry of edible fishes, certainly not that of round fish were met in number.

The results arrived at, after the investigation of the habitat of the fry in southern Norway during two summers, were, therefore, as follows: *The fry of flat fish (youngest yearlings)* was found to be scarce in the mouth of the Christiania Fiord, at Eløen near Larkollen, and Sandesund near Færder, for instance. In the Christiania Fiord, above Drøbak, not a single specimen of the smallest fry (the year's fry) of the plaice was met with. Out on the coast, it was found in certain localities, but everywhere scarce. It was most numerous on the flat, sandy beaches of Jæderen, where, however, the maximum catch was about 8 in one haul with a little silk net 6 feet in breadth. From, and including, Arendal, eastwards, the *fry of round fish* was very rarely met with; often none, very seldom 1 to 3 in a haul. On the west coast, on the other hand, the fry of round fish (Green Cod, cod, pollack) was found in great quantities (300 in one haul), and this wealth of young fish was found to exist from Farsund (Lister), west.

wards to Fæøen (Haugesund). The only fry met with in abundance east of Lindesnes was that of the following fish:

Gobies

Sticklebacks (*Gasterosteus aculeatus*),

Herrings (*Clupea harengus*).

III. Continued researches in the Christiania Fiord 1899.

By Alf Wollebæk.

A. Plankton Samples.

With the object of investigating the quantitative occurrence of spawn, and fry of fishes which have pelagic eggs, the researches in the Christiania Fiord which commenced in 1897 and 1898, were also continued, this year, under the direction of Dr. Hjort, with the Biological Station at Drøbak as a starting point.

The investigations commenced on the 13th February, with collecting Plankton, for which purpose a net of the same size and construction, and of the same number of silk-gauze* as those used by Hensen and Apstein when investigating the occurrence of ova in the North Sea, was employed.

During the whole spawning time, samples of plankton were constantly taken in the sound at Drøbak. Apart from those obtained from the Drøbak sound, other samples were also procured, one day in April, from various parts of the fiord between Færder (at the entrance to the Christiania Fiord) and Drøbak. As will be seen from the Table, both in the Drøbak Sound, as well as every where in the fiord where search has been made, an exceedingly small quantity of eggs were present.

By way of comparison with the quantity of ova existing in Danish waters, it may be stated that, off Fredrikshavn, in three horizontal hauls along the surface, each lasting for a minute, no less than 1386 eggs were obtained with a Plankton net of similar construction to the one that was used in the Christiania Fiord, where, on an average, not more than a few (6—8) ova *per* haul were found.

It might be imagined that the reason for this dearth of eggs on the surface of the Christiania Fiord, is due to the fresh water layer on

*) No. 3.

Date	Number of Trials	Horizontal or Vertical	Depth	Time occupied	Locality
13th Feb.	1	Vertical	50 Metres	—	Middle of the Fiord off Drøbak
24th "	2	"	"	—	"
1st March	"	"	"	—	"
6th "	1	"	20 Metres	—	"
— " —	"	"	50 "	—	"
— " —	"	"	"	—	"
10th March	2	"	"	—	"
14th "	"	"	"	—	"
21st "	"	"	"	—	"
25th "	"	"	"	—	"
28th "	1	Horizontal	Surface	Two minutes	"
5th April	2	Vertical	50 Metres	—	"
5th "	1	Horizontal	Surface	Two minutes	"
8th "	"	Vertical	50 Metres	—	"
8th "	"	Horizontal	Surface	Two minutes	"
10th "	"	"	"	"	"
10th "	"	Vertical	50 Metres	—	"
13th "	"	Horizontal	15-20 Metres	—	"
13th "	"	"	Surface	Two minutes	"
14th "	"	"	"	One minute	"
14th "	"	"	40 Metres	—	"
15th "	"	Vertical	50 "	—	Off Rauer
15th "	"	"	40 "	—	"
15th "	"	"	10 "	—	"
15th "	"	"	60 "	—	Between Lille Færder and Torbjørnskjær
15th "	"	"	"	—	"
15th "	"	"	4 "	—	"
15th "	"	"	60 "	—	Opposite Rødtangen
15th "	"	"	34 "	—	"
15th "	"	"	10 "	—	"
15th "	"	"	"	—	Holmsbo, Drammen Fiord
15th "	"	"	50 "	—	Between Svelvik and Drammen
15th "	"	"	"	—	"
2nd May	"	"	15 "	—	Christiania Fiord, middle of, near Drøbak.
2nd "	"	Horizontal	15 "	—	"
12th "	"	"	below Surface	2 minutes	Opposite Rødtangen
12th "	"	"	Surface	—	"

Number of Eggs	Number of Larvæ	Remarks
1	—	
9	—	
15	1	Two of the eggs much developed; the others inconsiderably so. Larva of a species of the genus <i>Gadus</i> ; measured 8 mm.
2	—	
6	—	
5	—	
14	—	
1	—	
—	—	
5	—	
77	—	Strong current inwards, with high water.
121	—	
—	—	
2	—	
—	—	
3	7	Quite strong southerly breeze. The three eggs quite newly spawned. The seven larvæ of <i>Clupea harengus</i> , newly hatched.
5	—	
1	6	The six larvæ, of <i>Clupea harengus</i> , newly hatched.
4	—	
16	—	
2	—	
16	3	One of the three larvæ was that of <i>Clupea harengus</i> , 8 mm. in length. The other two, of a species of the genus <i>Gadus</i> , but 3 mm. in length.
8	1	This one larva, of a species of the genus <i>Gadus</i> , measured 6 mm. in length.
2	—	
1	—	
2	—	
1	—	
3	—	
7	—	
8	—	
—	—	
—	—	
11	—	
7	—	

the surface of the fiord, so that the specific gravity of the eggs exceeded that of the water, and that they thus would sink to the deeper lying and salter layers. Horizontal hauls were therefore made, not only on the surface, but also 15 to 20 metres below it, and vertical hauls from a depth of 60 metres to the surface, but the same dearth of ova and larvæ prevailed throughout.

It was, however, surprising to find, that two of the samples from the surface of the Drøbak Sound contained, respectively, 121 and 77 ova (see the Table), thus many times more than were contained in all the other samples, combined, which were taken from the fiord; but in respect to the day when these samples were procured we find a remark: «*strong current flowing in*». This circumstance alone, viz., that a much larger quantity of eggs was found *on the surface* with a strong inward bound surface current, indicates that the salinity of the fiord was not, as a rule, too low to allow of the ova floating on the surface.

From the hydrographical investigations* previously carried out, it has been proved, that, the water, with an *in-flowing current*, was fresher than that of an *out-flowing current*.

The total amount of larvæ obtained in the plankton samples consisted, in all, of 18 specimens, of which but 4 however, belong to fishes which have pelagic eggs, the remainder being larvæ of the herring (*Clupea harengus*), which, as we know, shed their roe on the bottom.

B. Investigations of shallow waters.

After having studied the quantity of ova in the fiord contained in the plankton, the next task was to ascertain the quantity of fry present in the fiord.

In order to take even the very smallest bottom-stages of fry, a seine with very fine meshes was constructed of cotton twine (No $12/6$) of the following dimensions:

Length of arms:	8 feet.
Height » » at bag:	10 feet.
» » bag in the water:	8 feet.

Size of meshes throughout, 62 meshes *per foot*.

*) See H. H. Gran, Kristianiafjordens algeflora, P. 5 (Kristiania Videnskabselskabs Skrifter, Math.-naturv. Klasse, 1896, No. 2) and the following paper in this Report.

This apparatus answered every purpose. The fine meshes did not interfere with its good fishing capabilities, while, at the same time, it could catch the very smallest fry.

Various localities about Drøbak, such as the Sandspollen, Hallangspollen, Skiphellebugten and other parts, old fishing places for the ground seine, when its use was permitted, were specially chosen for investigation. Several hauls were also made between the islands near Christiania, as well as a cruise to Hankø, with its adjacent fishing places, and a cruise to the west-coast (Risevigen at Tananger and Hafns Fiord).

In the middle of May the search commenced for that year's fry, especially that of the cod, with the fine meshed seine.

Fishing was carried on not only at various depths from 1 to 12 metres, but also upon different kinds of bottom covered with *Zostera*, *Laminaria*, or else bare, and, as far as possible, also on a bottom covered with stones of no great size. In the latter half of May, the hauls made in the bays near Drøbak, yielded, on an average, about 3 specimens, *per* haul, of fry of that year of Gadoids. 12 hauls with the fine meshed seine between the islands at Christiania, during the same period, yielded altogether but two specimens of that year's fry of Gadoids (both *callarias*). These specimens were the only catch of that year's fry which, on the whole, were obtained in the latter half of May. None of that year's fry of the flounder species, or any other fish, was found, nor of those with pelagic or demersal spawn. Older specimens, however (of 1 to 2 year's growth) of *Pleuronectus platessa* as well as *flesus*, were quite often met with, also some *Bothus*, and, regularly, 1 to 2 year old *Gadus callarias*, *merlangus* and *pollachius*, and second annual class of *Gadus minutus* (numerous), and, in the laminaria region, always some *Cottus scorpius*; but the preponderate yield of the hauls consisted of the commonest shallow water fishes, such as *Ctenolabrus rupestris*, Gobies specially *G. ruthensparri* (*flavescens*); *Aphya pellucida*, which, in some hauls, were caught in enormous quantities; Needle Fishes (chiefly *Siphonostoma typhle* and *Nerophis ophidion*). Sticklebacks (*Gasterosteus aculeatus*) and the Viviparous Blenny (*Zoarces viviparus*).

As regular typical hauls from the bays about Drøbak, in the latter half of May, may be mentioned:

1 haul with the fine meshed seine, Sandspollen, 2 to 1 fathoms, zosteræ:

- 2 *Gadus callarias*, fry from 1899
- 1 *G. callarias* } 2nd annual class
- 1 *G. merlangus* }
- 12 *G. minutus* }
- 3 *Siphonostoma typhle*
- 10 *Gasterosteus aculeatus*
- 20 *Ctenolabrus rupestris*
- 200 *Gobius flavescens*
- some *Aphya pellucida*
- 1 *Pleuronectes platessa*
- 1 *Pl. flesus*

1 haul in the Hallangspollen, 2 to 1/4 fathoms, zosteræ:

- 2 *Gadus callarias* of that year's fry
- 5 *G. callarias* } 2nd annual class
- 2 *G. pollachius* }
- 1 *G. merlangus* }
- 50 *G. minutus* }
- 20 *Gasterosteus aculeatus*
- 20 *Ctenolabrus rupestris*
- several *Gobius flavescens*
- » *Aphya pellucida*
- some *Gobius minutus*
- » *Siphonostoma typhle*
- and *Mysidae*, *Asterias rubens* and Jelly Fishes.

The largest amount of fry of Gadoids, which, in May, was caught in a single haul, amounted to 18 specimens.

Generally, but 2 to 4 fry were caught in a haul, but several hauls were also made without obtaining any at all.

In order to make a direct comparison between the quantity of this year's fry on the West Coast, and in the Christiania Fiord, a cruise was made in the early part of June to Tananger (W. of Stavanger). There, three days' fishing was carried on with the same seine as was used in the Christiania Fiord. The following extract from

the journal, will furnish the best illustration of the difference in the wealth of fry in both places.

Risevigen, near Tananger

June 5th., 4 hauls, $\frac{1}{2}$ to 3 fathoms:

1005 *Gadus*-fry from 1899 (of *callarias*, *virens* and *pollachius*),
of which 582 specimens in one haul.

10 <i>Gadus callarias</i>	}	2nd annual class
4 <i>G. pollachius</i>		
1 <i>Anguilla vulgaris</i>		
2 <i>Pleuronectes flesus</i>		

June 6th, 4 hauls, 1 to 2 fathoms:

572 *Gadus*-fry from 1899

10 <i>Gadus callarias</i>	}	2nd annual class
4 <i>G. pollachius</i>		
2 <i>Anguilla vulgaris</i> (large specimens)		

June 7th, 5 hauls, $6\frac{1}{2}$ —1 fathoms:

761 *Gadus*-fry from 1899

10 <i>Gadus callarias</i>	}	2nd annual class
4 <i>G. pollachius</i>		

There were also obtained, apart from the above mentioned results of the hauls in the Risevigen, the commonest kinds of shallow water fishes, such as *Gasterosteus aculeatus*, *Spinachia*, *Centronotus gummellus*, *Ctenolabrus rupestris*, some *L. melops*, *Zoarces*, large quantities of *Siphonostoma typhle* and other Needle Fish (*N. ophidion* etc.), *Gobius minutus* and *flavescens*, and *Aphyia pellucida*. Independent of the Gadoids the hauls in the Risevigen exhibited a striking difference as regards the rest of the fishes.

While *Gasterosteus* and *Gobius* predominated in the hauls made in the Christiania Fiord, they occurred in far lesser numbers in the Risevigen. The fry of Gadoids, it may be said, had there taken their place.

In addition to using the fine meshed net a few hauls were also made with the Danish eel ground seine, the meshes numbering 26 *per* foot, and, on the whole, this net was of larger dimensions than the fine-meshed

seine. But as the fry were still no bigger, on an average, than some 4 cms., a great many escaped through the meshes.

Finally a silk-net was tried, in order to ascertain whether the fine-meshed net, generally adopted, would leave any of the small fry behind; but it appeared, that, not even with the fine silk net, could any more fry of the very minutest bottom-stages be caught, than with the recently constructed fine-meshed seine.

The Risevigen was systematically searched throughout, with the 3 above mentioned fishing-apparatus, from 0 to 10 fathoms of water. One side of the bay was very shallow, partly covered with short *Zostera* partly bare sand, with some patches covered with *Fucus*. Upon this stretch of shallow-water there was obtained at depths varying from 0 to 1½ metres, but 1 *Gadus*-fry (*virens*). The large quantities of fry kept within, and on the border of the belt of *Zostera*, at depths from 2 to 6 metres. On the bare bottom, where some hauls were also made with the three different apparatus, almost no fry was met with. The small number of fry found in the Christiania Fiord exhibited the same trait in respect to their habitat.

In the Hafvs Fiord, too, a few hauls were made, but there the yield was quite different. The dearth of that year's fry of Gadoids was there quite as apparent, if not more so, as in the Christiania Fiord. The average yield was not even 1 fry per haul. That year's fry of other fishes who have pelagic ova, was not found.

Of the older (1 to 2 year's growth) Gadoids (specially *G. pollachius*) as well as other fishes, there were caught about as many as we were accustomed to get in the Christiania Fiord.

In the middle of June, a cruise was made to Hankø in the outer part of the Christiania Fiord, and its adjacent fishing places. Though but a few hauls were made, they exhibited several interesting features, owing to which some further details of the cruise shall be given.

Besides the fine-meshed and previously mentioned Danish eel ground seine, there was also on board a seine, similar to that used by poachers.

It was, altogether, of much larger dimensions than both the other nets, the arms being 17 fathoms in length and 2 to 2½ fathoms in height at the entrance to the bag, the size of meshes in the arms being 13 per foot, and in the bag 21. It is a matter of course that a net with such open meshes cannot catch the small fry at this period, as they, at least on the

east-coast, scarcely attain an average size of 4 cms. It could therefore only serve to catch the previous year's, and the 2¹/₂ year old fry.

The localities about Hankø which were subjected to investigation were: Østre Vigene, Slevigkilen and Langvarp, W. of Strømtangen, all very frequented seining places, which were shewn to us by people* acquainted with the locality, as places where the ground seines would destroy the fry wholesale.

Østre Vigene (Hankø) June 13th, 1899 [sandy bottom covered with wrack (*Fucus*) in by the shore, and with eel-grass (*Zostera*) further out. Direction of wind: N. O. stormy, clear weather]. A haul was made there with the poaching seine, which gave the astounding yield of 52 large Garfish (*Belone acus*), while of the large quantity of Cod fry which it was prophesied we should get, no more than 8 specimens were caught, all of the 2nd and 3rd year class, as well as 2 Pollack (*Gadus pollachius*), 43 Whitings (*G. merlangus*), 1 Trout (*Salmo trutta*), 1 Eel (*Anguilla vulgaris*), 1 Herring (*Clupea harengus*) besides Needle Fishes (*Siphonostoma typhle* and *Nerophis ophidion*), Gold Sinnies (*Ctenolabrus rupestris*), Sticklebacks (*Gasterosteus aculeatus*) and Gobies.

Slevigkilen, near Hankø, 1 haul with the poaching seine, 3 to 0 fathoms, did not either in this locality occasion any wholesale destruction of cod-fish fry; on the contrary, there were still fewer cod taken than in the previous haul. From a biological point of view the haul was particularly interesting from the large number of whiting (*Gadus merlangus*) which, in addition to enormous quantities of transparent jelly fish, were then obtained. Of the former no less than 775 specimens chiefly measuring from 13—15 cms. were caught in this one haul.

About the same number of uneatable fishes were caught as in the previous haul.

The next station was

Langvarp, W. of Strømtangen, a small cove, where the Fredrikstad Fishing Society, two month spreviously, had placed 41 cod ready to spawn, (*Gadus callarias*) and stopped the entrance with a herring net.

One haul was first made with the fine-meshed net for the purpose

*) Two members of the Fredrikstad Fishing Society, who both had struggled to maintain the theory of the fearful destruction brought amongst the stock of cod-fish by the use of the seines.

of taking the small fry, which was expected to be found — the offspring of the cod referred to.

One fry of Gadoids of that year was also caught, but it proved to be a young Green Cod (*G. virens*). Besides this but 1 Cod, and 1 Pollack of 2nd annual class, about 250 Gobies, 20 Needle Fsh, and a few *Aphya* and *Palaemon* were caught. Subsequently a haul, intended to catch the cod-fish which had been let loose, was made with the poaching net, which could be stretched almost right across the bay, but without catching a single cod, only some golden sinnies, gobies, sea-scorpions and a few green cod and whiting being taken.

The investigations made, later on in the summer, were carried on exclusively in the neighbourhood of Drøbak.

Even in the latter half of June, a considerable difference in the number of small gadoid fry was apparent.

In the latter half of May, each haul might yield an average of 3 fry, and, in some hauls, up to 18 specimens were caught, but, in the latter half of June, it only twice happened that as many as 7 of that year's fry were captured in a haul, the majority of hauls yielding none. Of the older annual classes, there were then caught a much smaller number than formerly.

Simultaneously with this decrease in the take of cod-fish fry, which, in July, was still further reduced to 0 to 4 specimens per haul, did the earliest fry of the commonest shallow-water fishes begin to appear, becoming more and more plentiful in the beginning of July, and occurring in great quantities towards the middle of that month. First came the fry of *Gasterosteus aculeatus*, then *Aphya pellucida* appeared, and, finally, in the end of July, the *Gobius*-fry. The fry of needlefish and garfish (*B. acus*) could be caught in abundance on the surface-water during the whole of July.

Of the older year classes of the above mentioned species (*B. acus* excluded), as well as those of *Gadus minutus* and *Ctenolabrus rupestris*, a number of individuals were caught during the same period. Thus in the middle of June, 3 hauls with the Danish eel ground seine would yield 12 litres of these shallow-water fishes.

It is at once perceptible that, all the species of fishes, of which quantities of fry were found, have demersal eggs. Not a single specimen of the year's fry of *Gadus minutus*, which has pelagic eggs was

ever found; older individuals however (9 to 12 cm., never exceeding this size in shallow water) could be caught in great numbers. The whole catch of fry of fishes with pelagic ova, consisted, in that month, exclusively of the few Gadoids previously mentioned. The investigations made during the whole of August yielded similar results respecting that year's fry of fish with pelagic eggs. As that year's fry, in judging from the few individuals caught, had then attained such a size as to be caught in the more open meshed Danish eel ground seine it was then used just as frequently as the fine meshed net; but the results were the same as formerly.

All through September, and the first half of October, hauls were, likewise, regularly made with the Danish ground seine, but none of these yielded more of that year's fry of the cod-fish species, or other fishes with pelagic ova than in the two preceding months.

On the other hand, great quantities of fry of *Gobius*, *Gasterosteus* and other fishes were caught.

Towards the end of October, a very strong southerly gale prevailed, lasting for some days, and rendering all fishing impossible.

When the storm had calmed down, and the eel ground seine once more could be used, a single haul yielded no less than 40 specimens of that year's fry of cod-fish alone, besides green cod and whiting in those localities, where, previously, no more than a couple of specimens were caught in one haul.

IV. Researches in the Trondhjem Fiord 1898—99.

By **Knut Dahl**.

The researches commenced in March 1898. The features of the life-history of the fishes which have been chiefly studied are the occurrence of

- a) Spawning fish,
- b) Pelagic spawn and fry,
- c) Young fish.

a. The occurrence of spawning fish.

This first subject is very difficult to deal with so long as one cannot be satisfied with the mere statement that a particular species of

fish has been observed spawning in a certain place, but also desires information as to the number of spawning fish.

It is impossible to obtain any accurate idea of this, and one is, therefore, placed under the necessity of forming an estimate based upon the yield of the fisheries in the spawning-time, together with ones own observations of the spawning.

The conditions for making any estimate are particularly favourable when one can procure a statistical report on the fisheries, but such is not to be had, or, in any case, reports concerning the Trondhjem Fiord, are few, or wanting, and therefore the picture of the spawning there has to be drawn, partly from ones own observations of the spawning, and, partly, from observations of the fishery in general at the spawning-time.

It then appears that it is chiefly towards April that the spawning of the commonest edible fish of the fiord takes place.

With certain species this spawning may be very important, and occur on a large scale. Thus it was observed, in March 1898, that fishing in the Borgen Fiord, for instance, with a 300 hook line yielded more than 100 cod; on 400 hooks 170 cod, a circumstance, indicating the presence of great quantities of cod.

All through the spring, too, the fishermen catch very many cod, and in a certain locality, at Verran in the Beitstad Fiord, there is an annual, time-old cod fishery, where, regularly, considerable quantities of large spawning cod are caught. The yield generally amounts to several ten — thousands and is estimated, for instance, by *Schmidt-Nilsen* in an account of the Beitstad Fiord, at 40,000 cod and coal-fish in the year 1894.

As will be seen from this, the spawning of the cod, even in the inmost parts of the fiord, appears to be very considerable.

At that season, also, an annual haddock fishery is carried on almost everywhere along the shores of the fiord, when these fish, as the people there say «frequent the shallows» to spawn.

The apparatus used in fishing are nets, which, in some places, as for instance in the narrow waters of the Skarn Sound, are fastened to wedges of wood driven into crevasses of the cliff, and from which the net is laid, almost perpendicularly, out towards the deep.

The haddock are nearly all large, with fully developed sexual organs.

Along with the haddock are great quantities of pollack, whose ovaries likewise are in a very advanced stage of development, or entirely developed.

Adult green-cod are caught throughout almost the entire year in various parts of the fiord. During the great cod-fishery at Verran, and in Skarn Sound, it is caught along with the cod, and, according to what is stated by the fishermen, it has matured roe rather earlier than the cod. We, ourselves, have not observed it spawning.

The whiting, with sexual organs developed, is also caught in the spring at about the same time as other species of gadoids.

Besides these, I have found the various species of flounders generally spawning. *Pleuronectes platessa* which, however, does not occur in great numbers, spawns chiefly in April. *Pl. flesus* is likewise observed spawning about April, and is then found to be exceedingly abundant off the mouths of rivers, where from the fresher water it moves out towards the salter water. *Pl. limanda* and *Pl. microcephalus* are species which spawn in the summer, and are found everywhere, with matured sexual organs, from early in June to the end of July. In addition to these species, which must be said to be the most important edible spawning fishes observed in the fiord, all of which, as it is known, have pelagic spawn, I have also observed the following fishes either spawning, or with greatly developed sexual organs:

With pelagic spawn.

?*	<i>Labrus rupestris</i>	June—August
	<i>Callionymus lyra</i>	June
	— <i>maculatus</i>	—

With demersel spawn (or viviparous).

	<i>Zoarces viviparus</i>	November
	<i>Gobius minutus</i>	May—June
	— <i>Ruthensparri</i>	—»—
	<i>Nerophis ophidion</i>	June
	— <i>lumbriciformis</i>	—
	— <i>equoreus</i>	July
	<i>Siphonostoma Typhle</i>	May—June
	<i>Gasterosteus aculeatus</i>	June

Spinachia vulgaris	June—July
Cyclopterus lumpus	March—April
(also observed with fully developed roe in August)	
Cottus scorpius	March
Clupea harengus	April
?* Ammodytes lanceolotus	July

b. The occurrence of pelagic spawn and young.

The first researches into the occurrence of pelagic spawn were made in the beginning of March 1898. Several localities, between the city of Trondhjem and Stenkjær, were then fished with a pelagic net, and the only spawn found was that of cod, plaice, and flounders, in very small quantities. No spawning worth mentioning had, up to that time, occurred.

Later on in the spring, the occurrence of spawn was investigated. Thus, during an expedition undertaken on the 20th of April, from Trondhjem to the Beitstad Fiord, where horizontal hauls were made on the surface at 12 Stations, it appeared that, a comparatively great quantity of spawn was spread over the surface of the fiord.

The amount seemed to be greatest in the inner parts of the fiord.

The number of species was very considerable, and the species in some instances could not always be determined. The most conspicuous were: the cod, green-cod, pollack, haddock, whiting, plaice and flounder.

In the spring of 1899, as well as of late, the taking of spawn has been carried on.

Thus, in the last days of May 1899, I found at Skarn Sound, an abundance of spawn, chiefly that of the cod family.

By towing a pelagic net for ten minutes along side the boat, while sailing at a speed of about 2 knots, up to about 1 cc. spawn a haul could be taken. In no part of the fiord could great quantities of spawn be obtained by vertical hauls. A vertical haul most often yielded but few, from a couple, up to a dozen or two of ova. The greatest number of ova was obtained by skimming the surface-water in such a way that only half the ring of the pelagic net was kept in the water, and

*) «?» denotes a doubt as to whether the spawn of this fish is pelagic or demersel.

large quantities of spawn could not be observed deeper down in the water.

All attempts made to enquire into this circumstance have shewn that, it is the surface, and its immediate neighbourhood, which, in the fiord, is the layer which holds the spawn.

While thus the ova could be obtained without difficulty, it was soon perceptible, that most of the ova were in the earliest stages of development, the later stages being more sparingly represented, and that, practically, no *larvæ* were to be found in my samples.

Even as late as in the latter end of May 1899, this condition was found unaltered.

One supposition, viz., that they might be found at a greater depth than the ova, cannot be confirmed from the trials made by us, either with the pelagic net, or even with Dr. Petersen's trawl, with a bag of silk gauze and bobbinet which was used at various depths down to about 10 fathoms.

All attempts in this respect met with negative results. The *larvæ* of the ova that floated near the surface, were not, except in one or two instances, found in the fiord. Neither were any of the pelagic young of the spawning fishes that spawn in the fiord to be met with in the fiord.

Out on the sea-coast, by the belt of islands, we had occasion to observe pelagic young of gadoids amongst other plankton in the stomachs of coal-fish.

c. Investigations concerning Fry.

Extensive investigations were undertaken concerning the occurrence of fish in the littoral region, and especially concerning the occurrence of fry.

Somewhat more than 1000 hauls were made with the various nets described in Chapter II.

The eel-hand-seine was chiefly employed, as well as the fine meshed fry-nets already mentioned as well as a small tulle net which will be described below.

Fishing commenced in March 1898, when the shallow waters, in several places between Trondhjem and Stenkjær, were searched with an eel-ground-seine, thus at Tautra, Strømmen (Inderøen) Borgen Fiord, Stenkjær.

From the results of these trials, it appeared, that the year old fry of the cod, pollack, plaice and flounder existed in most places, though in no great numbers.

Thus at Tautra the result of several days' fishing yielded but a couple of a small cod about 12 cm. in length, besides some gobies and common needle-fish, and a single yearling of a flounder.

At Strømmen on the 7th March there were caught, for instance, during one day's close fishing in the bays about the entrance to «Strømmen» in all:

39 Plaice (33 of 5.5 to 10 cms. in length, 6 from 14 to 22.5 cms.)

3 *Pl. limanda*, about 6 cms.

32 Flounders (*Pl. flesus*) 7 to 38 cms. (the biggest very nearly matured)

1 Turbot (*Rhombus maximus*) 33 cms.

1 Cod 7.5 cms.

2 *Spinachia vulg.*

Some *Nerophis ophidion*.

• *Siphonostoma typhle*.

1 *Cottus scorpius*.

4 Trout, 32 to 35 cms.

Some *Crangon vulgaris*.

In the Borgen Fiord the shore region exhibited a great dearth of fish.

The result of a whole day's fishing yielded only a few needle-fish, cottus, and gobies, as well as a few small flounders and pollack from 10—15 cms. in length. At Stenkjær considerably more fish were obtained than at Strømmen.

Thus we caught in some dozen hauls, about 30 cod-fish from 7 to 34 cms. besides a number of the same species of flounders and other fish as we obtained at Strømmen.

In the Ilsvigen at Trondhjem on the 17th March, quantities of year-old fry of the cod, pollack and whiting, were found, besides which, but quite sparingly, year-old fry of various flounders, as well as the ordinary bottom-fishes of the fiord, such as Turbot, *Centronotus gunnellus*, *Spinachia vulgaris*, *Agonus cataphractus*, needle-fishes, and gobies. Besides these there were some tobis (*Ammodytes lanceolatus*), and a couple of rare fish, viz., 1 *Nerophis æquoreus*, and 1 *Zeugopterus punctatus*, measuring 6 cms. in length.

In addition to this, there were likewise found a great number of the larger stages of cod, coal-fish, pollack, haddock, ling and various flounders, of which spawning flounders were particularly numerous.

As the principal result of these preliminary researches, it appeared, as regards the young stages of edible fishes, that the one year old fry of most of the species, occurred in the littoralregion of the inner parts of the fiord; still the occurrence seemed to be very small, especially in respect to the flat-fishes.

Later on in the spring and summer, a great many hauls were made with the eel-net in order to study, more closely, the occurrence of this yearling fry, and also to ascertain where, and when the fry, that would develop from the ova spawned in the spring, would be found.

From early in May, to the last days of August the entire fiord was subjected to researches in a great many localities, from the sea-coast itself, to the inmost parts of the fiord.

From May, to the beginning of July, fishing was carried on towards the mouth of the fiord, from Orkedals Fiord, and Gulosen, to Lensvigen, Rissen, Selven, Bejan, Storfosen and Bjugn Fjord. The many hauls made in the Orkedals Fiord, and at Gulosen, shewed no essential difference, in respect to the fry, from the hauls previously made in the spring. It was ascertained that the occurrence of year-old fry of cod, pollack, coal-fish and haddock was about the same.

Fry of plaice and *pl. limanda* were very sparingly represented, very rarely more than 1 or 2 specimens in a haul, generally none.

The following extract from the journal will show the results of exceedingly good hauls:

8th June 1898. *Børsen* (Gulosen near Trondhjem).

- 1) Lundene, sea-wrack, sea-weed, gravel:
 - 1 *Pl. microcoephalus*, about 35 cms.
 - 3 Small *pl. flesus*, about 12 to 15 cms.
 - 6 Cod, 15 to 25 cms.
 - 1 Coal-fish, 15 to 20 cms.
 - 4 Pollack, 15 to 20 cms.
 - 1 *Calliomymus lyra*.
 - 2 *Labrus rupestris* (matured).
Gobius ruthensparrii.

2) Same locality:

- 1 *Pl. microcephalus*, about 30 cms
- 1 *Pl. limanda*, about 25 cms.
- 1 Cod, 15 cms.
- 1 *Labrus rupestris* (mature)
- 1 Small *pl. flesus*.

3) Same locality:

- 11 Cod, 17 to 25 cms.
- 1 Pollack, 13 to 15 cms.
- 2 *Labrus rup.* (mature).
- 1 *Lophius pisc.*, about 70 cm. (with rather big testes; in the stomach, 1 *pl. flesus* of about 25 cms. in length).

4) Vikan:

- 12 *Labrus rup.*
- 13 Pollack, 17 to 25 cms.
- 2 Cod, about 18 cms.
- 1 Small *pl. microcephalus*, 12 to 13 cms.
- 1 *Cottus scorpius*.

Some time ago, a half cran of herrings was obtained in the bay with a seine.

5) Elisløkken: sea-wrack, sea-weed, gravel, clay and stones.

- 2 Trout fry, about 15 cms.
Siphonostoma typhle.
- 1 Plaice, about 25 cms.
- 1 *Pl. limanda*, about 30 cms.
- 6 Pollack, 12 to 15 cms.
- 2 Cod, 20 cms.
- Gobies.

During the greater part of May, and the beginning of June, fishing was carried on in both these fiords, and during the whole of that time we obtained but a single, small, coal-fish of the year-old fry, measuring 4 cms. in length.

At Lensvigen, Rissen, Selvigen and Bejan (Ørlandet),* where from the 18th June to the 1st July a great number of hauls were made, there occurred, chiefly year-old fry of codfish, coal-fish, pollack, whiting and haddock, and, very sparingly, fry one year old of plaice, flounders and sand-flounders.

*) All these localities are in the exterior part of the Fiord.

I here append, as examples, some of the best hauls.

21th June 1898. *Outer Lensvigen.*

- 4 Hauls with an eel-net:
- 8 Trout, 13 to 29.5 cms.
 - 53 Cod, 13 to 26 cms.
one specimen, 68 cms.
 - 39 Whiting, 12.5 to 24.5 cms.
 - 20 Pollack, 12 to 32 cms.
 - 7 Coal-fish, 19 to 25 cms.
 - 3 *Zoarces*, 23 to 26 cms.
 - 1 *Pl. microcephalus*, 38 cms.
 - 1 *Pl. platessa*, 12.5 cms.
 - 1 *Centronotus gunnellus*, 18 cms.
 - 1 *Pl. flesus*, 12 cms.
 - 15 *Labrus rup.*

Inner Lensvigen.

- 4 Hauls with an eel-net:
- 1 Trout, 17 cms.
 - 2 *Ammodytes*, 23 to 23.5 cms.
 - 2 *Centronotus gunnellus*, 19.5 to 20 cms.
 - 1 Halibut, 40.5 cms.
 - 4 *Pl. platessa*, 10—47 cms.
 - 5 *Pl. limanda*, 15 to 30 cms.

24th June 1898. *Langsæter Bay.*

- One Haul with an eel-net at Rissen:
- 8 *Pl. limanda*, some of exceptional size
 - 2 *Pl. microcephalus*
 - 25 Whiting, about 20 cms.
 - 28 Cod, 15 to 45 cms.
 - 12 *Labrus rup.* (nearly mature)
 - 1 *Callionymus sp.?*
 - 2 Coal-fish, 6 cms.

27th June 1898. *Selven (Eel-net).*

- 1) At the bottom of the bay, sands:
- 3 *Pl. platessa*, 15 to 25 cms.

- 13 Cod, 17 to 25 cms.
3 *Pl. limanda* (small).
- 2) Further up on the sandy shallows:
18 *Pl. platessa*, 15 to 30 cms.
3 *Pl. limanda*, 30 to 35 cms.
12 Cod, 20 to 30 cms.
2 Haddock, about 25 cms.
Cottus scorpius.
3 *Pl. flesus*.
- 3) On the south east side:
81 Cod, 15 to 25 cms.
3 Haddock, 25 cms.
2 Pollack, 25 cms.
2 *Pl. microcephalus* (large)
1 *Pl. platessa* (large)
1 *Pl. limanda*.
1 *Pl. flesus*.
Gobius ruthensparrii.
2 Trout.
1 *Chrystallogobius Nilsonii*
Pandalus annulicornis.

28th June 1898. *Bejan* (Ørlandet).

2 Hauls with an eel-net in the harbour, and in Gartsound (Sea-bottom: tangle, green algæ, laminaries, lithotamnies and decayed shells) yielded:

- 70 Cod, 15 to 39 cms.
(1 very minute, 5 cms., year-old fry)
10 Coal-fish, 5 to 23 cms.
3 *Zoarces*, about 36 cms.
1 *Pl. platessa*, 21 cms.
2 *Pl. limanda*, about 20 cms.

It will be seen that the results of this fishing shewed no essential deviation from those obtained in the inner part of the fiord, respecting the year-old fry, or, more correctly, the then little more than year-old fry. Meanwhile, far up the fiord, at Lensvigen and Rissen, I had ob-

tained a few coal-fish of 6 cms. in length, which were preserved as rarities. Out at Bejan, this appearance of yearling fry commenced to assume large dimensions. The small green-cod there, and which were not only 6 cms. in length, but still much smaller, down even to 3 to 4 cms. in length, commenced to be common in the eel-nets. At the same time, we began, also, to catch a few specimens of that years' cod, from 4 to 5 cms. in length.

During the following period, from the 1st to 4th of July, I made many investigations, on the inner side of the island called Storfosen, into both the occurrence of year-old fry, as well as that of the fry of the preceding year.

Hauls with the eel-net along the shore then showed that, the number of green-cod fry of that year exceeded, by far, that of fishes a year older. Upon the wide, sandy beaches; bordered, on the outside, by belts of *Chorda filum*, and large algæ, 100 to 200 of the infant fry of the coal-fish, of 3 to 10 cms. in length, could be caught in one haul.

Amongst these were also some cod from 4 to 5 cms., also that year's fry.

In the quite short Bjugn Fiord, on the 4th and 6th of July, the same conditions of the fry as at Storfosen were apparent, in as much as buckets full of coal-fish fry, of 3—4 cms. in length, could be caught in a haul, along with lesser quantities of quite small codfry, of 4 to 6 cms., as well as a few haddock of about 4 cms. in length.

The fry, too, in many places could be observed in large shoals, swimming about in the *Chorda* and laminaries, on the shallows and rocks. The occurrence of the quite small bottom-stages of flat-fish could not be studied by means of the eel-seines, and a small trawl was therefore made, $\frac{3}{4}$ of a fathom in width. The material consisted of embroidery tulle, with about the same width of mesh as already illustrated in Chapter II. By the aid of this, on the sands of Storfosen, and also about the isle of Garten, a scanty occurrence of the earliest bottom-stages of plaice and flounders was observed. It being then decided that the fry of that year had appeared on the shore region, we sailed up the fiord, where the entire month of July, and a part of August, were spent in studying the occurrence of yearling fry.

The following localities were examined: Rissen, Taura, Frosten, Aasen Fiord, Holsanden, Levanger, Strømmen, Borgen Fiord, Beitstad

Fiord. As regards the roundfishes, eel-seines were used, and from 100 to 200 hauls were made, which yielded the astonishing result that, while the occurrence of fry from last year could be observed throughout, naturally in varying numbers, the yearling cod, coal-fish, pollack, haddock, and other fish, were not identified except in quite a few instances.

Thus during all this time, no more than 2 to 3 cod, and about 4 coal-fish were caught, while of fry of the preceding year, for instance, up to 100 specimens of the cod, could be obtained in one especially good haul.

The occurrence of flat fish was studied, partly by means of the eel-seine, and, partly, by means of the small tulle trawl, which was used in all shallow waters, with a sandy bottom, where the occurrence of fry might be expected.

The result was the same as that respecting the roundfish, viz., that yearlings could not be observed in numbers worth mentioning.

Thus the yield of these many hauls was but a single specimen of young plaice, measuring 6 cms. in length, which unquestionably could be described as that year's fry, while young of the preceding year, as before, were to be had in limited numbers.

Young of the more common bottomfish, which deposit their spawn on the sea-bottom, as the gobies (*gobus minutus*), *spinachia vulgaris*, *cyclopterus lumpus* and the common needle-fish, were met with in large, and, occasionally, enormous numbers everywhere where shallow water was to be found.

The young of the herring (6 cms. in length) could, in some places, be caught in great numbers.

The principal result arrived at was, that the fry of fishes with pelagic spawn could not be observed to any appreciable extent.

On the other hand, on a cruise which was thereupon taken to Helgeland, and Nordland, in the latter part of August, and the beginning of September, yearling fry were met with in great numbers. Different localities about Lekø, Vig, Torget, Brønø and Svolvær all out at the open sea were searched with the eel-seine. Fry of cod as well as coal-fish, haddock, pollack and whiting could be captured almost anywhere in large numbers, thus for instance at:

Skjeidshavn, Lekø, 30th August 1898.

One Haul to the shore with an eel-seine across sands, stones and laminaries yielded:

- 1 Pl. platessa, 20 to 60 cms.
- 1 » limanda, about 25 cms.
- 1 *Small halibut*, about 8 cms.
- More than 100 coal-fish fry, 8 to 13 cms.
- about 100 cod, 6 to 10 cms.
- Some whittings, 9 to 10 cms.
- 5—6 Haddocks, 10 to 13 cms.

Vik, in Nordland, 3rd September 1898.

5 Hauls with an eel-seine on the beach, over a bottom of very fine sand, yielded:

- About 1 doz. Pl. platessa, 60 to 30 to 20 cms.
- Some Pl. limanda.
- Some » microcephalus.
- 2 *young halibut*, 6 to 8 cms.
- 2—300 cod, 6 to 10 cms.
- »— coal-fish, 7 to 13 cms.
- Many pollack, 5 to 6 cms.

The fry were, moreover, so numerous, that, in many places, they could be clearly seen in great shoals which filled the water in the shallow places between the laminaries, and *Chorda filum*.

Later on in the *autumn*, some trials with the eel-seine were made in the Trondhjem Fjord. It then appeared that the cod fry of that year was to be met with in the Ilsvigen near Trondhjem.

On the 11th October 1898, there were thus caught in 4 hauls of an eel-net:

- 9 Trout, 20 to 30 cms.
- 56 Cod, 9 to 60 cms, (chiefly of that year's fry).
- Some Haddock of that year, about 14 cms.
 - » *Centronotus gunnellus*.
 - » *Labrus rupestris*.
- Syngnates, as usual.

Cottus scorpius.

2 *Lophius piscatorius*, 30 to 40 cms.

Gobius Ruthensparri.

— *minutus*.

Spinachia vulgaris.

1 minute *Pl. limanda*, 6 cms.

2 *Pl. microcephalus* (large).

1 *Zoarces*.

On the 16th November, year-old cod fry was also to be found at Strømmen, Inderøen, though in small numbers.

During the course of the winter, the presence of yearlings at Trondhjem was also ascertained, but no more than about 10 to 20 could be caught in a haul, generally far less.

As regards some species, the occurrence of yearlings was not observed until after Christmas — that of the plaice for instance. Some species, for instance the pollack, could not be observed in any appreciable numbers, as yearlings, even in the spring time, 1899.

During the summer, of 1899 a series of fishing trials were carried out partly with the eel-net, partly with the fine meshed fry-net mentioned on page 53, without any results being attained which deviated, to any great extent, from the results of the investigations in 1898.

The fry which was observed in the autumn and winter, and which in March and April became «yearlings», or fry between one and two years of age, could still be found present, just as recorded from the preceding year's researches.

As early as the middle of June, a rare occurrence of coal-fish fry, from 2.8 to 4.7 cms. in length, was discovered by means of the fine-meshed net at Garten (near Ørlandet), while previous trials, as well as those made immediately afterwards in the inner part of the fiord, did not result in the capture of even one young specimen of an edible fish.

Later on in the summer, trials with the eel-seine in the same parts at Storfosen, resulted in the capture of a similar abundance of coal-fish fry as in the preceding year, while the attempts in the inner fiord yielded, practically, the same results as before.

In August (31st) 3 hauls with an eel-net in the Ilsvigen thus yielded:

19 Whiting, 10 to 13 cms.

7 Cod, 4 specimens from 24.5 to 39 cms., 3 from 9 to 10 cms.

- 3 Pollack, 22 to 30 cms.
- 1 Pl. microcephalus.
- 1 » flesus.
- 1 Agonus cataphractus.
- 2 Zoarces viviparus.
- 4 Spinachia.
- Some Siphonostoma Typhle.
- 1 Nerophis aequoreus.
 - « Ruthensparrii.
- 219 Labrus rupestris, 9 to 18 cms.

In the Beitstad Fiord, during the last days of September, a scanty occurrence of cod fry of that year was ascertained by means of the fine-meshed fry-seine: thus 11 hauls, from the 24th to the 28th of September, at Waade, Bortnæs and Stenkjær, yielded 46 small cod, of a size averaging about 10 cms. (from 8 to 12 cms., some few slightly less).

In the Ilsvigen, at Trondhjem, on October 10th, 10 hauls with an eel-seine, and fine meshed fry-seine, yielded but 22 cod from 9,5 to 14 cms. (that year's fry).

On November 11th, after heavy gales from the West and North-west, 8 hauls with the same apparatus yielded 87 yearlings of cod from 9 to 16 cms. in length, besides a number of older fish.

Chapter IV.

The Deep Sea Fauna in the Fiords that have been Investigated.

By **Johan Hjort.**

In the years 1897 and 1898, a great number of hauls in deep water, at depths varying from 5 to 250 fathoms, were carried out with the trawl constructed by Dr. Petersen. The object of these trials was a special one, namely to settle the question respecting the vertical distribution of the fry of fishes. I certainly started with the prevailing theory that the fry of edible fishes only occur in the upper layers in the littoral zone, but the fact that I, inside the fiords, could not find the fry, caused me to search for it even in places where I did not expect to find it. The result arrived at from all the hauls, between 400 and 500 in all, led to the complete confirmation of the general supposition, in one way, as we only succeeded in catching, in deep water, the quite young stadia of the following fishes.

1. *Myxine glutinosa.*

Up to the present I have obtained 23 eggs, taken, at various seasons of the year, between November and May. All were caught in shrimp trawls (see below), in bunches, containing 3 to 13 eggs in a bunch at a depth varying from 50 to 60 fathoms on an oozy bottom.

All the eggs were in so early a stage of development that, from the investigations I have made from time to time, I have not been able to decide whether fecundation had taken place or not. Young individuals,

down to 10—11 centimetres in length, are not uncommonly met with on the bare bottom at Drøbak.

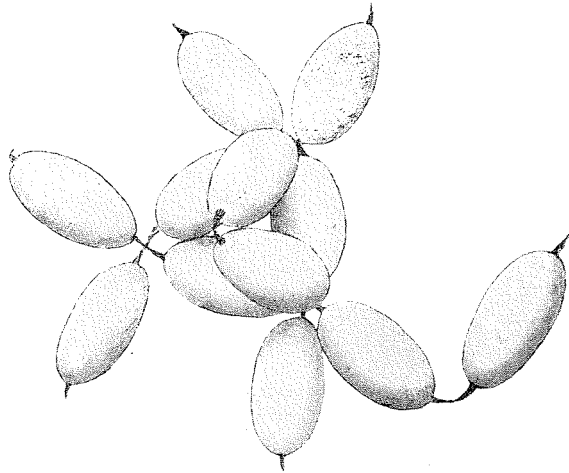


Fig. 17. A bunch of eggs of *Myxine*, found in May 1899. The bunch originally consisted of 13 eggs, but only those pictured now remain adhering.

2. *Chimaera monstrosa*.

In January, three specimens were obtained from a great depth (100 fathoms) in the Trondhjem Fiord, measuring, respectively, 15, 18 and 34 cms. (these measurements include the long tail).

3. *Spinax niger*.

Pregnant females are found at all times of the year at a depth of 100 fathoms off Drøbak. In January 1899, many newly born young were taken at a depth of 100 fathoms in the Trondhjem Fiord.

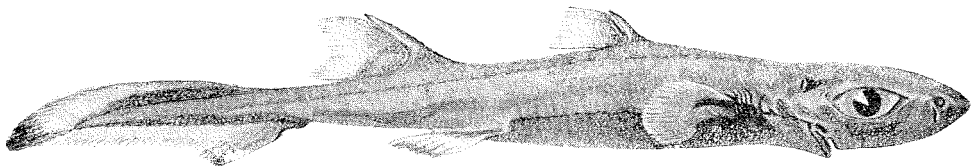


Fig. 18. Newborn *Spinax niger*, caught in a trawl at a depth of 100 fathoms in the Trondhjem Fiord. Natural size.

4. *Raja radiata*, and
5. *Raja clavata*.

Eggs, and young of these species are not uncommonly found.

Not quite uncommon, but, nevertheless, far more rare than adult specimens, were early stages of

6. *Pleuronectes cynoglossus*, and
7. *Drepanopsetta platessoides*.

Of the first, specimens between 4 and 5 cms. in length have been met with singly.

Of edible fishes' fry, only old stadia were found at a depth, for instance, of 50 fathoms. Thus in October, 10 successive hauls of the trawl in the Brevik Fiord yielded

20 *Gadus merlangus* from 16 to 33 cms. in length
30 « *eglefinus* « 19 « 25 « « «

of *Gadus callarias*, only still larger specimens have been observed at so great a depth.

I am doubtful as to whether I can, from the results of my hauls of the trawl, determine that the fry of edible fishes does not also occur in the middle of the water in our fiords. It appears to me to be reasonable to assume that the trawl, when being hove in, would catch, in any case, some of the small fry, provided such had been present in any appreciable numbers. I have all the more reason for assuming this, as the trawl employed in Denmark in eel fishing is able to catch even large cod, and, on the west coast of Norway, small cod, and coal fish are caught in round nets or catchers, whose opening is less than that of the trawl employed. I subsequently made such large nets, but as yet have not had an opportunity of using them, and hope to be able to return to that question in a subsequent work.

With the results of the last German «Valdivia Expedition» before us, one may on the other side doubt whether all crustaceans are caught at the bottom.

When thus up to 20 specimens of *Crangon vulgaris* have been caught in one day at a depth of 50 fathoms, it makes one doubtful.

From the above mentioned reasons I conclude, on the whole, that my numerous *trials with the trawl* have proved that, the fry of edible fishes in *our fiords* is not to be met with *in deep water*, or in the *middle of the water*.

Besides this result, my trawling trials yielded me no inconsiderable quantities of the oozy bottom's fauna, as well as a few results of economic importance which I shall deal with in the following pages.

The material of the fiords deep water fauna in my possession, certainly far exceeds in quantity the amount other zoologists have had at their disposal, thanks to the admirable trawl. The work of thoroughly examining and studying all this material has, however, in many respects, been more or less impossible. As the only zoologist on board, and being occupied in manoeuvring the vessel, and with the biological problems, I had, unfortunately, not an opportunity of entering into as many and interesting details as might have been desirable.

In arriving at my conclusions I have received much valuable assistance from Messrs. G. O. Sars; R. Collett; K. Dahl; and A. Wollebæk.

The following account of the fauna makes no pretence of being exhaustive or complete, but it will, probably, give a good general view of the most striking features of animal life in the deep fiords, and include the commonest — and therefore, probably, the most characteristic forms. It will, moreover, be noticed that none of the exceptionally small forms will be found on the list. One will thus miss very small gastropods, and amphipods, partly owing to their having escaped, as a rule, through the meshes, and, partly, because when they came up with the mud it required far too great labour, in proportion to the time at my disposal, to preserve them. Therefore, especially as regards these forms, no conclusion can be drawn concerning their non-appearance. As an example of the contents of a catch from a typical fiord-locality, the joint yield of two hauls of the trawl, at a depth of 50 fathoms, near Drøbak is appended here.

*The Christiania Fiord, inside Drøbak; 50 Fathoms; Two Hauls;
7th September 1897:*

Geodia Baretii, numerous.
Bolocera longicornis, numerous.
Numerous worm tubes, and
Aphrodite aculeata.
Astropecten Andromeda, common.
Cribrella sanguinolenta.
Goniaster granulæ.
Ophioglypha Sarsii, numerous.
Stichopus tremulus «
Oligotrochus vitreus.
Pecten septemradiatus.
» abyssorum.
Astarte sulcata.
Macoma calcarea } only dead shells.
Isocardia cor }
Abra longicallis.
Antalis striolata.
Scaphander punctostriatus.
Rossia macrosoma, 3 specimens.
Pandalus borealis, some litres.
» annulicornis.
Pontophilus norvegicus.
Crangon vulgaris, 1 specimen.
* Pasiphae tarda.
Hippolyte securifrons.
» polaris.
Munida rugosa.
Lithodes maja.

1 Chimaera monstrosa.
2 Argentina sphyraena.
3 Gadus poutassou.
9 « argenteus.

- 2 Gadus Esmarkii.
- 2 « callarias (large).
- 1 « æglefinus.
- 1 Lycodes gracilis.
- 1 Merlucius vulgaris.
- 1 Pleuronectes microcephalus.
- 9 « cynoglossus.
- 11 Drepanopsetta plattessoides.

If one gathers from all the hauls, the most important forms found on the oozy bottom in the waters that have been investigated we get the following list:

Animals from the muddy bottom (50—100 fathoms) of the Christiania Fiord and adjacent waters as, for instance, the northern part of the Skagerrak, the Brevik Fiord, and other smaller Fiords.

Foraminifera, vide H. Kjær's Paper (Nr. 7 of the present work).

Coelenterata.

Geodia Baretti. and different species of the Genus Reniera.	Common, especially in the inner part of the Fiord.
Bolocera longicornis.	Very common, for instance, at Drøbak.
Actinostula callosa.	

Echinodermata.

Asterias rubens.	Very common.
Astropecten Andromeda.	—>—
Cribrella sanguinolenta.	
Goniaster granulare.	
Astrogonium phrygianum.	
Ophioglypha Sarsii.	Very common.
Ophiopholis aculeata.	
Ophiothrix fragilis.	
Amphidetus cordatus.	
Brissopsis lyrifera.	
Stichopus tremulus.	Very common.
Mesothuria intestinalis.	
Oligotrochus vitreus.	

Mollusca.

<i>Pecten septemradiatus</i>	Very common, 50 to 60 fathoms.
" <i>abyssorum</i>	50 to 100 fathoms.
" <i>similis</i>	— " —
<i>Mytilus phaseolinus</i>	On dead <i>Oculina</i> Banks, 50 fathoms.
<i>Nucula tumidula</i>	50 fathoms, Steilene.
" <i>tenuis</i>	100 " Bolærne.
" <i>nitida</i>	— " —
<i>Leda pernula</i>	Drebak, below 30 fathoms.
<i>Arca pectunculoides</i>	" 100 "
<i>Cardium minimum</i>	" 50 "
<i>Cyprina islandica</i>	Only dead specimens.
<i>Isocardia cor</i>	— " — One living, from shallower water.
<i>Astarte sulcata</i>	Drebak, 50 fathoms. Very common.
" <i>compressa</i>	" 100 "
<i>Axinus flexuosus</i>	Bolærne, 100 "
" <i>croulinensis</i>	Drebak, 50 "
<i>Abra longicallis</i>	Bolærne, 100 " Drebak, very common
" <i>nitida</i>	Steilene, 50 "
<i>Macoma calcarea</i>	Living only in the inner part of the Fiord. Only 5 living specimens caught in the Bunde Fiord.
<i>Ncaera obesa</i>	Drebak, 50 to 60 fathoms.
" <i>rostrata</i>	" 25 to 100 "
" <i>abbreviata</i>	" 50 to 60 "
<i>Corbula gibba</i>	" — " — "
<i>Saxicava pholadis</i>	" — " — "
<i>Antalis striolata</i>	Bolærne, 100 fathoms.
<i>Siphonentalis tetragona</i>	Drebak, 50 fathoms, common.
<i>Velutella flexilis</i>	— " — — " —
<i>Lunatia groenlandica</i>	— " — — " —
<i>Bela trevellyana</i>	— " — — " —
<i>Buccinum undatum</i>	Lysakerfiord, 30 fathoms.
<i>Scaphander punctostriatus</i>	100 to 50 fathoms.
<i>Octopus Bairdii</i>	Bolærne, 100 fathoms.
<i>Rossia glaucopsis</i>	Several specimens, 50 to 100 fathoms.
" <i>macrosoma</i>	Common — " —
<i>Sepiola Rondelettii</i>	" — " —

Crustacea.

<i>Calanus Finmarchicus</i>	} In great quantities in hauls, with fine meshed trawls, from 50 to 100 fathoms.
" <i>hyperboreus</i>	
<i>Metridia longa</i>	
<i>Euchaeta Norvegica</i>	
<i>Boreomysis tridens</i>	
<i>Nyctiphanes Norvegica</i>	} Christiania Fiord, in different localities.
<i>Pasiphaë tarda</i>		Trondhjem Fiord, 225 fathoms.

Pandalus leptorhynchus	3 Specimens, Brevik Fiord.
" borealis	Very common on the mud line.
" annulicornis	— " —
Hippolyte securifrons	— " —
" polaris	— " —
Sabinea Sarsii	Brevik Fiord, 50 to 60 fathoms.
Cheraphilus eelunulatus	— " —
Pontophilus spinosus	— " —
" Norvegicus	Very common on the mud line.
Crangon Almanni	— " —
" vulgaris	Found in the Brevik Fiord in hauls from 50 to 60 fathoms.
Nephrops Norvegicus	Drøbak, Brevik Fiord, Larvik Fiord, 60- to 70 fathoms: Trondhjem Fiord, 100 fathoms.
Calocaris Macandreae	
Munida rugosa	Very common, 25 to 70 fathoms.
" Rondeletti	Brevik Fiord, 50 to 60 "
Eupagurus Bernhardus	} Drøbak, Brevik Fiord, 50 to 100 fathoms.
" pubescens	
Lithodes Maja	Very common, 20 to 70 fathoms.
Portunus depurator	Brevik Fiord, 50 to 60 "
Geryon tridens	Bunde Fiord, 80 fathoms.
	Beitstad " 80 "

Pisces.

Myxine glutinosa	Very common on the mud-line, at depths from 10 fathoms.
Raja radiata	Common.
" clavata	— " —
Spinax niger	On long-lines at Drøbak, 100 fathoms.
Seymnus microcephalus	Common in the Bunde Fiord, and, occa- sionally, taken at Drøbak on lines. Specimens, 9 feet in length, living at depths from 30 to 70 fathoms.
Chimaera monstrosa	On long lines at Drøbak, 100 fathoms. Caught in trawl in the Trondhjem Fiord, and Drøbak, in different stages.
Argentina silus	Drøbak.
" sphyraena	Drøbak, and Brevik Fiord.
Scopelus Müllerii	1 specimen from Drøbak, 50 to 60 fathoms.
Pleuronectes cynoglossus	Very common from 20 fathoms. Espe- cially plentiful in the Brevik Fiord. All stages.
Drepanopsetta platessoides	In all stages on the mud line.
Coryphænoideis rupestris	2 specimens in trawl, from 120 fathoms in Skagerrak (14 miles off the Brevik Fiord). Often caught there in great quantities on the long-lines.
Motella cimbria	Brevik Fiord, 50 to 60 fathoms.
Molva vulgaris	— " —
Merluccius vulgaris	— " —

Gadus poutassou	}	Common at Drøbak, and the inner part of the Fiord. 50 to 60 fathoms.
„ Esmarkii		
„ minutus	}	See Chapters V, VI and VIII.
„ merlangus		
„ æglefinus		
„ callarias		
„ argenteus		
Lycodes Sarsii		Common in the Brevik Fiord, and at Drøbak, 50 to 60 fathoms.
„ gracilis		Several specimens from Drøbak, Brevik Fiord and the Skagerrak.
Icelus hamatus	}	Some few specimens from Drøbak, 50 to 60 fathoms.
Centridermichthys uncinatus		
Sebastes norvegicus		Drøbak, Skagerrak, 120 fathoms.

Everybody who knows anything about the Marine fauna of Northern Seas, will understand that the above list is far from complete. As previously mentioned, it is due to the conditions under which the work was carried on that it could not be better. I will, nevertheless, not omit shewing, in a few words, the light that may be thrown upon some pressing biological questions.

1. In studying the fauna of any certain locality, it appears to me important, above all, to discover what forms they are which, *during the whole period of their existence, live there, and which forms only, visit the locality for short lengths of time.*

It has astonished me greatly, how the occurrence in quantities of a species, even as regards the crustaceans, can vary excessively. During my trawling operations, *Nyctiphanes Norvegica* was, as a rule, rather rarely met with, but in May 1899, in the Brevik Fiord, it suddenly appeared in such vast quantities, that the small sloops which trawled for *Pandalus*, required crews of 6 men to haul in the trawl with tackles, and when the trawl was got on board, shoals of *Nyctiphanes* had to be shovelled over the side. Some months previously, the crew of my steamer had, at the same place, made between 300 and 400 hauls of the trawl without catching more than quite a few specimens of that species, which were, then, regarded by me as quite uncommon. This immigration *en masse* lasted for 14 days, after which the *Nyctiphanes* disappeared without leaving any traces of themselves behind, and again became a «rare species»

The phenomenon, which shews what great changes can take place in the occurrence of animals, even in deep water, resembles the advent of herrings, and is even still more remarkable if one assumes that the chief filling of the trawl took place while it was being hauled in. The fishermen themselves were of this opinion, as they said that the trawl could not reach the bottom where the *Pandalus* lay.

In respect to the *Pandalus* I have met with a similar experience, though not on so great a scale. My fishermen, who, on 36 days in succession, made about 8 hauls, daily, over exactly the same spot in the little Brevik Fiord, were astonished at the irregularity of the take, notwithstanding that the trawling operations were carried out with the greatest exactitude. They believed that these animals moved, partly, from one spot to another, and partly, up and down in the water, a circumstance which appears to me to be of so great interest that it requires further investigation. In the Drammen Fiord, where, from olden times, *Pandalus* has been fished for during various years, the fishermen say that there have been years in which the animals disappeared altogether, only to reappear, subsequently, in equally great numbers as formerly. It is my opinion that, from such experiences, one must conclude that, also in respect to most of the other deep sea organisms, variations in their occurrence may well be imagined, as certainly most of them have a short, or long lease of life, during which they can be carried away by the waters.

Just as we have already shewn, in respect to the fish-fauna of the seaweed zone, that there are local forms of animals, which, throughout their lives, belong to a confined locality, and a certain depth of water, so are we of the opinion that the deep water layers of the fiord possess fauna consisting of species which live there at all times.

To these species belong, mainly, *selachians* (*Spimax*, *Scymnus*, *Chimaera*, *Raja*) and *cottidae* (such as *Sebastes*, *Icelus*, *Centridermichthys*), further *Clupea* and possibly also *Argentina*. In addition to these forms, which all lay demersel eggs, or are viviparous, we find, too, at the bottom, a fauna of fishes, whose yearlings are, at all events, occasionally found there, and which, in any case, during the best part of their lives, so far as we can make out, live a very local existence. Amongst such forms may be named *Pleuronectes cynoglossus*, *Drepanopsetta platessoides*, *Gadus poutassou*, *Esmarkii*, *minutus*, *argenteus*, as well as *Lycodes*. These animals lay pelagic eggs, but the history of their lives is very little studied, and I therefore am not as yet

in a position to contribute anything towards the knowledge of their passage through life.

I do not know, for instance, in what layers their eggs float, where the bulk of the smallest fry live, and so on. In respect to the adults, I am, however, of the opinion that they move but little away.

In contrast to this group, stands, in my opinion that consisting of *Gadus callarias*, *merlangus* and *eglefinus*, which only belong to the deep water in the older stages of life, and which, besides, move in and out of the fiords with a certain periodical regularity (similar migrations, from and to the shallow waters of the fiords, take place amongst the herring, mackerel, salmon and other fishes). Of what nature these migrations are, whether they occur spontaneously, or whether the water layers convey the fish with them, it is, at present, difficult to express an opinion.

From the knowledge that has been already gained, however, it appears that strong south westerly gales have driven both herring and cod in towards the Christiania Fiord. We have also found yearling cod suddenly appear in the inner part of the fiord after heavy gales.

2. All those who have studied the Norwegian Fiords, have noticed a peculiar contrast between the inner and outer portions of the fiord. This contrast has partly consisted in there being a *greater wealth of fish off the sea coast*, partly in the forms being of a more marked southern origin than those from the *innermost parts of the fiord*, whose characteristics were more *arctic*. In an interesting, but not sufficiently known treatise «Some Remarks on the Character of the Marine Fauna on the Northern Shores of Norway» («Nogle bemærkninger om den marine faunas karakter ved Norges nordlige kyster») contained in the «Tromsø Museums Aarshefter» Bd. (Vol.) II, 1879, G. O. Sars says: «On our southerly and westerly coasts, and especially in the deep, inclosed fiords, a number of animal forms are also found which must be regarded as the surviving remnants of the fauna that once existed there. But these remnants, or as one might very well call them «aboriginies» are in those parts of quite a different character, as all of them prove to be of true arctic origin. They live there only at a very considerable depth, whilst the corresponding «aboriginies» of southern origin, on the eastern shores of North America, are chiefly littoral forms. In our arctic region, too, we will find a marked difference in the character of the

fauna out on the open sea shore, and that of the deep inclosed fiords. Whilst, as already stated, the fauna out by the outermost islands, and rocks, are much mixed with southerly forms, it usually occurs in the fiords with a more pure, high northerly or arctic stamp. It is not difficult to understand the cause of this, for, in the first place, the warm Atlantic Ocean current must be less perceptible than out on the seaboard, and, in the second place, the sea water at such spots must be considerably cooled by the severe winter temperature, and also, owing to the melting of the ice during the spring, be more mixed with fresh water, which, consequently, causes the physical conditions there, to resemble more those of the Polar seas. From this it will, moreover, be concluded, that the fiords, which are most inclosed, and most protected from the immediate influence of the sea, must be better suited to retain, unchanged, the original arctic elements in the fauna, than those fiords which lie nearer the sea, or have a wide mouth or entrance. This has also been completely confirmed by direct observations.»

During my deep water investigations, I have often had an opportunity of proving the truth of that which has been stated concerning the interesting conditions indicated in this treatise, but the relations are, in my opinion, considerably more complicated. It has, namely, appeared from the hydrographical investigations, that it is not solely the conditions of temperature that create the difference between the outer and inner parts of a fiord. Even if they themselves are of great consequence, I nevertheless think, that the peculiar movements of the currents in the fiord, the *stationary state* of the deep-water-layers in the narrow mountain ravines in which the waters of the fiord lie, are just as important incidents. As may be seen from the following paper in this volume, I have succeeded in proving that in such long fiords as the Christiania Fiord, there is a steady decrease in the amount of oxygen the farther one proceeds up the fiord, while the volume of oxygen drops to a mere minimum in the deep pools of the fiord (such as Bunde Fiord, Drammen Fiord), which are separated from the other deeps by reefs or bars.

In conformity with these conditions, it is of interest, that there is a gradual decrease of animal life in the deep portions of the inner fiord. Thus, whilst out on the coast, in the Langesund and Larvik Fiords (small open branches of the wide Skagerrak), it was possible to take up to 30 litres, deep sea shrimps (chiefly *Pandalus borealis*) in half an hour's

trawling with a trawl of 15 feet spread, at a depth of 50 fathoms, we did not succeed in getting more than 1, or 2 litres, in one haul, in a similar net, and at a like depth, in by Drøbak; while in at the head of the fiord (Bunde Fiord) we only caught a few specimens. Such conditions sufficiently shew that, even in places of a similar depth, and situated in the same latitude, the greatest biological differences may be present. The shape of the seabottom, and the resulting conditions affecting the circulation in the water layers, play, in my opinion, the greatest part, and can cause the most varied conditions of life. Most of the fiords have a bar at the entrance, but the shape of these barriers are very different in different places. Thus, that of the Sogne Fiord lies at a depth of 100, to 200 fathoms, with a cavity behind it 600 fathoms in depth. Out by Færder, the Christiania Fiord has a bar lying at a depth of 40 fathoms, and, inside of it, a basin, in which there is a dearth of organisms, of 150 fathoms, after which comes a bar, at Drøbak, 30 fathoms below the surface, followed by a hollow, off Steilene, of 50 fathoms, then a bar between Næsodden and Snarøen of 30 fathoms, and, in the Bunde Fiord, a depression about 90 fathoms in depth (see the Chart). The entrance to the Drammen Fiord is covered by 20 feet of water, the depth inside exceeding 400 feet (67 fathoms). The entrance to the Frier Fiord, near Brevik, is 10 fathoms deep, and, inside, 50 fathoms. That of the Hafsr Fiord, in Jæderen, is 1½ fathoms, and, inside, the depth is 32 fathoms. When the volume of oxygen $\left(\frac{100 O}{N + O}\right)$ has been investigated in all fiords of the above description, it has been found to be very low, thus

in the Frier	Fiord,	at a depth of	60 metres,	11.5%					
«	«	Drammen	«	«	«	«	120	«	0.8%
«	«	Bunde	«	«	«	«	160	«	4 to 5%

The following statement gives the yield of some hauls of the little trawl in the above localities.

Bunde Fiord, near Christiania, 10th September 1897. 60 to 90 fathoms.

Brown clay, with great quantities of rotting vegetation (oak, pine branches, zosteria)

Annelids.

No Echinoderms.

Pecten pellucidus.

Macoma calcarea, several dead, one live specimen.

2 very large *Pandalus borealis*.

1 *Nyctiphanes norvegica*.

2 *Geryon tridens*, torpid condition.

3 *Pleuronectes cynoglossus*.

2 *Drepanopsetta platessoides*.

Frier Fiord, inside Brevik, 30th September 1898. 50 fathoms.

2 hauls of the shrimp trawl yielded but some black mud with rotting wooden shavings, leaves, twigs &c. The contents of the net smelt strongly of H_2S .

Drammen Fiord, near Drammen, 10th October 1898.

Seven hauls of the trawl yielded but black mud, stinking of H_2S . Below the depth of 15 fathoms, not a single organism was taken by the trawl. At a depth of 15 fathoms, some large, black ascidians and one annelid were found, but nothing else — admirable bottom for trawling purposes with no impediments.

These deep, isolated, fiord basins, remind one, to a great extent, of the Black Sea, and the conditions obtaining there, where in the great hollow, in the middle of the sea, black stinking stuff is found at the bottom, without any living organism, and with H_2S in the water. The Black Sea, too, is partitioned off by a bar (at the Bosphorus), and the in-flowing layers of water are so insignificant, that Wojeikow, from Makarow's observations, has calculated that it would take 3180 years to renew the water in the Black Sea. Its waters, therefore, become stagnant, and life has died out on the bottom. In the Baltic, similar conditions have also been observed. In the deep pools of that sea, H_2S is met with; the bottom is black, gives an acid reaction, and is destitute of all animals with lime shells. There is, consequently, a great dearth of both fish and lower organisms in that sea.

We have already seen, above, that there is a perceptible difference between the inner, and outer portions of the fiord, in regard to the wealth of individuals, for instance of crustaceans. Besides this, it is certain that there is a clear difference in the systematical composition of the fauna of the two localities. Thus I found *Macoma calcarea*, only in the inner part of the fiord, and, alive, only in the innermost portion, the Bunde

Fiord. Up in the fiord I also found dead shells of such animals as *Cyprina islandica*, *Isocardia cor*, not uncommon. It is also my impression, that such fish as *Lycodes*, *Centridermichthys*, *Icelus Scymnus* and *Spinax* are much more common there than in the outer portion of the fiord. On the other hand, a southerly form, such as *Merluccius*, was found only at the outermost part of the fiord, and was there quite numerous. It thus appears, also, from my investigations, that the innermost portion of the fiord has a more decided *arctic fauna* than the outer part near the sea, as forms, like those of the above mentioned fish *Lycodes*, *Icelus hamatus*, *Centridermichthys*, *Scymnus microcephalus*, *Sebastes viviparus* (or *marinus*), are certainly typical arctic animals.* The same applies to many crustaceans, thus there exists on the bottom of the fiords, but only at great depths, a plankton fauna consisting of *Calanus hyperboreus*, *Metridia longa* and *Euchaeta norvegica*, forms which were found by *Nansen* to be spread over the entire Polar Sea in its surface layers. On the whole, the deep water fauna of the Norwegian Fiords has a very great resemblance to the Arctic shallow water fauna, a circumstance to which *G. O. Sars* has also called attention on several occasions.

Respecting the question as to the reason why the fauna existing far up in the fiords is of a more decided arctic character than that met with on the sea coast, I am of the opinion that the hydrographical conditions furnish many handles on which to base an explanation. From the following paper, it will be seen that the *boundary between the cold and warm layers inside Drøbak, lies far higher than out at the mouth of the fiord*. Whilst, for instance, in September, water of a temperature of 12° Celsius can, out at the mouth of the fiord, be met with down to a depth of 120 metres, we find, in by Drøbak, that all water below 30 metres is of a temperature of about 6° Cels. In the inner part of the fiord, one can, therefore, meet with cold water, *throughout the year*, at a comparatively lesser depth than out on the coast, where the great movement of the waters can cause a wave of warmth to descend, to a comparatively great depth. From this I judge that the limit of the occurrence of the true deep-water fauna *lies deeper* out off the coast. On the other hand I con-

*) See, for instance, *Collett*: Fiske i den norske Nordhavsexpeditions generalberetning. *Lönnberg*: Notes on the Fishes collected during the Swedish Arctic Expedition to Spitzbergen and King Charles Land 1898. B. K. Sv. Vet. Akad. Handlingar. Bd. 24.

sider it quite possible that the deep Skagerrak could produce just such an arctic fauna as is met with in the innermost portion of the Christiania Fiord.

3. During the fishing trials, I always had the question before me as to whether the deep sea fauna could give rise to a profitable fishery. It was especially the number of crustaceans, and, amongst them, *Pandalus borealis*, which aroused my hopes in respect to that matter. I, however, only first succeeded in making good hauls when I commenced to investigate the two fiords of Larvik and Brevik, both of which are openly connected with the Skagerrak, in having no bar at their entrance. These fiords were found to possess so great a wealth of deep sea fauna, that its like had not been formerly met with in this country.

This wealth was first discovered in the Larvik Fiord, as, on the 19th September two hauls made there, yielded, respectively, 18, and 13 litres of shrimps. On the 23rd of the same month, between 9.30, a. m. and 4.30, p. m., 12 hauls of the trawl were made at depths between 50, and 60 fathoms. These hauls, of which, unfortunately, two were failures, yielded between 85, and 90 litres (about 45 Kilogrammes) of shrimps, chiefly *Pandalus borealis*.

This deep water shrimp was already known to exist in the Norwegian Northern Sea from the researches of the Northern Ocean Expedition, and also in the fiords of Norway, from some few specimens taken during the dredging operations that were carried out by Professor Sars, and Curator Storm. During a long period had shrimps (Drammen shrimps), too, been caught in the Drammen Fiord, but such quantities as those mentioned above were unknown.

The shrimps were found to be even more plentiful in the Brevik Fiord. On the 29th September, one haul, during the space of half an hour, with Dr. Petersen's trawl, yielded 24 litres, and, on the 5th October, between Langesund and Brevik, from 5.30, a. m. to 4.30, p. m., ten hauls yielded, altogether, 171 litres (about 85 to 90 Kilogrammes). In each of the ten hauls, the yield was as follow:

1st haul	lasting	30	minutes,	10	litres.
2nd	«	«	40	«	15

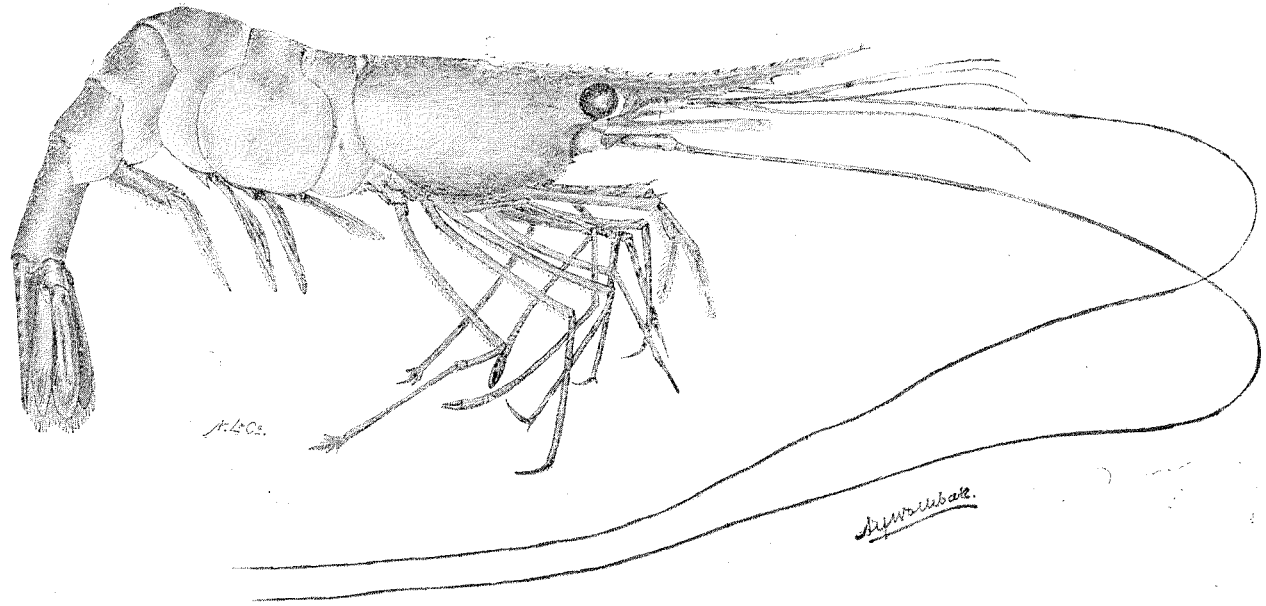


Fig. 19. Deep water Shrimp, *Pandalus borealis*, full Grown Specimen. Natural size

3rd haul	lasting	18 minutes	17 litres.
4th	«	« 45	« 20 «
5th	«	« 30	« 21 «
6th	«	«	« 8 « (the haul was a failure).
7th	«	«	« 20 «
8th	«	«	« 24 «
9th	«	«	« 26 «
10th	«	«	« 10 « (the haul was a failure).

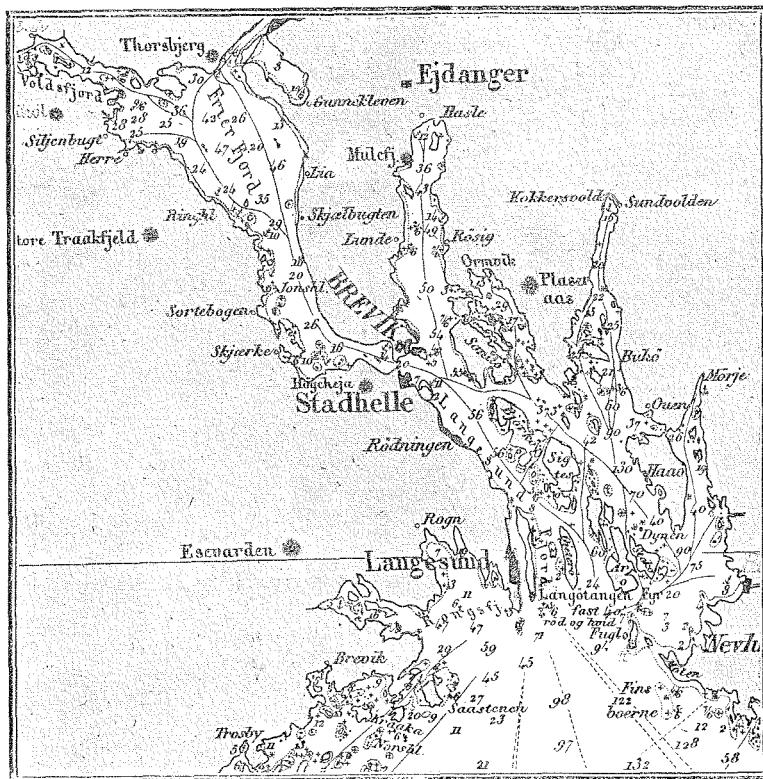


Fig. 20. Chart of the Soundings in the Frier, Brevik, and Langesund Fiords.
 ──────────── | = 4 Geographical Miles. The Depths in Fathoms.

All these hauls were made, so far as the taking of bearings made it possible, at exactly the same spot. The great quantities of shrimps, which was thus established in the Brevik Fiord, was found to extend almost from Eidanger, past Langesund, and far out to sea. Thus on the 24th September, when from 4 to 8 miles off the coast between Langesund and Fredriksværn, 8 litres of shrimps were obtained at a depth of 120 fathoms.

In order to thoroughly study how great the wealth of such a fiord could be out by the sea itself, I, during the Autumn of 1898, investigated the fiord more fully by sending out a small steam boat each day, to make about 8 hauls of the 15-foot trawl in quite a small portion of the fiord, the area being estimated at about 100 acres of surface. The results were as follows:

		Kilogrammes, <i>Pandalus borealis</i> .	
16th November	25		
17th	—	21	—«—
18th	—	20	—«—
19th	—	39 ^{1/2}	—«—
21st	—	35	—«—
22nd	—	68	—«—
23rd	—	37	—«—
24th	—	43 ^{1/2}	—«—
25th	—	26	—«—
28th	—	72	—«—
29th	—	39 ^{1/2}	—«—
30th	—	22	—«—
1st December		21	—«—
2nd	—	48	—«—
3rd	—	20	—«—
5th	—	35	—«—
7th	—	48	—«—
8th	—	35	—«—
9th	—	6	—«—
10th	—	13 ^{1/2}	—«—
13th	—	17	—«—
14th	—	21	—«—
15th	—	22	—«—
16th	—	19	—«—
17th	—	31	—«—
19th	—	32	—«—
20th	—	20	—«—
21st	—	17	—«—
22nd	—	21	—«—
23rd	—	15	—«—
28th	—	30	—«—

} Only a few hauls were made on these days.

29th December	34	Kilogrammes, <i>Pandalus borealis</i> .
30th	—	—«—
31st	—	—«—
2nd January 1899	11	—«— only a couple of hauls.
3rd	« 27	—«—

36 days' fishing. 1040 Kilogrammes of Shrimps.

In addition to Shrimps, no small quantities of the Witch, or Pole Dab (*Pl. cynoglossus*), a valuable species of flounder were caught, and these were sold at 80 øre (about 10¹/₂ d) a Kilogramme. The prices obtained for the shrimps, varied from 1 Krone 60 Øre, to 2 Kroner (about 1 sh. 9 d, to 2 sh. 3 d) per Kilogramme wholesale.

From the above table it will be seen that the quantity, notwithstanding the great fishing that took place, has not decreased. During the whole period, the average take was 30 Kilogrammes. In respect to the take, it must, moreover, be pointed out, that the trials were made in the darkest, and, in every respect, the the most unfavourable season of the year. As will be seen, the fishing in October was even still better.

When the above mentioned trials became known, and that, during my cruise, I had succeeded in using trawls from sailing boats, trawl fishing, with such boats, was started in the Langesund fiord. In January, it was carried on, continually, by two such boats: in February with five, and in May, from what is reported, with ten. It would be difficult to find out, exactly, the quantity taken during these months, but a sort of estimate may be formed. We have thus learnt that one firm alone, in Christiania, up to March 1899, had received 2671 Kilogrammes of shrimps, and paid for them 4869 Kroner 30 Øre (about £ 270 : 10 : 0), as well as 200 Kilogrammes of flounders at a cost of Kroner 145 (£ 8.) Another firm sold over 1000 Kilogrammes, and as, moreover, considerable quantities have been sold in other towns, it may be fairly stated that at least 5000 Kilogrammes, of a value of 8000, to 9000 Kroner (about £ 444 to £ 500), had been obtained during the course of 3, to 4 months, and that the chief fishing was carried on during the last two. It may thus be concluded, that the deep-sea bottom is proved to have been more remunerative than had hitherto been expected, in any case so far as our country is concerned, and that the results thus attained are striking when one recollects that the fishing, carried on during these few months,

has taken place on a surface of about 5 square K'ometres (about 1250 acres), (probably, really, on a much smaller area). It will be of the highest practical, and scientific interest to watch the development of this fishery, and to see how much fishing this little area will stand. Up to the present no falling off has been observed, and at the end of the first year's fishing about 10 tons shrimp were sold to a price of about 15 000 Kroner.

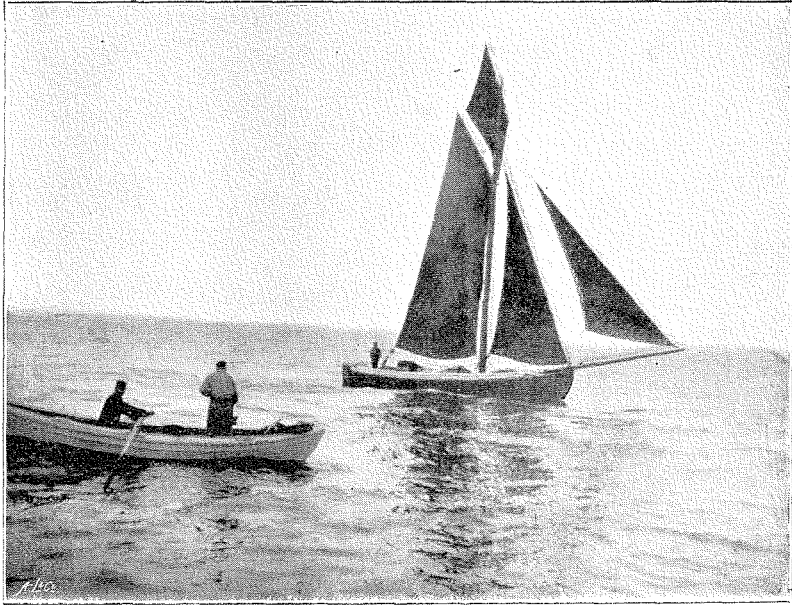


Fig. 21. Sailing Boat, like those now employed in trawling for shrimps.

As these shrimps occur on the whole of our littoral round to the Murman coast, and are regarded as being an Arctic species whose occurrence one could imagine would be greatest far north, there is every reason to hope that similar fisheries, such as that already described, will be established at many places along our coast.

From experiments in canning, it has been proved that the shrimps are well suited to that process.

(The question of the injurious effects of the fine meshed trawl will be dealt with subsequently).

Chapter V.

Some Biological Notes.

By

A. Wollebæk.

I. *Gadus callarias*, Lin.

If one arranges the measurements of the cod-fish, caught both in deep and shallow water during the months of April and May, in the manner given below Tab. I, and in which each (point) indicates a measured individual, it will be seen, that they divide themselves into 3 large groups, in which Group 0, represents the fry of the year; Group 1, cod of 1 year, and Group 2, cod of 2 years of age. As regards older fish, the want of a sufficient number of measurements prevents us from tabulating the fish of various years.

In April and May, the fish of Group 0, average a length of 1¹/₂ to 4 cms.; Group 1, 7 to 27 cms., and Group 2, 30 to 45 cms.

It will be subsequently shown, how neither the fry of the year, nor the older classes, have made any appreciable increase in size from November and on during the winter season, but that their rapid growth first commences in April and May. Without destroying the curves of the various annual classes, one may, therefore, place on the same Table, as is done in Tab. II, the measurements of the cod of one locality, from November and on throughout the winter season. Thus on Table II, the measurements of cod taken in the Drøbak Sound, between the end of September and the end of January, are recorded, in order to

Gadus callarias, Lin.

April—May, 1899. Drøbak.

Cm.	
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34
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36
37
38
39
40
41
42
43	.
44
45
46	.

1.

2.

Gadus callarias.

Dreøbak Sound, 19th September, 1899 to 20th January, 1900.

Cm.		
1		
2		
3		
4		
5		
6		
7	} chiefly during the latter half of October
8	
9 and others. 0	
10	
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12	
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15	...	
16	.	
17		
18	.	
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20	.	
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24	} 1.
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57	..	

} 2.

Gadus callarias,

Drøbak Sound, 1899.

	19 to 30 September	October	November	December	January
18	In fish-pots at	* in fish-pots at 10 fathoms.	On lines 12 to 110 fathoms.		
19	. 10 fathoms.	. on lines, 60 to 100 fathoms.		. On lines 10 to 60 fathoms.	. On lines 3 to 20 fathoms.
20					
21	.	*	
22		*****
23	**	..	.	
24	***
25	...	*****
26	...	*****
27	****
28	...	*****
29	****
30
31	..	***
32	..	*****
33		*
34		*
35	.	**
36	..	* *
37
38
39		*
40		
41	.				.
42		
43	.	*	
44		*
45		*
46		
47	
48	.	*
49	.		. 2	..	
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51			.		
52		
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57		.	.	.	
58		
59			
60		
61		
62		

render the various annual classes more apparent, as, in the method here employed to indicate the various annual classes, it is necessary to obtain as great a number of measurements as possible.

If one divides the measurements, recorded in Table II, in such a manner as to arrange the measurements of each month (November, December and January), in separate tables, these would be somewhat alike, and not shew any difference in size of the various annual classes (see Tab. III). From these Tables it will be seen that the opinion held by Prof. Sars, that the cod, in its second year, may reach a length of 40—30 cms. is confirmed.

If Tab. I, be compared, with Tab. II, it will be found, that the largest specimens of the 1 to 1¹/₄ years old cod in April and May, attain a length of 27 cms. These will, during the course of the spring, summer and early autumn, increase in size by 14 to 15 cms., which, compared with the, comparatively, still more rapid growth of the younger annual classes, is not at all striking. The entire Group (1) on Tab. I, which includes individuals from 6¹/₂ to 27 cms. in length will be met with again in Tab. III, in November (December and January), between 21 and 40 cms.

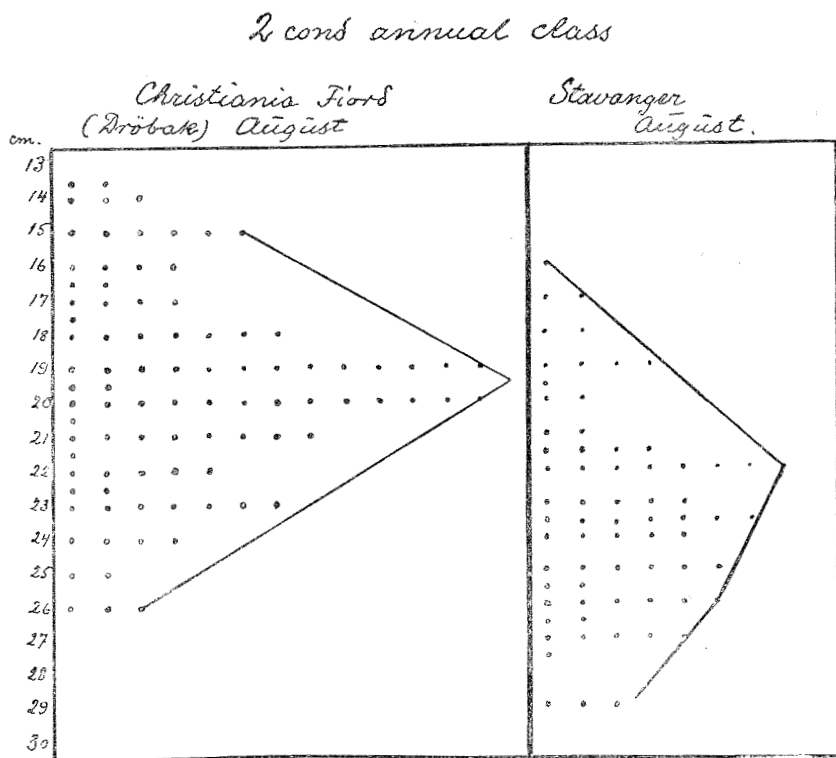
As an illustration of the rapid growth of the older classes, it may be mentioned that, a marked cod-fish of 44 cms. in length, put into the water at Drøbak on June 10th. 1899, was, when caught (same locality) on the 18th October following, 51¹/₂ cms. in length. — It had thus grown 7¹/₂ cms. in 4 months and 8 days. If the size of this cod, early in June, be compared with its size about the middle of October, it will be found, from the accompanying Tabs. No. I, and No. II, that the entire bulk of the annual class, Group 2 on Tab. I, to which the above mentioned cod belongs, shews the same difference in size, on an average, on Table I, and Table II.

If we, for instance, add to each specimen contained in Group 2, on Table I, 7 to 8 cms., we will have a curve which will be almost identical with that of Group 2, on Table II.

The reason of the curves in Group 1, being so wide, and running to so many points, is not due to the length of period which the Table represents, but to the fact that the measurements, no doubt to a great extent, are those of individuals which have come in during the autumn, whose average size is greater than that of individuals of the same annual class which belong to the fiord.

It will subsequently be shewn, how the development of the year's fry on the sea-coast, is more advanced than that of fry of the same age, inside the fiord. This same applies to the year-old fry, as denoted by the curves given below.

The inconsiderable difference between Groups 1 and 2, on Tab. II, is, certainly, also partly due to the fact that, the early developed individuals of the immigrated cod of Group 1, in its second year may have



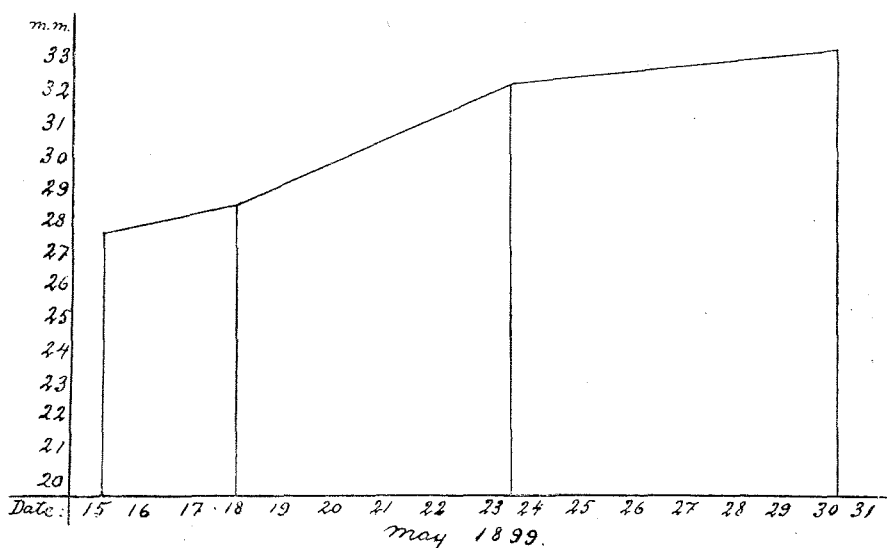
attained a greater length than the late developed fiord individuals of Group 2.

When it is considered, that the year's fry may be found in August ($\frac{1}{2}$ year old cod), up to a size of 12 cms., together with various individuals of 4, to 5 and 6 cms., and, in September, individuals up to 16 cms., the smallest of the same annual class being $\frac{1}{3}$ to $\frac{1}{4}$ the length of the largest, it will not be so astonishing, as would appear at first sight, that a cod of about 20 cms. in length, is a fry of the same year as one of 40 cms.

So long as one can follow the growth of the various annual classes, it will be seen how the rapidity of growth steadily diminishes with age.

The smallest fry in May, has by August, or September, attained 3 to 4 times its former size. On the other hand, the cod, which, in May, is a year old, at the same period of the autumn averages twice the size it was in May. The increase in the growth of the 2, to 2¹/₄ year old cod during the summermonths, is about 7 to 8 cms.

It has, hitherto, been fruitless to determine the growth of the older annual classes, as it has not been possible to obtain a sufficient number of measurements. It is, however, very probable that their curves would,



to some extent, be merged into one, so that it would require a far greater number of measurements than those of the junior stages, to enable one to indicate the various annual classes.

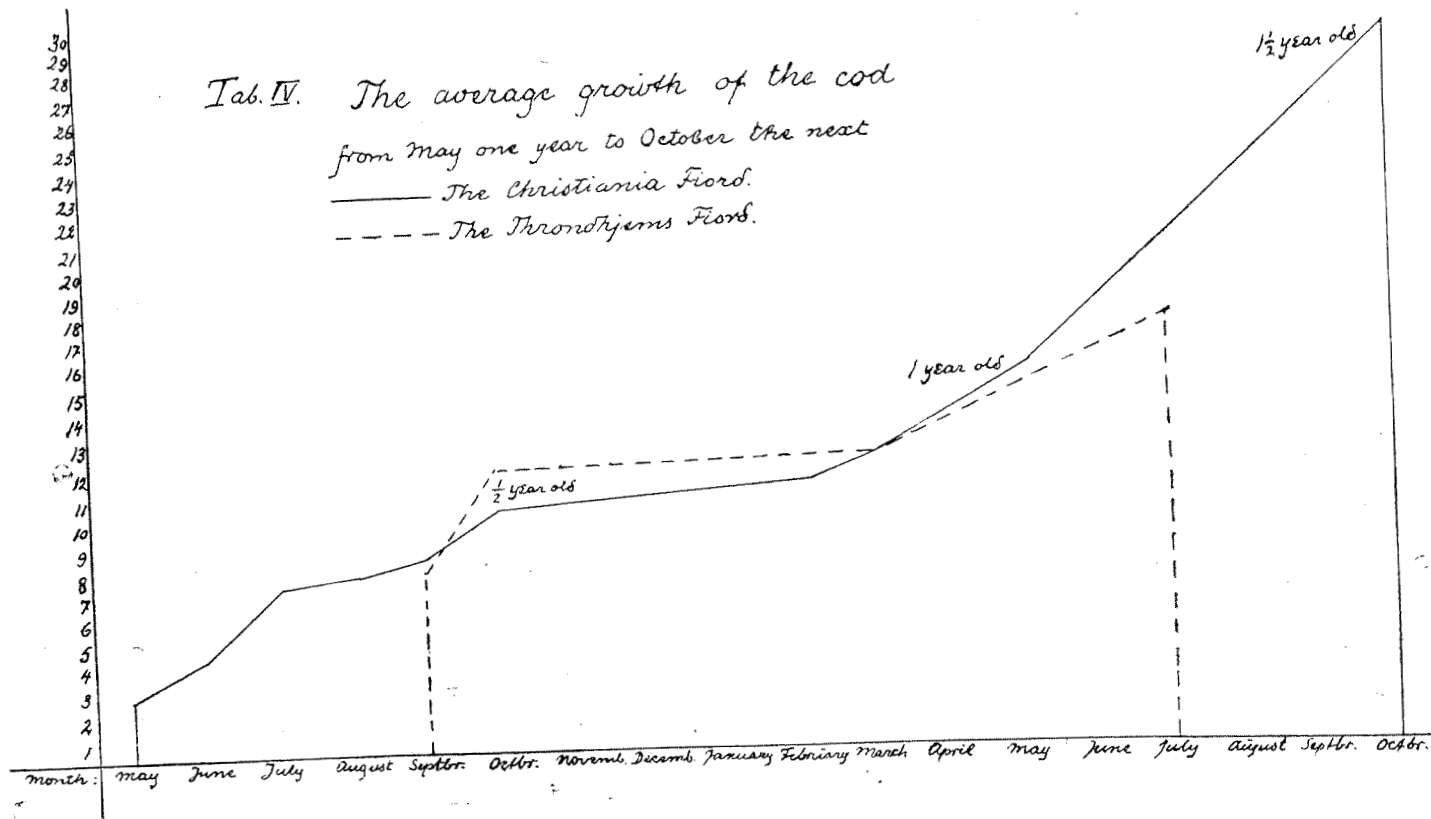
If one takes the average measurements of the cod-fish fry (fry of the year) that were caught in the Christiania Fiord on the various dates given in the latter half of May, (see the Figs. above) and arranges them in curves, in the manner mentioned below, one will clearly perceive how the growth of these small fry advances in but the course of a fortnight. These measurements are all derived from individuals of the same locality.

Tab. IV. The average growth of the cod

from May one year to October the next

— The Christiania Fiord.

--- The Throndhjems Fiord.



In a like manner, curves representing the growth of the fry throughout a whole year, may be drawn.

The accompanying Table No. IV, exhibits the average size of the fry in each month. From this Table it is clearly seen, how the fry, in the summer months, from May to July, increase rapidly in size, while, in the autumn and winter, hardly any growth takes place. In the Report of the Fishing experiments carried out in the Christiania Fiord, 1899 it is shewn how, at the end of October, after a heavy southerly gale, a few hauls yielded a far greater quantity than that caught during the previous months. The average size of specimens of this cod fry that, so suddenly, made its appearance, without doubt from other parts, proved to be a great deal above the average size of the specimens of the year's fry caught earlier in the month. This accounts for the quick rise of the accompanying curves of growth in October.

This difference of size will be found to be still more perceptible in the fish of the Trondhjem Fiord.

In the months of November, December and January the ice prevented all seine fishing in the shallow waters of the Christiania Fiord, owing to which the measurements of the fry could not to be recorded during those months, but the months of February and March denote how very inconsiderable must have been the growth during the winter months.

From the Trondhjem Fiord, measurements of fry were obtained during November and December.

The average measurements for these two months are, as nearly as possible, the same, and do not present any great difference from those of October. From the curves of growth of the cod in the Christiania Fiord and Trondhjem Fiord, given in Tab. III, it will be seen how the rapidity of growth varies at the different places, but agrees in all its main features. If, in like manner, one framed curves of growth for different years, they might also shew variations in one and the same locality.

The fry of Gadoids (the year's fry) in Risevigen, near Tananger, was, generally, far more developed than the fry of the Christiania Fiord at the same period.

While the fry of Risevigen, by the 5th June, were of an average size of $4\frac{1}{2}$ cm., the fry of the Christiania Fiord did not reach this average size until towards the close of that month. This difference in size is chiefly ascribable to an earlier spawning. More favourable natural conditions play therefore a great part.

Both in the Christiania Fiord as well as in Risevigen near Tananger, we have found both the small stages of that year's fry, about 2 cm. in length, as well as the larger of 5 to 6 cms., they being most frequent in and on the borders of the belt of *zostera*, as well as in the laminaria region.

In the Christiania Fiord, at Drøbak, the belt of *zostera* was met with in all the investigated localities, such as the Sandspollen, Hallangspollen, and other places, down to a depth of 3 to 3¹/₂ fathoms, and at that depth we found most of the individuals obtained. In hauling the fine meshed seine further out on the bare bottom, absolutely no, or exceptionally few individuals were caught.

In Risevigen, near Tananger, during the first days of June, one haul was made at a depth of half a fathom to one foot, on a sandy bottom, covered with short, and slender *zostera*. This yielded but a single young green cod (*G. virens*). At the depth of about half a fathom, there commenced a thick belt of *zostera* of fresh shoots of that year. The belt extended, outwards, to 1¹/₂ and 2 fathoms. There the *zostera* commenced to be scarce, and great patches of bare bottom could be seen.

One haul was first made in the belt of *zostera*, at a depth of 1 to 1¹/₂ a fathom. The yield consisted of 131 specimens of that year's fry, both of cod, green cod, (*G. virens*) and pollack (*G. pollachius*).

Another haul was made from the outer edge of the belt, inwards, to a depth of 1 fathom. The yield of this one haul was 582 specimens of that year's fry. A haul was also made further out, where the bottom was only patched with *zostera*, but the yield there was not even one tenth of that of the previous haul. With a strong on shore breeze, the shoals of fry will approach the land.

The question concerning the resorts of the various animal classes is, too, one which must be solved empirically.

It is impossible to say anything with certainty on this point, as, up to the present, too little is known of the movements of the cod, and too little of «local fiordbreeds».

It seems to be a general fact, that the largest cod are usually caught in the deepest waters. The weather, and season of the year, naturally play a great part, so that, occasionally very large, as well as very small individuals may be caught at one and the same depth.

We will, in Table V, (pag. 100) make a comparison, graphically represented, of the individuals' size, together with the depths at which they were caught, of cod from the Drøbak Sound, in the autumn and winter 1899. Tab. V, thus shows how the numbers of smaller individuals diminish, and those of the larger increase with the depth at which they are fished.

The stage in which the fry on the west-coast were found to be, in the early part of June, should, according to Sars, be their «Jelly-fish stage». The individuals brought by Sars from Lofoten, which were found underneath the Jelly-fish, were of the same size as those met with early in June in Risevigen.

If the existence of the cod fry, at this stage of their development, should, indeed, be conditional on their living beneath the jelly-fishes, the seine would, necessarily, have been full of them, as well as the thousands of fry which were captured. Such, however, was not the case. We did not catch a single jelly-fish. It seems, therefore, inconsistent to speak of a «*Jelly-fish stage*», as one which the cod-fish fry must pass through, or as being something characteristic of, and requisite for the development of the cod.

Of the small *Copepods* on which the cod fry chiefly live, some species are to be met with in plenty beneath the jelly-fish, and when the shoals of jelly-fish drift into the bays and creeks where the fry exists, it would seem strange if it did not seek the food where it occurred in the largest quantity; but that its life, at a certain stage of development, should be dependent on its living below the jelly-fish cannot be admitted, as *Copepods*, and other animals, which constitute the food of the cod fry are also to be found in abundance at other places, and not exclusively beneath the jelly-fish.

III *Gadus Virens*, Lin.

The curves representing the various annual classes of the Coal Fish are far more distinct than those respecting the cod.

On the accompanying Table, No. VI, will be found the measurements of the coal-fish from the Trondhjem fiord in August (from 5th to

24th). These measurements give four very distinct and well separated curves, each representing an annual class. Group 0, the fry of the year, represents, in that month, specimens between 8, and 16 centimetres in length; Group 1, the year and a half old coal-fish, between 18, and 27 cms., Group 2, the two and a half years' old fish, between 30, and 41 cms., and Group 3, the three and a half years' old fish, between 45, and 56 cms.

The reason of the difference between the well separated curves of the coal-fish, and the wider, and in part confluent curves of the cod, must, first and foremost, be attributable to the fact that, the spawning of the coalfish lasts for a shorter period than that of the cod. The longer the spawning time, the wider the curves will be. In the second place, those coal-fish, whose measurements are recorded in Table VI, were all caught at the outermost portion of the Trondhjem Fiord (Garten), and we thereby have escaped getting, in this instance, a mixture of measurements of immigrating fish, and those that had been in the fiord from former years, which undoubtedly was the case in respect to the cod. That which will strike the observer at once, when he compares the annual classes of the coal-fish with those of the cod, is, that, the smallest fry of the coal-fish, Group 0, is considerably further advanced in size than that of the cod.

In Table VI, where the measurements of coal-fish in the month of August are given, Group 0 represents specimens between 8, and 16 cms., in length, the bulk of them being 11, and 12 cms. Even so late as the end of October (See Table II), the bulk of specimens of cod, represented by Group 0, are between 8, and 10 cms.

How much more rapid is the growth of the fry of the coal-fish during the summer months than that of the cod, will best be seen from the following curves of growth, representing the average size of about equal numbers of coal-fish and cod fry, taken at the same time from one locality.

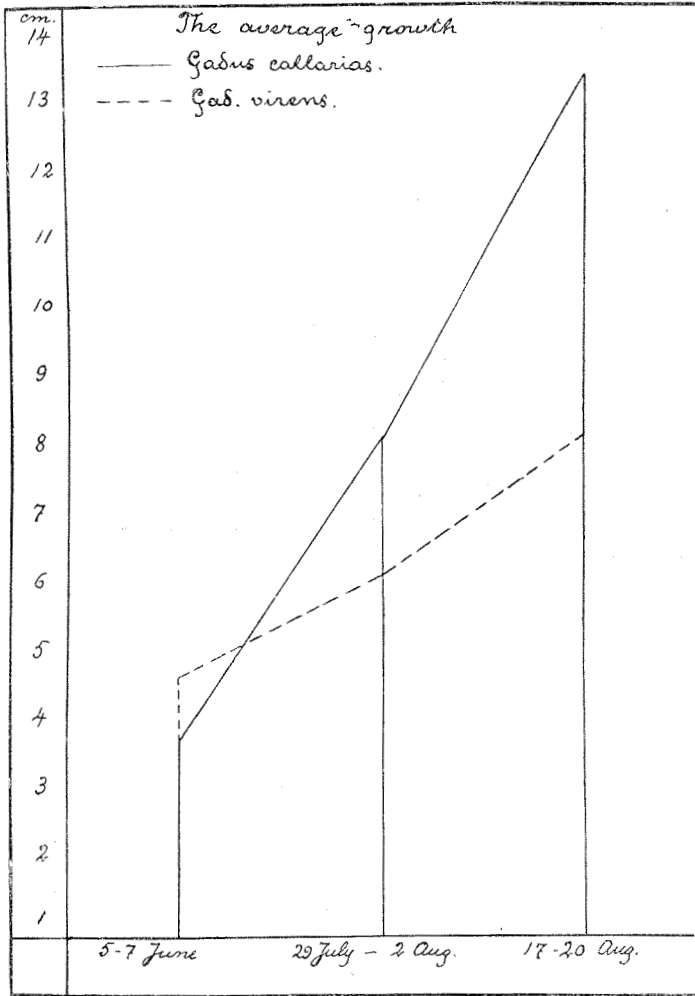
If the measurements are recorded in curves by the aid of dots, Table VII, the curves for the three periods (5th to 7th June; 29th July to 2nd August; 17th to 20th August) representing cod fry will become completely merged in each other, while those respecting the coal-fish are clear, distinct, and well separated, and all the individuals are of the same size, which is caused by their having been spawned during a shorter period than the fry of the cod.

Gadus virens,

Trondhjem Fiord (Garten) 5th to 24th August 1899.

Cm.		
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It might be thought that the difference between the size of the coal-fish and cod fry, was owing to the coal-fish having been spawned earlier, but that this is not the case will be seen when one glances at the accompanying curve of growth, which even would tend to shew that the opposite



was the case, in that the cod fry is larger than that of the coal-fish in the beginning of June.

The curves in Table V, shew, very clearly, how quickly and regularly the growth proceeds amongst the older classes. The coal-fish of one and a half years of age, in August, whose Group in Table V, represents specimens between 18, and 26 cms., will, during the course of one year

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8 } 74 specimens.
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15 } 818 specimens.
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5 .. 0
6 Risevigen 1st to 15th August.
7
8
9
10 Kristiania Fiord 1st to 15th August.
11 of which, still over 200.
12 1
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14
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16
17
18
19
20 Risevigen
21 2
22
23
24
25
26
27
28 Kristiania Fiord.
29 3
30
31
32
33
34
35
36
37
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41
42
43
44
45

4
5
6
7
8
9
10 1
11 Larvik Fiord.
12
13
14
15
16
17
18
19
20 2
21 Larvik Fiord.
22
23
24
25
26
27
28
29 3
30 Drobak Sound.
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increase some 12 cms., in length, so that the Group, in August of the following year, will represent specimens between 30, and 38 cms.

Group 3, representing the three and a half years' old coal-fish, is too weakly marked to allow of one deciding how great its increase in size has been from its second to third year.

It is probable also, as regards the coal-fish, just as has been proved in respect to the cod, that the growth proceeds less rapidly the older it becomes.

It is, therefore, not improbable that the measurements of 55, to 56 cms., given in Table V, belong to a fourth annual class.

The small fry of *Gadus virens* lives amongst the *Laminaria*, *Corda filum*, and *Zostera*, at about the same depth as that of the cod.

During the investigation of the shallow waters at Tananger, in the beginning of June 1899, it was clearly perceptible that the main bodies of both cod, coal-fish and pollack fry kept apart.

A couple of hauls of the fine meshed hand seine thus yielded in the first haul, 218 coal-fish fry, and but 4 cod. The second haul, on the other hand, made at a somewhat greater depth, yielded 180 cod fry, and but 15 coal-fish. If one is to recognise any difference in the depth at which coal-fish and cod fry live, it may be said that the main body of coal-fish fry generally frequents somewhat shallower water than the cod fry at a similar period.

At a depth below 6 fathoms, and on a bare bottom, both species are very seldom met with.

During the spring and early summer, the one year old fry is to be met with at the same spots as the smallest fry. Later on in the summer, and during the autumn, Dahl could not find the one, to one, and a half year old coal-fish in the Trondhjem Fiord. This is also the case in respect to the Christiania Fiord.

Without doubt, that annual class leaves the shores at that period, and commences its migratory life in shoals. As regards the older classes, the same rule holds good as that respecting the cod, viz., that, as a rule, the largest specimens are to be met with deepest down in the sea.

IV. *Gadus merlangus*, Lin.

Notwithstanding that there have been caught, and measured, many thousand specimens of this species, we will never, when we arrange the measurements of those caught at one place and at one time, obtain more than two curves; but these are, uniformly, very distinct, and, generally, very much divided, with the exception of the curves for November and December.

It would thus appear easy to determine which annual classes &c., are represented by the various curves, but if one looks into their mutual relations (the size between which they fall) during the various months, we will find that this question is a far more varied one than that respecting the two *Gadus* species already referred to.

In order to allow of its being possible to clearly understand the various things which will be dealt with in the following pages, we are compelled to include a large table of the entire series of measurements for the various months and localities.

If we take this table, and commence with May, which is the earliest month of the year in which a large number of measurements have been made, we find a large, very sharply defined curve (Christiania Fiord, 2nd May), which lies within the narrow boundaries of 7, and 9 cms., in consequence of which it was not found necessary to give the measurement of each individual, but, on the other hand, sufficient to denote the curve by the aid of brackets only.

From the middle of June, we obtain from the Christiania Fiord, a still greater curve which lies between 13, and 19 cms., corresponding exactly with that from the Trondhjem Fiord during the same month.

The first thing now to be done, is to find out whether the curve of 2nd May, which lies between 7, and 9 cms., is the same as that of the middle of June — in other words, to discover whether, in the course of $1\frac{1}{2}$ months it has increased from 7, to 9 cms., up to 13 to 19 cms. If such be the case, it will be quite impossible to understand whence the curve between 8, to 14 cms. in August has originated.

That this curve cannot represent the fry of the year, may be easily seen when we compare it with that of the same period from Risevigen (South West Coast). If the curve from the Christiania Fiord in August, between 8, and 14 cms., really represents the fry of the year, then, in

the first place, the fry in the Christiania Fiord must be in a much more advanced stage of development than the fry of Risevigen, which is the opposite to what we found respecting the two previous *Gadus* species. In the second place, such a phenomenon is inexplicable. How is it that one can meet with hundreds of the year's fry of this species in the fiord, whilst of the two *Gadus* species referred to, which also have pelagic eggs, and whose spawning takes place about the same time as the whiting's, are only to be found in infinitesimal numbers?

We must regard the curve for the 2nd May, between 7, and 9 cms., as representing fry of the previous year, therefore then one year old, and of a different year's class to those represented by the 13 to 19 cms., curve for June, for we must regard the latter as representing the 2 year old fry. It is necessary, now, to follow these annual classes through the various months.

As regards the Christiania Fiord, we will, for August, find two sharp and widely separated — 10 cms. — curves, marked on the appended Table. The two curves lie between 8, to 14, and 25, to 31 cms. From Risevigen we also find, at the same period, two curves, separated by a broad space of 7, to 8 cms., but these two curves lie between quite other boundaries than the curves of the Christiania Fiord during the same month, viz., between 4, and 11, the bulk at 6 cms., and 18 to 24 cms.

If we place the August measurements for Risevigen and the Christiania Fiord together in one Table, we will get four different curves, as the first curve for Risevigen, representing the bulk of the fry of 6 cms., the fry of the year, will lie above the first curve for the Christiania Fiord. On the other hand, the second of Risevigen's curves would lie exactly midway between the two curves for the Christiania Fiord.

The sharp curve for May, between 7, and 9 cms., corresponds to the curve of 8, to 14 cms. in August. The June curve, 13, to 19 cms., which is the same for both the Christiania and Trondhjem Fiords, corresponds to the 18, to 24 cms. curve in August.

We find, moreover, in August, in addition to the curve for the fry of the year, another new annual class to which there is nothing corresponding in the previous months — the reason why will be given later on in the Biological Notes on this species.

The new curve represents the $3\frac{1}{2}$ year old fish.

In the Table for August, we thus find the curves for four different series, Group O, representing the fry of the year, the bulk of which, in August (first half), come under 6 cms., Group 1, the year and a half old fry, between 8, and 14 cms., Group 2, the two and a half years old fish, between 18, and 24 cms., and Group 3, the three and a half years old whiting, between 25, and 31 cms.

If, in the same manner, we regard the curves for September, we find, as regards the Larvik Fiord, two curves; for the Drøbak Sound but one (with the trace of another) clear curve, which, when compared with the measurements from the Larvik Fiord, will form three distinct curves, as the curve from Drøbak Sound, whose boundary lies between 26, and 34 cms., will lie below the curves from Larvik Fiord which lie between 9, to 16, and 18, to 25 cms.

These three curves correspond exactly with Groups 1, 2 and 3 for August.

Curves for September and October, shew how the various Groups approach each other more and more in size, as the younger classes grow more rapidly, and in the latter half of October, to some extent merge into one, so that in November and December, we will obtain some broad curves with several sharp pointed projections. The large, wide curves between 23, and 38 cms., in November and December, thus represent several (at least two) annual classes. If the growth of the annual classes of whiting, be compared with the corresponding classes of the cod and coal-fish, that of the whiting will appear to proceed much more tardily. But, in making such a comparison, one must bear in mind the size the whiting can, on the whole, attain, compared with that of the cod and coal-fish.

Amongst the great numbers of whiting that have been caught, but very few specimens have been met with exceeding 38 cms in length, and none over 43 cms.

Notwithstanding that this species, from a systematic point of view, is nearly related to the two preceding species, its biology presents many deviations.

Although many hauls have been made in shallow water with fine meshed apparatus, we, even so late as September, were not able to find the year's fry in the Christiania Fiord. Neither were any whiting ever caught on long lines in deep water.

Only the one measurement of 7 cms., noted in the September Table, belongs, probably, to the 0 Group. Several investigations of shallow waters were, likewise, made during the course of October, but all the *Gadus merlangus* which were caught belonged, both then, as in September, to Groups 1, and 2, mainly to the former; nor were any specimens belonging to Group 0 met with in December.

We think that the year's fry leave the shallow waters during the course of the autumn, and lead a pelagic life, and first approach the shallows of the fiord in the spring of the following year as fish of nine to twelve months old (see the Table for May).

That which strikes one at once, when one looks into the accompanying Table, is, that, from one and the same locality, and during one and the same month, one can find only 2 annual classes. This is due to the spots, and the depths that are fished. The whole impression one obtains of the fishing of this species, is, that the various annual classes, — possibly more than is the case in any of the other species of cod, — generally keep together in large shoals. Thus at Drøbak, on the 2nd May, one haul with a Danish ground seine, at 0 to 4 fathoms depth, yielded amongst *Laminaria*, and *Corda filum*, 74 specimens (7 to 9 cms. in length), consisting exclusively of fry from the previous year. On the other hand, later on, in June, one haul made at Hankø yielded 775 specimens, consisting, exclusively, of $2\frac{1}{4}$ years old fish.

In consequence of the separate occurrence, on the whole, of the various annual classes amongst themselves, it is much easier, than in respect to the cod, to discover the depth at which the various annual classes of this species live.

The Whiting of one, and two ($2\frac{1}{4}$) years of age in May and June, whose curves are given in the table, were all caught at depths varying from 5, to 0 fathoms. In August, at similar depths, one and a half year old specimens only were caught, whilst at 20, to 40 fathoms, fish of three and a half years might be taken on long lines.

During the autumn it appeared as if some of the one and a half, and two and a half years old whiting descended to deeper water.

During the great line fishing in Drøbak Sound, from September till, and including, December, but two specimens of the 2nd and 3rd annual classes ($1\frac{1}{2}$ to $2\frac{1}{2}$ years of age) were caught below 20 fathoms during September, whilst during October, November and December, more and more of these classes were caught down to a depth of 100 fathoms, while they were also met with in shallow water.

The haul, previously mentioned as having been made at Hankø, which yielded 775 whiting, was also interesting, from a biological point of view, from the vast masses of *Aurelia aurita*, which were caught at the same time, together with lesser numbers of *Cyanea capillata*. In respect to the whiting, it might be more correct to speak of a «Jelly Fish stage», and that, not exclusively as regards the youngest annual class, but also in respect to the one, and two year old fish, which, during the time the jelly fish are abundant in the sea, swarm beneath them in great numbers. We do not, however, consider that the jelly fish are necessary to the development of the whiting.

If we compare that which has been stated here, concerning the growth and biology of the whiting, with that which has been set forth by former authors, we will find that it differs in many points.

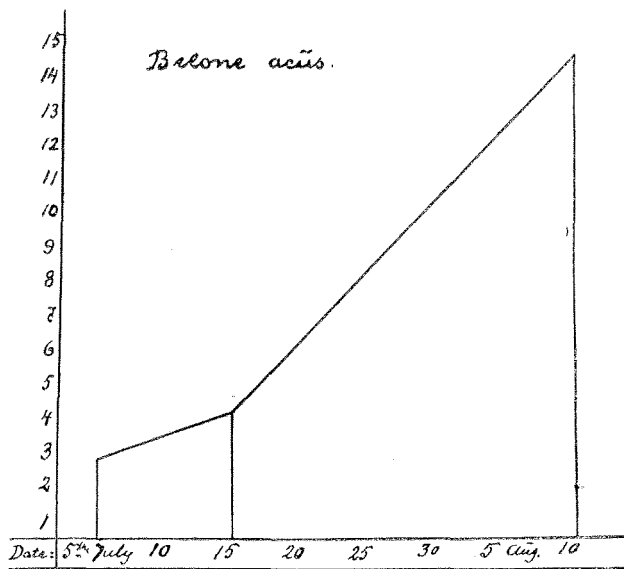
Smith, and Stuxberg after him, say that, the whiting is never met with at great depths. «During the summer, from 12, to 16, or at most 25 fathoms. During the autumn and winter, in shallow water close in to the beach. It is never found in large shoals except at spawning time.» Fries says that, in the beginning, the fry grow quite rapidly, so that in the month of October, when they proceed to the shallows, they are of a length of 10, to 12 cms. These, it may be mentioned, are not fry of the year, but fish one and a half years old.

Belone acus, Risso.

In the Sandspollen Creek, near Drøbak, on the 30th June 1899, a minute larva, but 2mm. in length, was caught on the surface. It was kept alive in a glass vessel for five days, and during that time grew to

a length of 12 mm., when it was easy to recognise it as a young garfish. Later on in July, during calms, the young of the garfish were to be seen constantly on the surface. On the 5th July, a number of specimens were caught, their average length being 2.9 cms. On the 14th July, many were caught of an average length of 4.1 cms., and again, on the 9th August, several averaging 14.7 cms.

If we record these average measurements in the following manner, we will obtain a good idea of the rapidity with which the garfish grows during the summer months.



During the whole of the month of August, large shoals of garfish fry were to be seen in the water. On calm evenings they could be seen on the surface hunting for their prey, or a whole shoal splashing about on the surface at one time. They were then so active in their movements that it was hardly possible to catch them. In the end of August they had attained a size of 20 cms. and upwards. In the middle of June, 52 adult garfish were taken in one haul of the seine in a shallow bay at Hankø, at a depth of 3, to 0 fathoms, the bottom being covered with fucus near the beach, and zosteria further out.

Chapter VI.

General Results.

In Chapter I, we have given quite a short account of how it can be proved that, both in the Christiania and Trondhjem Fiords, the surface currents during spring, mainly, run outwards, occasionally with considerable force.

In respect to South Norway, the strong current which runs from the mouth of the Christiania Fiord to the westward of Lindesnæs, through the northern portion of the Skagerrak, is a well known hydrographical phenomenon.

From our fishing trials in the Christiania Fiord, the Skagerrak, and Jæderen, as well as in the Trondhjem Fiord and parts of the coast outside it, we obtained the following main results.

1) Proof that, occasionally, considerable numbers of fish spawn in the fiords themselves.

2) Proof that the number of pelagic eggs was small. They were, most often, in early stages of development, and larvæ were almost entirely absent.

3) Proof that fry (of the year) of fish with pelagic eggs, were, during summer, only found in great quantities by the sea coast; in respect to south Norway, to the westward of Lindesnæs, and in respect to the northern portion of the country, only about the island belt and on the open sea coast.

In the Christiania Fiord, and the whole portion of south east Norway, as well as in the Trondhjem Fiord, only inconsiderable numbers

of the year's fry of fish with pelagic eggs could be found, whilst a far greater occurrence of older annual classes was easily confirmed.

4) First, late in the autumn, during October, November, and even later, there suddenly appeared great quantities of fry of the year in the fiords that were investigated.

5) During summer, great numbers of fry of fish with demersal eggs were met with in the fiords.

The clear disproportion, thus exhibited, between the richer occurrence of the older stages of fish with pelagic eggs which spawn in the fiords, and the excessive paucity of the fry of the year in the fiords, during summer, *can, in our opinion, only be explained by the strong out-flowing current, during the spawning season, removing the pelagic eggs from the fiords and our south coast, thereby preventing the bulk of them being hatched prior to their reaching the waters of the coast. The sudden occurrence of the fry of the year in the fiords, during autumn, must be regarded as an immigration.*

We shall, further on, endeavour to elucidate, and enter more fully into the details connected with this explanation, which, in our opinion, throws a new light upon many truly scientific and practical questions.

That part of the results of our labours which affords the strongest basis for our view of the circumstances, is, undoubtedly, the peculiar distribution of the quite infantile fry, this being a fact which must be regarded as allowing of no controversy, it having been proved to be so, as regards south Norway, by the researches undertaken during three, and, in respect to the northern portion of the country, during two succeeding years. We are, naturally, aware that, within certain limits, variations may occur in the distribution of the fry during various years, and we shall, subsequently, return to this question.

In order, however, to shew that our explanation of this fact concerning the peculiar distribution of the fry during summer, is correct — a fact that has been established by much labour — it is, first and foremost, necessary to prove that, the outflowing current of the spring and early summer is an equally indisputable and well founded fact.

The current running from the mouth of the Christiania Fiord to Lister, which forms the northern branch of the Baltic current, runs, according to Professor Mohn's statement in the Report of the Norwegian North Atlantic Expedition, at a speed of 10 miles in

the 24 hours, and is, moreover, so well known to all seafaring men, that it is quite unnecessary to make any further attempt to prove its existence.

That this current contributes to drawing the surface layers away from the Christiania Fiord is apparent. In their treatise on the Christiania Fiord and Skagerrak, No. 2 of this Volume, Hjort and Gran have also shewn how the spring, and especially the spawning season, are characterised by outflowing surface currents, which can, almost entirely, remove the surface plankton from the fiord. Thus they state, see page (37), «Fig. 9, shews a section of the Fiord in December 1896 (Tab. I. d) . . . It was remarkable that, at the two innermost Stations, Drøbak and Steilene, temperature and salinity of the surface, were greater than those of the outer stations; yes, higher even than in the whole of the northern portion of the Skagerrak. This can only be explained by the surface water having been forced in an outward direction by the prevailing northerly winds and replaced by warmer, and salter water from the deep. The Plankton Tables shew the same: the two innermost stations are wanting in the characteristic plankton which, otherwise, is spread over the entire surface of the Skagerrak and the Christiania Fiord.»

We may also further refer to Fig. 10, on which it is stated: «The farther the advancement up the fiord at that time of the year, the higher, therefore, will be the salinity of the upper layers, down to a depth of 40 to 50 metres. In the summer and autumn the salinity was, invariably, lowest in the inner part of the fiord, both on the surface and in the deep — — — This could only be explained in *one* way, viz., through the bottom layers in the inner portion of the fiord having moved in an inward and upward direction whilst the surface layers have flowed outward. The northerly winds having, probably prevailed for a time, forced the the surface water outwards and the inflowing undercurrents ascended as a necessary compensation. It is, also commonly known that, the surface water in the Christiania Fiord is saltest during northerly winds, whilst southerly winds dam up the fresh water, as it were, in the inner portion of the fiord. It may therefore happen that the fiord during winter is free from ice as long as the weather keeps cold. with northerly winds, but when milder weather sets in with southerly winds it freezes as the cold, fresh water on the surface, remains stationary, and the inflowing warm undercurrents are stopped.

Further on it also states how (Fig. 10) the plankton is clearly conveyed away by the outflowing surface layers. Numerous direct observations, and also experiments with floats (bottles), have clearly proved that, the current of the Christiania Fiord, during spring, mainly flows in an outward direction (we naturally do not deny that variations may occur).

Thus, on the 15th April, 150 bottles, containing post cards, were set adrift at three Stations in the Christiania Fiord, viz., Filtvedt, Vallø and Færder. Of these 72 were recovered.

The bottles from the innermost as well as the outermost stations had all drifted outwards. About half of those set adrift at Vallø had drifted outwards, the other half having gone ashore in the neighbourhood of the spot, at the east side of the fiord. The length of time that passed ere we got back the bottles varied greatly, which might be expected, as some of them may have lain for a very long time on the beach before they were recovered. It is thus those that reached us soonest, which must be regarded as being the most instructive. We give herewith a few instances of setting them adrift, and their recovery.

Set Adrift.	Recovered.
Filtvedt, 50 bottles, 15th April	Borre, 23 bottles, 15th April
	Vallø, 5 » 16th »
	Aasgaardstrand, 1 bottle, 17th »
Vallø, 50 bottles, 15th April	Bollærne, 8 bottles, 17th »
	Tjømmø, 2 » 18th »
Færder, 50 bottles, 15th April	Grimstad, 1 bottle, 11th May
	Lindesnæs, 1 » 24th »
	Lyngby Strand
	(West Jutland) 1 » 30th »
	Sylt, Schleswig 1 » 17th June

Many bottles, especially those set adrift at Færder, had covered great distances, many being recovered and returned from various parts of the south coast, even west of Lister. The greater part had, however, drifted to Jutland, and down the west coast of Schleswig and North Germany.

In respect to the Trondhjem Fiord, we also deem it to be a fact that the surface current, during spring and early summer, mainly runs in an outward direction. That fiord is very favourable to direct observations of the current, as it contains many very narrow channels, as at the outlet of Beitstad Fiord, where the fiord is not more than 600 metres in width, and at Agdenæs where the width is about 2 miles. In Skarn Sound (the outlet of Beitstad Fiord), it has often been observed that, even the highest flood tide has done no more than check the speed of the out-flowing current. It has, besides, been a long established and well known fact to navigators there, that in calm weather, during spring and early summer, one may let ones vessel drift out with the rapid current during ebb tide, even when the water has commenced to rise, whilst it is impossible to drift in on the flood. This is the case too at Agdenæs which, during the whole of the first part of the summer, is an extremely difficult spot for sailing vessels to pass on their voyage up the fiord, unless favoured by a strong favourable breeze, no matter whether the tide is flowing or not.

As a general phenomenon it may also be mentioned that vessels, which at that time of the year are, in almost any part of the Trondhjem Fiord, caught in one of the frequent calms, drift outwards.

We might add numerous examples, from our own experience, illustrative of this well known phenomenon, such as how at the island Garten (off the point of Ørlandet) we saw that the current, week after week, flowed outwards with great force, both in June as well as July, and that only very strong, and prolonged westerly gales first brought about a change in that respect. Thus about the 20th July 1899, hurricane-like gales commenced, and caused the surface current to flow inwards. These gales only ceased towards the middle of August, and the pent up waters then ran outwards with a strength that proved an obstacle to navigation with sailing ships. This surface current has also been tested with floats. Thus at different times, during April, August, and November 1898, bottles containing post cards were set adrift at the island Tautra, of which a large number were recovered. Those set adrift in April had all drifted outwards, some 50 *per cent.* of the entire number reaching us after the course of a week, even from the outermost parts of the fiord.

In August the conditions were alike, as bottles were found even in the course of two days on the island Storfosen. All the cards received

from these two trials had been spread over the outer parts of the fiord and island belt. Not one was found inside of the spot where they were set adrift. First in November did the trial exhibit any change, as the bottles were then recovered at various places in the neighbourhood of the place where they were set adrift.

All our observations thus shew that, on the surface of that fiord, currents exist analogous to those that have been observed in the Baltic, Cattegat, Skagerrak and Christiania Fiord. The existence of a predominating, outflowing current on the surface of the Trondhjem Fiord during spring and summer, must thus be regarded as an indisputable fact. That differences or doubts may arise as to what physical causes play the greatest part in producing the phenomenon is quite another matter, and really has nothing to do with the problem we have endeavoured, mainly, to solve by our researches, as it is the existence of a current, and not its causes, which is of general interest to the subject we have to deal with.

The value of the various hydrographical factors respecting this current can, naturally, only after lengthy observations be explained, and it will also be of importance that this is done in order to allow of ones comprehending the variations which we know must take place in the general distribution of the fry of fishes.

We will, however, now state, as our opinion, that the two most important factors are, probably, on the one side, the amount of the rainfall, and on the other, the Atlantic water which, during summer, as an undercurrent accelerates the outflow of the surface water.

How great a part the rainfall plays in this connection can easily be seen when one takes into consideration the very great size of the fluvial basin presented by the fiord. It is bounded on the north by the heights of Namdalen, on the east by the Swedish frontier mountains, and on the south by the Dovre-Field. Almost all water from the northern slopes of the Dovre Field descends to the Trondhjem Fiord. The rainfall in that district averages 816.8 mm. Most of this rainfall occurs in the autumn and winter, and the greater part is stored in the form of snow and ice so that it is first during spring and early summer it finds its way to the fiord, or just at the time when the outflowing currents prevail. An accurate study of the Rainfall Observations in Norway, published by the Meteorological Office, makes this condition very apparent.

The next question of importance to us is, Do the majority of the pelagic eggs float in the surface current?

As will be seen from our account of the fishing trials, we have not, from our fishing investigations, found any reason to allow of our replying to this in the negative, as we regard it as exceedingly significant that we never were able to procure large quantities of eggs unless we skimmed the surface water with our pelagic net. As, however, many scientists have, formerly, investigated the vertical distribution of pelagic eggs, we cannot omit going more deeply into the results attained by those scientists, the results of which, at first, caused us to entertain considerable doubts respecting the facts established by our own investigations.

Hensen and Apstein, the first who had undertaken comprehensive investigations concerning pelagic eggs, classified them in 5 stages, and, by the aid of their great numbers of vertical hauls, endeavoured to shew how the eggs were distributed down in deep water. They thus assume that the older stages, generally, are suspended at greater depths than the younger. They also appear to hold to the idea that the larvæ also keep down in deeper water.

Our investigations shewed, as will be remembered, that it was, chiefly, the younger stages of eggs we procured in the uppermost layers of water, whilst the older stages were scarcer, and the larvæ as good as absent altogether. According to Hensen's theory, this condition, which we have ascribed to the influence of the out flowing current, is due to the sinking of the older stages.

In respect to this we may remark that, notwithstanding the most numerous attempts, both with pelagic nets, and engines of such a size as Dr. Petersen's trawl covered with tulle and gauze, at depths down to 15, 20 and 30 fathoms, we did not succeed in finding other stages than those we obtained on the surface. 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. Opposed to such a distribution as that assumed by Hensen, is, too, the first classical experience gained on the subject, and published by G. O. Sars in his account of the investigations undertaken in the Lofotens. He thus stated several times (in the scientific Report published in *Chr. Videnskabselskabets forhandling*, 1865, P. 248) that the larva, after leaving the egg, floats upon the yolk sack.

We have often had an opportunity of proving that this is the case from our own experiments in aquariums. Only when the yolk sack has been absorbed, does it appear that the pelagic young fish become gradually distributed throughout the water, notwithstanding that, even then, great numbers of them move about close to the surface itself. This is all very clearly seen from Sars's Report, 1866—67. On pages 34, and 35, one may read:

«During the days following my arrival (at the fishing haven Skraaven, 7. 5. 1866) on fishing with a fine net on the surface of the sea, I still obtained floating cod spawn in no inconsiderable quantity, but always only in the very latest stage of development. — — Wherever I tried, I caught a number of young cod in the net, both those that had just left the egg, and which were still furnished with the large, shapeless yolk sack, as those in which the latter was quite absorbed, and which, consequently, had commenced to lead a more independent existence. — — Thus, a little while after, one calm, lovely day — 20th May — I observed in the shallow sounds and creeks, which had light sandy bottoms, on the east side of Skraaven, great numbers of them on the surface of the water. — — They were still, at all events, but 7 to 8 mms. in length, and their transparency was so great that it was even difficult to perceive them against the light, sandy bottom. — — As they all swam on the very surface of the water, I could catch them in a flattish china cup, and thus, without handling them, or removing them from the water, could place them in my glasses».

On the 12th June, the current in the bays had packed together great numbers of calanids; and, respecting the young cod, we find the following notice:

«They could be seen everywhere, from the surface itself down to the greatest depth my eyes could penetrate, as small, rapidly vibrating darkish threads, dilligently employed in seizing the small species of calanus. By that time they had grown considerably, as the biggest were up to 24 mms. in length».

We also are of opinion that very great doubts may be thrown on the correctness of Hensen's theory concerning the vertical distribution of the eggs, as such forcible objections can be raised to the method employed by him, that the results derived from it are unreliable. Thus, in our opinion, there were *far too few hauls made on the surface* to allow of any

comparison being made between them and the vertical hauls. Many of the surface hauls will, on examining closely Apstein's Tables, be found to have been unsuccessful (probably an account of bad weather), and even concerning those hauls which one must presume were good, one will find statements which, in our opinion, do not confirm the theory of the gradual sinking of the eggs and larvæ. Thus it appears, for instance, that up to 178 eggs of the 3rd stage might be caught on the surface, and of the 5th stage up to 6. Neither were the larvæ scarce in the surface hauls; thus on the 15th Febr., off Sylt, 6; on the 18th Febr., on the great fishing banks, 1; on the 15 March, on the Doggerbank, 2; on the 21st April, off Heligoland, 2 (haul from a depth of 5 metres). These results are thus not convincing proofs of the theory that the fish live, chiefly, deeper down, especially when it is considered that most of the surface hauls were made very early in the season when larvæ were scarce, as will clearly be seen on making a close comparative examination of the Table.

The very fact that Hensen's vertical hauls were effected with a pelagic net which could not be closed at certain desired depths, sets aside, in our opinion, all right to draw conclusions, concerning the vertical distribution of the eggs, from the materials he had procured. It must be apparent that, when the figures representing the occurrence of an organism on the surface can vary so greatly, a fact that everybody who has studied this question concerning the eggs well knows, and which, moreover, is shewn by Hensen's own trials, it is but an illusion to imagine that one, by inference, can form conclusions concerning the distribution of organisms down in the deep. when one has not employed apparatus which prevent any mixing of the organisms caught in different layers of water.

As regards ourselves, we have not had any need of employing closing apparatus, as we never caught, not even in trials with the ordinary appliances in the deep water of the fiords, any specimens differing from those of the surface in respect to the stages of eggs.

Amongst other investigations in this field of research, we may also mention a newly published work by H. Chas. Williamson. «On the Pelagic Fish Eggs and Larvæ of Loch Fyne» (Seventeenth Annual Report of the Fishery Board for Scotland).

It will be seen that the Author, who has studied the occurrence of

pelagic eggs in Loch Fyne, Scotland, quite independently of our researches, has arrived at results in respect to that loch, which in many points remind one of those obtained by us in Norwegian waters. In going through his Tables respecting the take of eggs, one will perceive a similar peculiar occurrence of early stages of development predominating in the inner part of the loch (fiord), and one will also perceive that the Author has been of the opinion that the out flowing current which prevailed there, had removed the eggs from the upper parts of the loch. The Author has not been able to go beyond this point, as he had no opportunity of investigating the further occurrence of the growing fry in the vicinity of the beaches. That Author's method of testing the vertical distribution of the eggs is, however, open to the same objections as those we have already made in respect to the results arrived at by Hensen.

We have had an opportunity of, cursorily, making some investigations of the fry of that loch, and we may say that on a closer examination of the distribution of the fry, it will probably be seen that the conditions are very similar to those of the Norwegian fiords that have been subjected to our researches.

Concerning the specific weight of the eggs, and its possible influence on their vertical distribution, we have not had any grounds for instituting any special enquiries, as our investigations proved that the bulk of the eggs float in the uppermost layers of our waters. Neither can we attach any decisive importance to such specific gravity determinations in deciding the questions before us, and it especially appears to us to be wrong to form any theory concerning the vertical distribution of the eggs on the basis thereof. In our opinion it seems to be of far greater consequence to determine, by fishing, in which layers the eggs *really float*, than, guided by their specific weight, as found in a laboratory, to determine the layers in which they *ought* to float.

We mention this here, because, in this country, such purely speculative theories have been set forth in certain quarters, based upon investigations, concerning the specific weight of the eggs, which have been carried out in other countries, for instance by Dr. Petersen in Denmark, and Prof. Hensen in Kiel. Such investigations have, however, been partly supported by contemporaneous studies of the resort of the eggs in reality, and are thus of considerable value. These researches have thus shewn that in the south-west portion of the Baltic, and the Danish Belts, the pelagic eggs

may sink down to deep layers when very fresh bodies of water are conveyed to those localities from the eastward. Hensen has even shewn how the sperm is killed, and the reproductive elements become destroyed when the salinity falls below a certain point.

According to Dr. Hensen the non-impregnated eggs of the plaice are of a specific weight which allows of their floating in water of 18 ‰ salinity. Eggs of cod that have just been impregnated (covered with sperm) float, according to the same authority, in water of 19 ‰ salinity. In the open sea they float in water of even lesser salinity.

According to Dr. Petersen (Biol. St. Beretn. 1893 p. 28), the lowest salinity in which all of the plaice eggs, investigated by him, float, is 18.5 ‰. Half of the eggs sank in water of a salinity of 17 ‰, and all sank in water of 14 ‰ salinity.

Dannevig, in Flødevigen states that, in his aquariums, water of a salinity of 26.7 ‰ is required to support the eggs of cod.

Even if special importance is attached to these results, it cannot be doubted that the eggs must float in the waters that have been subjected to our researches, as the salinity during the spawning season was, according to our observations, greater than that of the above mentioned figures. As regards the Christiania Fiord, the reader is referred to the accompanying treatise (No. 2). According to Dahl, the salinity of the Trondhjem Fiord, during the spawning season, is even considerably greater, most often exceeding 30 ‰.

We will, furthermore, not omit mentioning that the determination of the specific gravity of an egg in a laboratory cannot, as a matter of course, apply to an egg floating in the sea, as, naturally, in such an experiment, no allowance can be made for variations of temperature, salinity and other physical factors which occur under natural conditions, whose influence on the eggs have not been studied.

In thus regarding it as certain that the bulk of the eggs, in those waters investigated by us, float very near the surface, the current must have a decisive influence on their distribution.

The question then arises «to what distance can these eggs be removed from the places where they were spawned, before they become developed to the size of fry which we were able to secure with our apparatus in the littoral regions, and on the bottom?» It is, naturally, impossible to give a direct reply to this question, but we believe, that our experiences concerning

the distribution of the fry along the beaches of the waters we have investigated, will add something to our knowledge of the general course of the phenomenon.

When one remembers that the pelagic eggs drift in the sea for some 18 days, and that the larvæ drift about for a still longer time, and when we also recollect that the floats we set adrift were clear of the fiords in the course of a few days, it is not wrong to surmise that it *is possible* for a pelagic egg, or a larva, to travel a very great distance.

We do not for a moment imagine that their drift should always be the same, or that all the eggs should travel an equal distance, as it is but reasonable to assume that the conditions must to a very considerable extent vary.

When, as the main result of our researches, we have given prominence to the fact that, the infantile young of fish producing pelagic eggs but very rarely occur in the Christiania Fiord, and parts of the south coast, as well as in the Trondhjem Fiord, and, as a contrast to this, have pointed out the vast wealth of such young to the westward of Lister, and in the vicinity of the island belt off the Trondhjem Fiord and Nordland, it has not been our intention to imply that the eggs of the Christiania Fiord had arrived on the coast of Jæderen, or that the eggs of the Beitstad Fiord had hatched, and developed into fry in the belt of islands off the Trondhjem Fiord.

In our opinion there are many factors which must be taken into account, whose value we, for the present, are not in a position to determine.

It must thus, therefore, be certainly presumed that, the distribution of fry, in its details, may be very different in respect to the various species.

That which we, however, consider to be of general value, in regard to the distribution of fry, is that the shores of the open sea, or open waters, may be said to be preeminently the resort of the year's fry (of fish with pelagic eggs) during summer, and that both from the fiords, as well as the more open waters inside the fiords, a transportation of eggs and fry takes place with the flowing waters, of far greater dimensions, and far greater scope than has, hitherto, been presumed, so that neither eggs nor larva can be regarded as being confined to any fixed locality.

In attaching so great importance to our fishing of fry, and the results gained respecting its peculiar distribution, it is because we regard these as a basis, as facts that cannot be disputed. We will, however, state that our fishing trials were carried out, practically only in the littoral region, and on the bottom, so that there thus remains a possibility open, viz., that the fry may live in mid-water layers both in the fiords, as well as in the open sea, but of this, however, so far as we know, nothing is known, and we have had no opportunity of carrying out investigations, chiefly because we have not known of any apparatus suitable for such a purpose.

The possibility may be imagined that the scarcity, for instance, of cod fry in the fiords, and the sudden increase in the numbers of the fry that takes place during the autumn, might be due to the bulk of the fry having, until such time, led a pelagic existence. Nothing, however, can be stated positively as regards this question, and as regards the fiords, we are not inclined to attach any great weight to such a possibility. The results we have obtained from our researches in the fiords renders it, in our opinion, improbable that great bodies of fry should lead a pelagic existence, or that the time of the occurrence of fry in the littoral region should be later in the fiords than on the coast just outside them.

Both the outflowing current, as well as the appearance of the eggs in it, and the excessive paucity of larvæ, does certainly not appear to encourage the belief that later stages should occur in numbers in the mid-water layers of the fiord (we have not been able to prove the existence of pelagic young of fish with pelagic eggs, even by trawling in the mid-water layers down to a depth of 15 to 20 fathoms).

Another fact that is very striking, owing to its contrast, is, that quite small fry of most of the species which lay demersal eggs (or hatch them on, or inside their bodies) and of which the first stages, in any case are quite bound to the locality, were caught everywhere in the fiords without difficulty, occasionally in great quantities. We thus constantly caught the young of gobies and *gasterosteus aculeatus*, (at times many litres in one haul), *cyclopterus lumpus*, *zoarces viviparus*, *centronotus gunnellus spinachia vulgaris*, all the *syngnates*, *raja* species *chimæra monstrosa*, and *spinax niger*. All the young of these species, at all stages, can be caught without difficulty and, occasionally, in great numbers when the species is numerous.

Even of such a fish as the herring, whose young are to a great extent pelagic, we have had no difficulty in catching the quite small fry. Up at the very mouth of rivers, too, we have been able to catch thousands and thousands of young herrings, 6 cms. in length in one haul. Even of such a fish as the capelan (*Mallotus villosus*), which, for instance in the Trondhjem Fiord, is somewhat scarce (one full grown specimen was caught in 1895), quite infantile young have been taken in the littoral region of the fiord. These facts alone shew, in our opinion, how much less dependent these young fishes are on the movements of the water than are those of fish which produce pelagic eggs.

That, however, which is most favorable to our opinion that even within the fiord region but very few young of fish producing pelagic eggs are to be found, is the fact that there is a paucity of almost every species of fish during the first summer of their existence, yes, even during their first year of life, yes, even later on during their development. In our opinion it is exceedingly significant that, the smallest plaice caught in the Trondhjem Fiord, inside Agdenæs, was 6 cms. in length, and that, inside Drøbak, none were found of a lesser length than 8.5 cms., whilst even the smallest stages were obtainable on the coast (We naturally do not deny the possibility that small ones *may* be met with in the fiords; but as, notwithstanding all our endeavours, we did not get them, we must regard the circumstance as being exceptionally striking).

Neither in the Christiania Fiord, nor the Trondhjem Fiord did we get *one* specimen of the young of the first year of the whiting, while, for instance in the Christiania Fiord, up to 800 of older stages may be taken in one haul, and this notwithstanding that the fish in great numbers spawn in both those fiords, and notwithstanding that the infantile young whiting may be caught, even at midsummer, on the shores of the open sea.

A fish like the pollack, which, in great numbers, spawns in the Trondhjem Fiord has not been observed in any great number until it is about one year old, and, in abundance only, when it is about two years old. On the west coast and in Nordland, we have caught pollack, as half a year old young, in numbers.

The coal fish, a fish which gives rise to an important fishery in the Trondhjem Fiord, and which in some places, even in the innermost portions of the Fiord, may occur in such numbers that the

shoals can disturb the surface like a gale of wind, was even as a year old fish, and even as a fish of two years, comparatively seldom caught by us. The coast, and outer parts of the fiord swarm with coalfish of all stages.

Of the *Gadus minutus*, which, for instance, in the Christiania Fiord may be caught, when adult, in great numbers in the littoral region, not a single young was obtained in that fiord.

Concerning these conditions and a more detailed description of them, we must refer the reader to Chaps. III, and IV, in which everything has been more fully discussed.

As specially illustrative of our views concerning the involuntary migration of the eggs and larvæ from the inclosed waters, we must also refer to the conditions of the coves, or creeks, which are connected with the fiord by narrow sounds. In many of these there will be found, especially during spring, multitudes of full grown fish (for instance, cod) and, in parts, great spawning takes place, but, notwithstanding this, the young of the year are not found during the summer, and even older annual classes, especially 1 to 2 year old fish, but rarely are met with. As an instance of this we may refer to the experiment mentioned by Wollebæk in Chap. III, Page 58, where such a creek was blocked with a net, and ripe cod transferred to it, but where not a single young fish was subsequently caught when fished for.

The Borgen Fiord, in the Trondhjem Fiord, may be mentioned as another example. There, during 1898, great numbers of cod were caught. Fishing for plaice was also carried on there. Both those species (besides others) spawn in the fiord; yet, nevertheless, though many fishing experiments were carried on by Dahl, no great occurrence of fry was observed.

As regards the open coast, and the sea itself, we do not consider it precluded that fry of the year, of a similar size to the young that may be met with in the littoral region, may also occur as pelagic fish; but, in such a case it must be assumed that, probably, some portion of the multitude of fry has been temporarily prevented by the action of winds and currents, from reaching, or remaining in the littoral region, which, in respect to the bulk of such fishes, must, at all events at present be regarded as their true habitat.

(Sars, in his previously mentioned Report, 1866—76 Pp. 42, 43, states, that he had caught great numbers of young cod, 5 to 6 cms. in

length, which swam on the surface, in shoals, at a great distance from land. The size of these was even greater than that of the smallest fry we have caught in the littoral region).

We are also of the opinion that the sudden immigration which takes place, during autumn, in some years, is due to similar causes, and *may* thus be accounted for.

It is not, in our opinion, necessary to assume that such a migration must necessarily take place actively; but that it may well be imagined to occur, as a matter of fact, with the moving layers of water. This assumption gains in force from the fact that, the sudden appearance of both great quantities of fry, as well as of older fish during the autumn, which is observed at Drøbak in respect to the cod, occurs simultaneously with the influx of water layers from the Skagerrak during heavy south westerly gales. Yes, in years in which such changes have taken place later than usual, the appearance of the fry *en masse*, has only been observed after the hydrographical changes had occurred. — Thus, for instance, during the autumn of 1899, when the cod fry appeared in the middle of November, after *hurricane-like westerly and south westerly gales*, which forced the waters of the Skagerrak into the fiord. In the previous year the fry appeared so early as the middle of October.

Hjort has already explained, in «Hydrog. Biol. Studier over Norske Fiskerier 1895» (see Pls. A and B), how, during the autumn, the water layers of the outer Skagerrak, gradually move in towards the fiord.

That these water layers *may* convey with them even full grown fish — for instance, herrings — appears from the investigations that were carried out by Hjort, Petersen, Ekman and Cleve. It is thus, for instance, well known that, strong south westerly winds, which force the water in from the Skagerrak towards the entrance to the Christiania Fiord, may bring about the arrival of vast shoals of herrings at the mouth of the fiord, so that such weather is regarded as indicating the approach or presence of those fish («a Herring sign»).

The results gained by us thus throw some new light upon a very important scientific question, viz., the question of the local confinement of the edible fishes. Especially as regards the fiords and more inclosed waters, it has been regarded as a given fact that, those fish which lived there spent their entire lives in such waters, and formed so-called «local tribes» or «races».

The results attained by us upset this idea, as the dependence of the pelagic spawning fish, in their various stages, on the waters, cause the young fish to be removed far from the spot to which their parents resorted during the spawning season. The very circumstance that a fish produces pelagic eggs, ought, in our opinion, to be sufficient to throw doubt on the existence of local tribes, so far as those fishes are concerned. We will not deny the possibility of finding some few fishes which spend the greatest part of their lives, in the fiords. Thus it might well be imagined that the few fry which remain, may grow up in the fiord and assume a somewhat different character from that of the more migratory individuals, but even those cannot be described as a race or tribe, as any assumption of their being so would, necessarily, require proof that their young also grew up in the fiord, or, in fact, that they lived there generation after generation.

Our view concerning the passive movements of the fish in its earliest stages tells, however, against such a theory, and that the fry, or young fish, which immigrate during the autumn, or even later, are the offspring of the very fish that spawned in the fiord can hardly be maintained.

It is only amongst those fish which deposit and fix their eggs at the bottom (demersal eggs), or those that are viviparous, that one can imagine local tribes, and, even amongst such fish, there are many which are nearly just as little confined to one locality as those that produce pelagic eggs.

The support which the «local tribes», or «races», have given to the theory concerning the decrease in the number of edible fishes (especially locally) must thus give way, and, therefore, as regards such localities, our results form bases on which a fresh knowledge of this condition can be built.

We have shewn how the edible fishes, which possess pelagic eggs, do not belong to any certain, confined, fiord or locality, but belong to

considerably vaster waters or pales of ocean, and before any local diminution could be noticed, a general decrease throughout the entire water region would have to take place.

These, our results, however, only throw light upon some more general factors respecting this question, and before we proceed to further extend their bearing on practical problems, we will give further details of our experience concerning three different species.

Chapter VII.

The Plaice.

So far as our knowledge of this species extends, we know that it never lives at greater depths than 50 fathoms, or 100 metres, and not in abundance at any depth below 30 fathoms, or some 60 metres. With the exception of the eggs, and the early pelagic stage of their existence, *all* sizes of this species will be found on the bottom between depths of 60 to 0 metres, from the tiny young fish, in its first bottom stage, 15 mms. in length, to the gigantic adult fish, which may attain a length of almost 80 cms. (weight about 8 lbs). These different sized fish will be found distributed in a fixed, consecutive order, the smallest fish being nearest the shore, the largest at the greatest depth. This species is, to a very great extent dependent on the nature of the bottom, especially in the first bottom stage of its existence. For instance, small plaice are to be found only on sandy bottoms, this including, too, very shallow, sandy bottoms.

The range of this species is thus very well defined, and the distribution of the various sizes, in connection with the small depths at which they occur, contribute, not a little, towards making a study of the species an easy task.

So dependent, is it on its natural surroundings, that even in the laboratory, when studying a chart of depths which gives good information respecting the bottom, one is able to form, pretty accurately, a very good idea of its occurrence.

And when sailing along the coast, the very configuration of the land itself, will often give one some conception of the conditions essential to the life of this species.

If we turn to those countries where the plaice fisheries are greatest, where the species occurs in vast numbers, for instance Denmark, Holland and England, it will be found that all those countries own *open* sandy shores. And if we study the waters which surround them, we will find that they are of very little depth, and that the smooth bottom, mile after mile, evenly, yet almost imperceptibly, rises towards the shore.

On the western shores of Jutland one has thus to proceed over one degree (or 60 miles) to sea, in order to obtain soundings of 30 fathoms. On the shores of Holland, and the south east of England, 30 fathoms of water are not met with except at a distance of $2\frac{1}{2}$ degrees (150 miles) from land. Off St. Andrew's Bay, in Scotland, 30 fathoms of water are only met with 20 miles from the shore, and for every mile seawards the depth of water does not increase much more than one fathom; and this is generally the case off the shores of the countries mentioned.

From this it is easy to understand that enormous tracts exist suited not only to the existence of fully grown fish, but to that of the infantile fry, and all sizes of growing fish.

If one recalls all that we have previously related concerning the Norwegian Coast, one will perceive that, at a very short distance from land, the bottom falls abruptly down to a depth at which the fish cannot live. The steep rocky cliffs, stony slopes and débris of rock at the bottom of the sea, do not offer them any conditions under which they could exist, and the regions inhabited by the fish are confined to a very narrow, and often interrupted or broken ledge, along the shore or islands, on which the nature of the bottom, itself, may often be more or less unfavourable to the life of the fish. The shallow sandy bays and beaches in, and on which the small fry are reared, are few, and far apart, seldom facing the open sea, being generally shut in by islands rocks and reefs.

When the plaice has spawned, and its eggs, after impregnation, rise to the surface of the water, and there undergo their process of development, they often drift, both as eggs and larvæ, far from those spots where they were spawned, and if the young fish, at the end of their larval stage when the eyes move over to the left side, find themselves

at any great distance from the shallow waters that they *must* frequent, their chances of life become, naturally, diminished, according to the distance between themselves and the shallows. It must be assumed that great numbers of young fish are therefore lost through their inability to reach those resorts that are suitable to their existence.

On the shores of Denmark, Holland, and England, where the shallow waters cover enormous open tracts, the fry can, with far greater ease, reach its resort on the bottom; all the more so, indeed, because it certainly often terminates its larval existence over, or in the vicinity of such shallows.

When, in our Norwegian fiords, sounds, bays and on the open coast, the eggs of the flounder are driven out with the fresh surface currents of spring, they are soon conveyed away, and the larvæ undergo their development floating above those vast depths that exist but a short distance from land. And when the development is concluded, it is quite a chance whether the quite infantile fish can reach those localities, so diminutive in comparison to the vast extent of the coast, which are most suited to the growth of the fry of the plaice.

The quantity of the fry has been investigated by means of the eel hand seine, and even still finer meshed nets, at very many spots from Christiania to Jæderen, and from the Trondhjem Fiord to Bronø, and, in order to give an idea of its abundance, we may give an account of some of our best hauls.

Extract from Hjort's Journal.

3rd September, 1897. North east shore of Eløen, near Larkollen Christiania Fiord.

Bottom covered partly with tangle, partly sand, close to land. Fine meshed ground seine; *many hauls*:

28 plaice, from 7 to 27 cms. in length (about half, of the smallest annual stage).

20th September, 1897. Sandøen, Sandøsund, near Færder; fine-meshed eel ground seine, sandy bottom (many hauls) — — 26 plaice, 7 to 11 cms. in length.

20th September, 1897. The islands near Færder. Large meshed Danish plaice seine, 12 to 14 fathoms; two hauls, 120 and 60 fathoms of rope on each arm, respectively, — — — — 54 plaice, 17 to 32 cms.

29th July, 1898. Hafrs Fiord.

Four hauls at the head of the fiord, of which three in very shallow water, with a bottom of fine sand, one being in somewhat deeper water on a bottom covered with *zostera* — — — 32 plaice, 8 to 28 cms. in length.

1st August, 1898. Solesand, Jæderen.

Ground seine, and silk seine (several hauls) — — — — —
«not a few young of the plaice (8 to 10) from 3 cms. in length, upwards»
— — — — —

(The Figures from Hafrs Fiord, and Solesand were characteristic of those obtained at many places along that part of the coast).

Extract from Dahl's Journal.

7th March, 1898. Strømmen, Inderøen (Trondhjem Fiord), many hauls (about 10) in the neighbourhood of Sundnæs Bay and Vika Bay, on a sandy bottom (eel ground seine) — — — — 39 plaice, 5 to 24 cms. in length (most about 9 cms).

17th March, 1898. Ilsviken, Trondhjem. Sand bottom. Many hauls with the eel ground seine. — — — 11 plaice, 6 to 11 cms, in length —

End of June. Bejan and Storfossen.

Many hauls during the course of several days yielded but a few plaice of the previous year, and 3 or 4 of the present year's fry (2 to 3 cms. in length).

It is, naturally, but a few of the localities investigated that are mentioned here. We deemed it only necessary to give the figures obtained at those places which, from a Norwegian point of view, must be regarded as possessing an abundance of fish, and which we only succeeded in finding with difficulty.

By way of comparison we may add some extracts from the Danish Journal of Fishery Investigation.

29th May, 1883. 2 miles S S E. of Dueodde Light (Bornholm), 18 fathoms. Sand. Fine meshed seine (1 haul) — — — 162 plaice $5\frac{3}{4}$ to $11\frac{1}{4}$ " — — — —.

7th August, 1893. Møens Lighthouse, $8\frac{1}{2}$ fathoms. Sand. Fine-meshed seine (1 haul) 295 plaice, 4 to $13\frac{1}{2}$ ".

9th August, 1893. 18 miles S E. of Møens Lighthouse, 10 fathoms. Brown sand. Fine meshed seine (1 haul). — — — 594 plaice $4\frac{1}{2}$ to $11\frac{3}{4}$ " (over 1000 flat fish in the one haul),

20th September, 1893. Northern Cattegat (Bangbosstrand).

Shrimp net on the beach — — — — 234 plaice, 1 to 2" — — — —. In his treatise on the flounder in the Lim Fiord, D. Petersen states, *inter alia*:

«When the cutter, which fishes for fry to be placed in the Lim Fiord, does not obtain at least 4000 in each haul of the seine, the fishermen are displeased, and move her to some other spot; and they take but fish belonging to group II (2 year old fish), thus comparatively large undersized fish».

If we compare the above figures with our own, the difference in the numbers obtainable on the two coasts must be very apparent.

Whilst on the flat shores of Denmark hundreds, aye thousands of fry, or young fish may be caught in one haul, it is only by using the same apparatus many times that we, amongst the islands, in our fiords, and along our coast — and this only at a few places — can succeed in catching one or two score small sized plaice.

The same immense difference will also clearly, aye, possibly still more clearly, appear on comparing our figures with the reports on the number of flat fish fry which are *destroyed* at some places on the English coast, for instance, during the shrimp fishing in Lancashire, to which we will refer later on.

Whilst on the Danish coast, hundreds, or thousands even, may be caught in one haul with good apparatus, the figures in respect to Lancashire mount up, occasionally, to *tens of thousands*. It is true that the total catch includes several species of flat fish, but the figures appear, to us, to be sufficiently instructive in shewing the difference existing between a shallow, sandy shore, and the rocky coast of Norway.

If, to this, one further adds the facts concerning the conditions respecting the reproduction of fish possessing pelagic eggs, which, in our opinion we have established, and which in a previous chapter have been generally given, the reason of the scarcity of this species along our coast will, certainly, be understood.

We have by direct experiments shewn that the current, for instance in the Trondhjem Fiord can convey a drifting body out to the island belt in the course of a couple of days, while the strong current running out of the Christiania Fiord and the whole of the Skagerrak is well known. And those currents are, certainly, not peculiar to those fiords or waters.

It must be presumed that the surface of the whole of the waters washing the shores are in a general state of outward motion during the entire spring and early summer. The plaice, is, along the coast and in the fiords, compelled to spawn very close to the shore — it has but a ledge to live on. The eggs are thus conveyed outwards, and may, certainly, until the whole period of its pelagic development is ended, be removed exceedingly far from the resort of their parents. But when the infantile fish is prepared to find a resort in which it can live, it finds itself, not like those of countries bordering the North Sea, floating in comparatively shallow waters, but over depths in which even the full grown fish of the species cannot exist.

Only a few succeed in reaching the few spots at which the conditions are suitable to the life of the infantile fish when in its bottom stage of existence. To what extent they reach such spots by their own endeavours, whether by the aid of fortune, or owing to their finding themselves, at the conclusion of their pelagic life, in the neighbourhood, cannot be stated, and is a question that has not, as yet, been decided by the aid of the technical resources of the present day.

It decidedly appears from our experiences that, *the annual number of the species on our coast must be regarded as very small*, not only in comparison with those countries washed by the North Sea, but also in comparison to the extent of the coast, the chief cause of this dearth being, in our opinion, the fact that, *the greater part of the eggs and pelagic young are removed from those parts of the waters in which they might have a chance of living and growing up.*

And even the annual stock of infantile fry which manages to settle on the coast, is diminished, probably, through many of the fish, entering the fiords during their subsequent development.

At no spot were we able to discover a *great annual number of the species* (great abundance of fry). *On the other hand, we have, at some places, been able to confirm the fact that great numbers of full-grown fish, are to be met with, without our being able to prove that the annual number (the increase of the fry) was greater*, a phenomenon to which we shall soon refer. First, however, we shall give a short account of the plaice fishery.

In the southern part of the country, the plaice fishery has been carried on from time immemorial, and at no spot do the fish appear to be remarkably numerous.

There appears to be a pretty close equality in the numbers of the fry, and those of fish of older stages.

At Smølen, Trøien and Vigten, the plaice fishery has only been carried on energetically for about a decade, and the further north one travels one will find the fishery to be of later date, until, finally, on many of the islands of Nordland, one comes upon virgin grounds where the inhabitants will not fish the plaice, partly because they have a prejudice against eating them, partly because they would have difficulty in getting them to market. The whole development of the fishery in the north, is closely connected with the origin and progress of the trade in fresh fish, and no inconsiderable quantities are caught yearly. There is not any statistical report on the yield of fish, and it is difficult to obtain information concerning it. Some of the fish are sent in ice to Christiania, but the greater part, doubtless, passes through the hands of 2 or 3 fresh fish dealers in Trondhjem and by their courtesy we are enabled to judge, to some extent, of the quantity that passes through that city. In any case we are not stating too high a figure when we put down the amount that reached Trondhjem, during 1898, at more than 200 000 Kilogrammes.

The greater part of the fish are caught during the spring in nets, or by spearing. When the plaice during the breeding season collect in great shoals, the fishermen visit the spots, shoot their nets, and often haul them in full of fish (often over 100 Kilogrammes in one haul — 3 nets). To a great extent, the yield consists of but *very large* ripe fish. The width of the meshes too (about 10 to the metre), only allows of large fish being captured.

During the remainder of the year but little fishing is carried on. The fish appear to be much more dispersed, and it does not pay to use nets. The inhabitants themselves often say they would not dream of fishing with nets for plaice at any other time than the spring.

Spearing is pursued more regularly, but even that is carried on with most energy during the spring. On the whole, the greater part of the quantity obtained during the year falls to March and April. During the course of April, 1898, one of the fish dealers, in Trondhjem, alone received over 75 000 Kilogrammes weight of plaice.

The greater part of the fish caught are generally quite ripe, or else have just spawned, a circumstance which considerably impoverishes the quality of the article. The spent fish is so thin, loose and impalatable, that, as fresh fish, it cannot find a market. It is, therefore, generally salted

in barrels, and exported to Holland, but the prices obtained in this manner are small compared with those that might be had if the main fishery were deferred to another season, for instance the close of the summer, the autumn, and winter.

It was with this object in view that a firm in Trondhjem made a trial with Danish apparatus on the coasts of Helgeland and Nordland, The people employed had been instructed in the use of the appliance while in the service of the Fishery Investigators, and one of us Dahl, kindly obtained permission of the firm to be present at some of the experiments.

Many of the places between Risvær and Brønø (at some of them a considerable fishery of flounders had been carried on during the spring) were tried with the plaice seine without any considerable occurrence of fish being discovered. Only some large plaice were found dispersed in deep water.

At many places it is true, it was difficult to handle the Danish plaice seine, but other trials with nets, to check the results, gave a similar result. Trials made at many spots in the vicinity of the beach with fine meshed apparatus, shewed that the stock of fry and young fish was very small. There were also very few places suitable for the growth of the fry.

Only as one advanced northward, and got amongst the islands where fishing had never taken place, did one meet with a great abundance of fish. At Trænen, for instance, in comparatively narrow channels between the islands, when the plaice seine was shot from the land with very short ropes the yield was up to *one barrel of fish in a haul*.

The greater part of the fish thus obtained were of a *large size*. The size can best be judged when it is known that a barrel only held about 50 fish.

None of us, certainly, had any opportunity then, of, personally, investigating the occurrence of fry by the beach, but we believe, nevertheless, that we can, with some certainty, express our views on that subject. The people who carried out the trials were, as previously mentioned, taught the work during our fishing investigations, were accustomed to our methods, and, moreover, were instructed to have an eye to the fry.

From their report, no great occurrence of small plaice (fry and growing fish) was perceived, just like at those spots to the southward which we had investigated.

We here, too, again perceive the small annual supply, and, therefore, the great stock, which now and then appears, is an accumulated

stock, a stock of fully grown fish which has been formed by the freedom from pursuit they have enjoyed for decades, or any number of years, and it seems to us to be an exceedingly striking example of this fact that hauls with a plaice seine which catches fish down to 15 cms. in length — hauls to the shore *in a couple of fathoms of water on a bottom of fine sand* — can yield 50 fish, which, together, fill a barrel (a good 100 Kilogrammes), of an average weight of 2 Kilos. per fish.

A visit to one of the fish dealers in Trondhjem, who receives great quantities of plaice will also furnish quite a striking picture of this fact, as the greater part of the fish one sees, consists of large, that is to say, generally full grown fish, 50 to 70 cms. in length. It is true that fish from some districts, for instance Vigten, may be smaller, and we, certainly, have had no opportunity of making accurate measurements of any great number, but the prevailing size of the fish on our repeated visits to the fish stores was most striking.

We will therefore state that the *annual* stock must, at all those parts of the coast that have been subjected to our researches, be regarded as small.

In regarding the wealth of fish occurring at some spots as an accumulated stock, it necessarily follows that great fishing would reduce it considerably. Waters can surely be fished out. To collect evidence, really effective materials to prove this is very difficult, as no trustworthy or specified statistics are obtainable.

We have been obliged, in this instance, to, chiefly, but with all due reserve, note down what has been constantly related by the fishermen in the parts we have visited, and compare their statements with the results derived from our own researches.

The leading features may be summed up, pretty well, from our experiences in the following words. In those parts of the country in which the fishing has been carried on from time immemorial, the fishermen, as a rule, are not able to report any considerably greater take of fish in former times than at present. But, the younger the fishery is, the more numerous are the reports of there having been a greater number of fish there in former times (naturally with the exception of those parts where the fishery is flourishing).

If this be placed in connection with our own experiences concerning the stock at places where, but a short time ago, a great fishery

really was carried on, and where, now, but few fish can be caught, we believe that the matter at all events can be enlightened. Many examples from the north might be brought forward shewing that where once the fishing was good it is now very poor, but the difficulty of obtaining figures respecting this — not as regards our own trials, but in respect to the fishing in former years — may be understood. One may

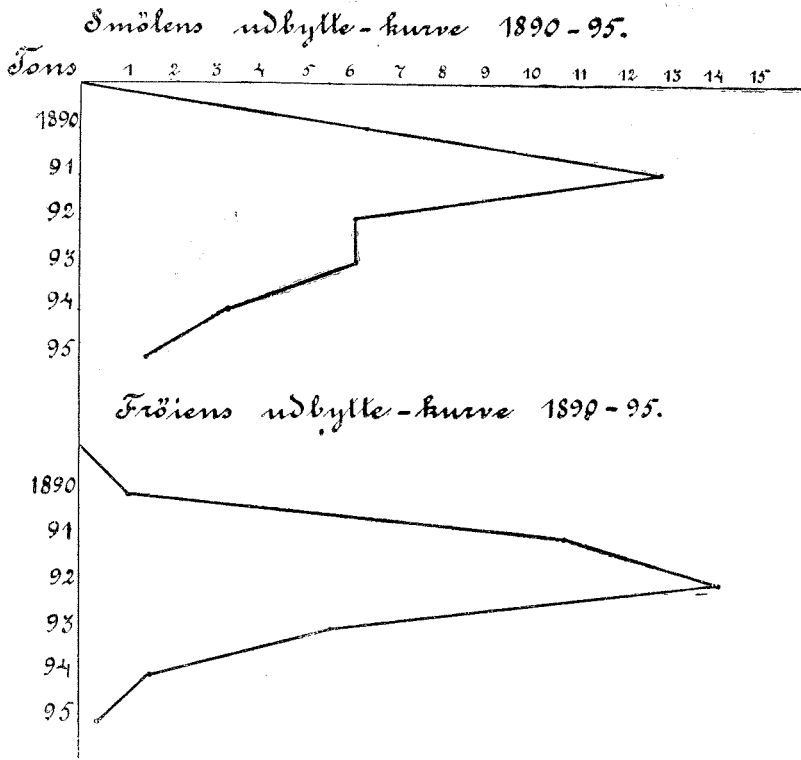


Fig. 20. Diagram, illustrating the catch at Smølen and Frøien, 1890—95.

hunt for such in the official statistical reports in vain. The sale of fish at the market in towns, the fishing pursued for home necessities, and the minor direct export carried on, escape all notice. There thus remain but the large export houses to hold to for information, but it must necessarily be seen that a working business can, only to a very limited extent, be at ones service for statistical purposes, and that a general report on the knowledge gained from the business, could, as a rule, only be supplied to us by the kindness of the managers.

And the experience gained by these business men is, that a few years' abundant supply of plaice, from one district, is followed, usually, by a scarcity.

And the history of the professional fishermen generally shews that, they steadily move northward to virgin fishing grounds.

Mr. G. Helgerud, with great kindness, has furnished us with a report on the supply of plaice obtained by him at Smølen and Frøien from 1890 to 1895, the fishery having been commenced about the time of, and probably undertaken in consequence of the great rise in, the fresh fish trade.

The accompanying two curves (Fig. 19 appear to us to illustrate in a very instructive manner the history of the fishery.

The great rise which, even during the second year is shewn by the curve for both, Smølen and Frøien, decreased very soon, and the catch, at both places, during the course of the next few years became reduced to a minimum. This appears to us to be a very good example of fishing out an accumulated stock. We will allow that the curve instead of representing the *catch*, may represent only the *business* (a decline in the trade), but from information received from other business sources, such as Mr. Hægstad's fresh fish business, it would not seem that such was the case, as Mr. Hægstad declares that the comparatively large quantities of fish which at first were forwarded to him from those places, very soon began to decline, and have now ceased altogether, or, in any case, have become reduced to a minimum. The decrease of fish at the spots mentioned is, likewise, commonly known. The Master of one of the fishing cutters which supplies Trondhjem with live fish thus states that, he had endeavoured to find places about Hitteren, Frøien &c. where he might, possibly, obtain enough plaice (500 to 600 fish), to fill the well of his vessel, but that he could not do so (he is a man who knows the locality thoroughly).

We therefore regard the above curves as indicating the economy of the stock of plaice on those parts of the north coast with which we are acquainted.

The accumulated stock of plaice is thus, in our opinion one that can be fished out.

The question now arises: «Ought it to be fished out»?

In our opinion the reply must be dependent on *whether the stock of fish that then would remain could, by spawning, be capable of producing an annual growth equivalent to that now existing.*

It may appear reasonable to assume that a large, accumulated stock of ripe fish was capable of producing a quite considerably greater annual amount of fry than the lesser stock that remains on grounds that have been fished out. This, however, does not appear to be the case from our investigations, as the annual increase, or, in other words, the number of the fry of the year *has not been proved to be greater at those places where great fishing is carried on, than at those spots which have been fished out within the memory of man.*

If one recollects what we already have said concerning the chances against, or unfavourable to the growth of the fry, and our supposition that the greater part of the spawned eggs of the plaice can never be of any benefit to our coast, one will be able to understand to some extent why a large stock of fish need not necessarily produce a great quantity of fry.

According to our conception, fishing for plaice on our coast ought only to be carried on where there is an accumulated stock, and no fear need be entertained for the undersized fish, as it cannot be imagined that fishing them would pay, owing to the small annual increase peculiar to the coast, or, in any case, under the conditions prevailing, at present, in the northern parts of the country.

From several quarters attempts have been made to obtain a close time for the fish during the spawning season. Attempts have also been made to prohibit the spearing of flounders. Of what little account protection of the spawning fish would be, will be clearly seen from what we have already stated concerning the conditions affecting the reproduction of the fish and the occurrence of the fry, and we must take the liberty of pointing out that the carrying out of the two proposed protective measures would place great obstacles in the way of the only two effective methods of catching the fish that are employed at present. Protection of spawning fish would, even if it were only intended to keep the unclean fish of the spring away from the market, certainly prevent, to a great extent, the use of nets during, practically, the only season in which such can be employed with advantage, and prohibition of spearing would put a stop to the use of the other apparatus employed in catching the fish.

In many parts, those sand patches, which form the resorts of great quantities of the plaice, are very small, and vast numbers of fish often lie on a patch of sand but some few square fathoms in size. It is only by diligently scanning the bottom by means of a water telescope that

the fisherman can see them, and, with his spear, secure them one by one. In our opinion it would be a great injustice to fishermen to forbid them to employ the only appliance which, under the circumstances, is a practical one, and thus compel them to use the other apparatus, the net, which under the mentioned conditions, is, practically speaking, useless.

We consider that such prohibitions, instead of increasing would decrease the yield of the flounder fisheries, as the people would at once be prevented from employing those methods which have been, and are suitable for the purpose.

If, above all, it is possible to alter the time for the main fishery to another season than the spring, it appears to us that even the *better prices* obtainable at other seasons would, presumably, form an attraction in the desired direction.

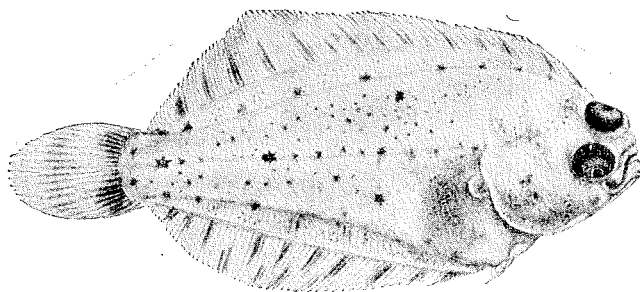


Fig. 21. First bottom-stage of the Plaice. Natural size, 13 mms. (After Dr. Petersen).

The immediate consequences of fishing out the accumulated stock on our northern shores would, presumably, be, that it, naturally, would not pay to carry on the fishery at those places where such accumulated stock was exhausted, until a certain stock of fully grown fish had had time to re-establish itself, the real reason of such accumulated stock being fished out being the small annual increase.

The prosecution of such fisheries as that of the plaice on our northern shores, may, certainly, in some ways be compared with cutting down a slow growing arctic forest. When such a forest is first attacked by man, it is full of gigantic trees (an accumulated stock of full grown individuals), but when once the old trees have been removed, many years must elapse before it can regain its former state, and prove remunerative.

We do not consider ourselves in a position to state whether a stock like that existing at the commencement of the fishery could ever accumulate again, but we regard it as improbable. In any case it could not occur without protection. But it is not reasonable to assume that arrangements for a systematic working of those localities frequented by flounders could be set in force except as a consequence of far more detailed researches than those which, up to the present, it has been possible to carry out. It is impossible to cherish even an idea of what might be the result of such researches with that object in view at present, or even in the immediate future. Our knowledge of the rapidity of the growth of the fishes in their older stages of existence is, above all, still, too incomplete.

We may finally state that, in our opinion, even at the few spots in the fiords, and along the coast, suited to the growth of the fry, very many more fry of the plaice *might* exist than, at present, is the case, and that the numbers of the year's fry *could* be far greater. We have already shewn that it is not the want of spawn that causes the small quantity of fry, but the physical conditions which are unfavourable to the young in their pelagic state.

In this we think we may have discovered a thread which may possibly guide us in the future towards increasing the *annual numbers of the fish*, as, if one could procure those that have once passed the pelagic stage, and place them on those grounds which suit the infantile *fish* in their bottom stage of existence, one could thereby eliminate the most critical period of the fishes' life. Such an experiment with small plaice some inches long, has been tried in the Lim Fiord in Denmark, and has been proved (the fish having been marked) by Dr. Petersen to be successful. Similar experiments have also been tried at the Biological Station at Drøbak, as a load of fry from Denmark was let loose in the Christiania Fiord.

It may be *thought* that one way of attaining such an object would be by artificial hatching. When, however, we recollect that the technical work of hatching during a long series of years has not yet succeeded in getting beyond the stage of producing newly hatched eggs in large quantities, such a great advance at that above surmised remains to us but as a distant possibility.

We may yet add some words of more general interest. As is known, very many reasons have been advanced to account for the decline in the yield of the plaice fishery of the North Sea, without their leading to

any final or definite result concerning the causes — we, naturally, mean the deeper causes which affect the economy of the fish themselves. Certainly we have not had an opportunity, by investigation, of studying the conditions of the North Sea, and therefore shall not attempt to frame conclusions respecting the economy of the North Sea fisheries on the basis of the conditions existing in Norway, but it appears to us, nevertheless, that a comparison may be attempted.

We consider that the conditions affecting those small localities on our coast are exceptionally synoptic, and far easier to grasp than those of the exceptionally complicated, and vast territory of the North Sea in which the plaice lives. If, therefore, we take the results we have arrived at concerning the accumulated stock in virgin localities as the basis of comparison, it then appears to us that the «fishing out» of the North Sea stock of flounders will have a new light thrown upon it. It appears to us reasonable, to regard the *large, and numerous fish*, which filled the nets of the first trawlers when the North Sea was still a virgin fishing ground, as, possibly, part of an adult stock, accumulated during very many years, and safe from the attacks of man. But the enormous amount of fry, which so vastly exceeds that of our Norwegian coast, shews, in our opinion, (based on the *annual* supply of fry) that, all reasonable measures being taken to protect the fish, an *annual* fishery can, really, be carried on in the North Sea, whilst, in Norway, *many* years would have to elapse between each fishing of an *accumulated* stock, rational fishing, of course, being assumed.

Chapter VIII.

The Cod.

The cod is known to be our most important roundfish. It is a denizen of the Northern Seas. It is met with in the western portions of the Atlantic Ocean, from the coast of Greenland in the north, to Cape Hatteras in the South, and in the Eastern part of that ocean from Spitsbergen in the North, to Bay of Biscay in the south. It appears to be most plentiful in the Northern regions, for instance near Spitsbergen, where in the summer it is sought by Norwegian fishermen in their fishing vessels. As an instance of its abundance in those parts, Professor Sars states that, on the cruise of the North-Atlantic Expedition, he witnessed the capture of 2253 cod on ordinary hand-lines by 6 men in 12 hours, which is equal to 375 fish a man, or more than 1 fish every second minute. According to Smith, 300 to 400 million kilogrammes weight of cod are annually caught, of which 160 millions fall to the share of Newfoundland, about 50 millions to Norway, and 37 million kilogrammes to Great Britain.

The Cod is found along the entire coast of Norway; and even in the Bohuslæn, in Halland and Denmark, it gives rise to considerable fisheries, but in the Baltic becomes more and more scarce, until it is an uncommonly rare fish in the Gulf of Bothnia.

Throughout the greater part of the year, the cod lives down in deep water. Thus during the summer it is caught along the entire coast, chiefly at a depth of 50 to 100 fathoms, and, so far as is known, it appears to be most plentiful on the so-called «edges», or slopes in the

ocean which drop towards the greatest depths, and also off the coast beyond the outlying rocks. In the winter the cod, as is known, frequents shallower waters. It then approaches the shore, and is caught during the spawning season, February to April, often in very shallow water along the entire coast of Norway, and especially in suitable localities, of which the Lofoten is the most celebrated.

The life-history of the cod has been studied by Professor G. O. Sars, whose accounts have gained great notoriety.



Fig. 22. Cod fry, just hatched. Natural size. Of similar size to the Fry placed in the sea from various fish hatcheries.

Sars shewed, how the roe, shed in February to April, after the lapse of 18 days, developed into minute larva, 7 to 8 millimetres in length, which, for a considerable period, between 1 and 2 months, lead a drifting existence, and subsist on the small drifting crustacea (the plankton), 1 to 2 millimetres in length. Towards the summer, when they have attained a size of 3 to 4 centimetres, they approach the shore. In July and August, they attain a size of 6 to 7 cms., and then grow rapidly throughout the autumn, measuring, in October, 10 to 12 cms. (about 5 inches).

During that period they live close by the shore in sandy bays, and in the uppermost seaweed. During the course of the winter they do not shew any very perceptible increase of growth. From February to April, when just a year old, they are at their largest, at most 13 to 14 cms. in length. Already at that stage it appears, and afterwards becomes, indeed,

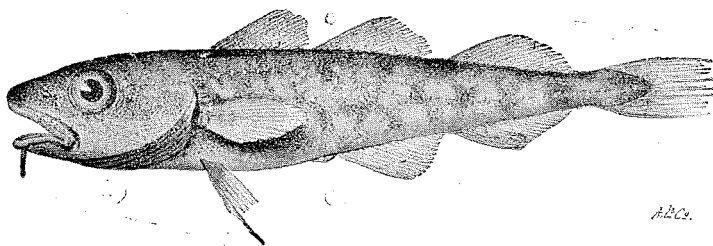


Fig. 23.

more apparent, that the various individuals are of different sizes, the size of the *annual class* varying from 8 to 15 cms.

When of this size, as Sars has proved, the cod commences its migration towards deeper localities, and then grows rapidly.

During the second summer of its existence, when a year and a half old, it attains a length of 18 to 24 cms., its chief resort being then the fucus region (especially that of the tangle) of the coast, at a depth of 5 to nearly 20 fathoms. It then chiefly subsists on the crustacea of the sea-weeds (Sand-fleas etc.).

The table on the next page gives a statement of the size of the various ages in the south-western part of Norway during summer (August). Each dot on that table indicates a cod-fish of the size indicated by the adjoining figures which represent centimetres.

The older the cod becomes, the deeper it goes. Some old individuals of 40 to 60 cms. in length, may still be found in the tangle regions, all being of the reddish-brown colour of the tangle, and are generally termed Red-Cod, or «Seaweed Cod», but the majority go down to the bare bottom (the clay) where they may be caught during the summer in the southern part of Norway measuring up to one metre in length. In the north it is occasionally obtained much larger (exceeding the height of a man). The age and number of annual classes of these large specimens have not yet been clearly established.

In Chapter III, which concerns our labours during our fishing trials, we pointed out how, from February to April, we found the roe of the cod drifting about in the Christiania and Trondhjem Fiords, though by no means in so great a quantity as previously found by German scientists in the North Sea. We further mentioned that we only succeeded in finding specimens of early stages of development in the fiord.

From April to October we could not find fry of any stage in numbers. Even 35 successive hauls in a shallow bay (the Frognerkilen) yielded but 7 cod, measuring 7.5 to 11.5 cm., of which some, probably, represented fry of that year, and, in spite of our diligence, no better yields were obtained in the fiord until October. The annual class therefore may be said to be most poorly represented.

Such a dearth of fry was established by us in a very decisive manner both in the Christiania Fiord and the Trondhjem Fiord, and we thought it likely that this was also the case in respect to the whole of that portion of southern Norway lying to the eastward of Lindesnes. Owing to want of time we were not able to define, accurately, any further limits of the occurrence of fry.

0	
1	
2	
3	
4	.....
5	..... 27
6	..... 60
7	.....
8	..... (about 1/2 year old).
9	.....
10	.....
11	.....
12	.
13	.
14	
15	
16	.
17	..
18	..
19	.....
20	.....
21	...
22	..
23	.....
24	..... (1 1/2 years old).
25	.....
26	.....
27	.....
28	.....
29	.
30	..
31	
32	.
33	.....
34	.....
35	...
36	..
37	...
38	.....
39	.. (2 1/2 years old).
40	.....
41	.....
42	..

On the other hand, great quantities of the youngest annual class were found in all those parts of western, and north western Norway, out by the open sea, which have been investigated by us.

The fry was caught there in quantities of up to 100 in a haul with a small eel ground seine. The multitude found there would probably compare with that of any other locality noted for its abundance of fry.

By way of comparison, we may give here some of the best hauls ever recorded in literature.

E. W. Holt reports from the east coast of England, that between the 19th of October and 17th of November on the «Trinity Ground» (the Humber) at a depth of 30 to 70 feet, he made 8 hauls with an English shrimp-trawl, lasting about an hour, and caught from 15 to 179 small cod (from $2\frac{1}{2}$ to 7 inches) each time, averaging 79 small cod per haul. (These, as it will be seen, consisted, however, of two annual classes) Another haul on the «Sand Haile Ground» (also on the Humber), lasting for our hour, yielded 115 small cod, and 410 small whiting.

From the west coast of England (the Lancashire Sea Fisheries District) we add the following two fishing trials (Superintendent's Report 30th April 1893).

- 1) *August 12th. The mouth of the River Dee.* 1 to 4 fathoms, on sands. 1 haul with a shrimp trawl 21 feet wide. The haul lasting one hour. The catch being:

About 7 litres of shrimps.

3 250 undersized edible fish, of which:

144 Cod less than 5 inches in length,

180 Whiting — » — » —

2 910 Plaice from $\frac{1}{2}$ to 2 » —

- 2) *August 19th. Outside Dee Lightship.* 1 haul with a shrimp-trawl, 21 feet wide, lasting 1 hour and 25 min., in 7 to 11 fathoms on sand and clay bottom., yielded:

$4\frac{1}{2}$ litres of shrimps.

5 697 undersized fish, of which:

434 small cod (3 to 5 inches in length)

4 154 whiting ($2\frac{1}{2}$ » 6 — » —)

930 plaice (2 to 5 — » —)

Compared with such hauls each lasting for 1 to 1¹/₂ hours across extensive level stretches, our quite short hauls of the seine on the Norwegian coast must be said to be extremely good, and it is our conviction that the Norwegian coast, with its mighty areas covered with tangle, and sheltering belt of islands, possesses, in its adjacent seas, waters second to none in their wealth of cod-fry, and not in respect to cod fry only, but also as regards most of the *gadus* species, such as, for instance, the pollock, coal fish and others.

Apart from the Norwegian coast, the fry of the cod is found on the shores of the North Sea (the coasts of Jutland, Germany, Holland, Great Britain), while, according to Sars, it does not exist North of Norway, (as for instance at Spitsbergen).

Not until the autumn, when about ³/₄ of a year old (in October) does the fry make its appearance in the fiords, such as the Christiania and Trondhjem Fiords, and during the months, October to May, may be caught in great quantities. During that period we have obtained up to 100 fish in one haul, both in the Christiania — as well as the Trondhjem Fiords.

From that time, and, for a long time afterwards, the cod remains in the fiords. The «small cod» which is caught on lines throughout the year along by the shore, at a depth of about 20 fathoms, measuring some 20 to 30 cms., is well known.

As proved by Professor Sars, it is characteristic of their annual stages that they, successively, make their way out towards deeper water. In the summer one finds then, partly in the fiords and partly out by the coast, simultaneously, several *annual classes* of cod, represented by several different sizes.

After consulting our tables on the growth of the fishes, it may be concluded, that the cod remains within the fiords and close to the shore until about 2 years of age, after which it commences to withdraw from the land. The older annual classes are but sparingly represented along the coast during the summer.

Of this older, shallow water cod, some individuals, more especially the smaller annual classes dwell at a depth down to 20 fathoms, chiefly in the large forests of tangle, which, especially on the west-coast, are very extensive.

About 4 to 6 miles distance off the Coast of Jederen inconsiderable numbers of such cod are caught throughout the summer (see Chapter III). Cod of a very great size (up to a yard in length) may be caught, and are conspicuous from their deep crimson colour, almost like that of the red sea-perch.

Such a fishery is carried on along the entire coast both with long and hand lines, but the commonest cod-fishing during the summer is carried on in deep-water at a depth of 80 to 100 fathoms. At that depth large cod of a grey colour are met with, which dwell on the light blue mud.

During the summer, however, the cod is very scarce along the entire coast; but an exceedingly small stock of adult fish is to be found at this time of the year: (See Chapter III).

This is illustrated, better than any other way, by the statistical reports on the fisheries in fiords, or similar spots at different seasons of the year.

As an example of this, we may append the following table:

Month	Number of Cod brought to Christiania wharves 1898.		Denmark 1894	Denmark	
	From the fiord inside Drøbak	From the fiord outside Drøbak	Danish Custom Houses. Number of pounds	average price per pound	Percentage of catch, according to Drechsel
				øre	
January	5 915	14 395	57 749	5.4	11
February	5 444	12 471	38 906	6.3	11
March	6 074	12 200	108 046	5.3	12
April	7 381	16 828	555 553	5	7
May	4 888	7 157	190 531	4.6	5
June	4 247	5 175	36 403	6.2	2
July	3 566	5 815	2 580	6.1	1
August	6 058	7 238	25	4	1
September	7 540	17 399	8 790	5.2	6
October	10 944	22 899	169 122	4.9	15
November	11 670	26 920	332 906	5	16
December	7 610	64 516	231 422	5.3	13

From this table it will be seen that the cod-fishery is at its worst during the summer (according to Drechsel averaging 1 to 2 % a month of the annual catch). In the autumn, more especially from the month

of October, the catch increases most rapidly, and with greater or lesser fluctuations, remains great until April (spawning time), at the end of which the fishery again begins to decline fast.

It is evident that small variations in the regularity of the fishing must occur, thus the fishery may begin earlier in the autumn one year than in another, without this fact having any diminishing influence on the regularity of the fishery in its entire course.

From many quarters it has been contended that, fishing is not carried on in summer owing to the cod being then regarded as a bad article.

This may possibly be the case, especially where the fish, during summer, have to be conveyed a long way, as the difficulty of preserving the fish is then great; but that the cause of the fishery's periodicity cannot be due to this may be clearly seen from the Danish average prices for each month (see the Table).

One will there observe that, the prices obtained in June and July, are particularly high, and would then be likely to encourage the fishing, if the same number of cod were to be found in the waters. (See our Fishing Trials at Drøbak, in August, Chapter III).

These conditions can only be explained by the cod *approaching the coast and entering the fiord*, with certain periodical intervals, conditions which, on a small scale, correspond with those of the great periodical fisheries in the northern parts of the country. [The Lofoten and Søndmøre fisheries].

Nothing would tend more to confirm the above theory than a contemplation of the *summer conditions* on those stretches of the coast at which these periodical fisheries occur.

While, according to the Norwegian Statistical Reports, in 1897, 9,879,400 spawning cod were caught in, and about the Amt (Province) of Romsdalen, the Annual Report of the Christiansund Fishing Society, of 1896—97 states that, «a transference of fry to fiords in which there is a dearth of fish would be a measure which might be of great service.»

We are informed that so few fish are caught in those fiords of the Romsdalen, that in stormy weather, when no one proceeds to sea, there is a great dearth of fish in the little market at Christiansund. And this despite the enormous spawning, and the abundance of fry, which are met with in those parts.

Such conditions can surely only be explained by the disappearance of the fry, which was so abundant along our coast, on reaching a certain size, and leaving behind but a small number, the coast cod.

The conditions here described give rise to a great number of exceedingly important scientific and practical questions, of which the majority have already led to various discussions amongst our maritime population.

Such questions are:

1. Where does the cod go to when it leaves the coast?
2. Why is there but a small quantity of fish left behind, and why are our fiords so destitute of cod, especially at certain times of the year?
3. Can anything be done to improve the cod fisheries in the fiords?

A solution of the two former questions has been attempted on the supposition, that our stock of cod consists of two different types, 1. the open sea type of the cod, and 2, the coastal breed. If one converses with the fishermen along the coast, one will find that they clearly recognise several kinds of cod, shallow water cod, rock cod, grey cod etc.; and if one examines these different fishes, one will find that they present considerable differences. Most conspicuous is the colour, which may be of a deep crimson, as for instance with the seaweed cod, or a pale bluish grey (the grey cod); but other distinctive marks are present, as, for instance, differences in the shape of the body, which lead the fisherman to make distinctions between them.

The important questions then arise, as to whether these peculiarities are *hereditary* or otherwise; whether the egg of a shallow water cod can become but a shallow water cod, or if it also may become a cod proper; and whether the qualities and peculiar shape of the sea weed cod are inherited, or else caused by the influence of its surroundings (as for instance *the nature of the sea-bottom, the salinity, depth etc.*)?

It has been commonly imagined in this country that there are several breeds of cod, and the people argue that the sea cod (skrei) visits our coasts but occasionally, whilst the coastal cod remains on the coast the whole of its life, and that *its present scarceness is due to its having been fished out.*

This very general idea is instructively brought forward in the following account taken from «Beretning om Flødevigens udklækningsanstalts virksomhed i femaaret 1883—88 af G. M. Dannevig. Arendal 1889».

«If the cod-fish on our coast be classified according to colour, they will be divided into the following three main groups:

1. Light grey coloured cod, elongated, with a pointed head, firm, and palatable flesh. It is called the deep sea cod, and is, here, comparatively rare. It is caught in deep water, chiefly on a sandy bottom, and on the outermost banks. The roe* is light-grey, the milt white.
2. Red cod of coarser shape. Altogether of a stouter appearance than the former, but the flesh is softer and more watery. It is met with on a rocky bottom, off the coasts, in the seaweed, and is, consequently, in many places, called the seaweed cod. It frequents shallow waters. The milt is more or less yellow, in some instances with a tinge of red. The roe is of a strong yellowish red colour.
3. Dark-grey and yellowish-grey cod, with somewhat distinct spots. The flesh is firmer than that of the former. Occurs in the interior of the fiords, and on a bottom covered with zosteræ, from which it is, also, called the wrack or zosteræ cod. Both the roe and the milt are of a light grey, and, occasionally, yellowish colour.

Of the above mentioned groups Nos. 1 and 2 seem, best, to have preserved their characteristic features, while in the third group there are many varieties.

All that has been said respecting the colour of the roe and the milt, applies also to the fry in its earliest stages. It thus commonly happens that eggs are found in which there are young of a strong yellowish red colour which gradually vanishes, however, as their development proceeds, so that it is imperceptible when the fry leaves the egg. In any case I cannot remember having noticed any difference in colour at that stage.

If it be the case, as asserted by certain some scientists, that the colour of the cod depends upon that of its nearest surroundings, as well as on its food, and thus perpetually varies with its change of domicile, no light can be thrown on the migration of the cod, as there is then nothing to prevent a crimson coloured cod-fish from becoming, in the course of a very short time, a dark grey rock cod, or *vice versa*. In that case it may travel as far it likes, and no one is a bit the wiser when it is asked, whence it originated.

*) When *roe* is mentioned, the ripe roe is always meant.

If, on the other hand, it should be, as maintained by me, and which I shall endeavour to prove, viz., that the colour of the cod is both hereditary and unvarying, the case will be placed in quite a different light.

I shall now bring forward evidence.

To begin with I shall refer to the considerable difference in colour, of the generative substances, the difference being retained by the fry in its earliest stages. Secondly, I can state the result of an experiment made in 1885, which, in my Report for that year, is thus described: «A subsequent experiment, carried out with small young cod which had been caught in the Flødevigen at the end of August, and kept in an aquarium until the 10th of December, yielded a similar result, the colours remaining unaltered (the difference in colour was in this instance very great)».

In three instances I have kept a stock of fish alive in the fish tank from one year to another, without their colours altering otherwise than that their intensity became somewhat dimmed.

The most striking proof still remains. It is, namely, clear, that if the colour of the cod were dependent on its surroundings and food, then it would have been absolutely the same in all the individuals, brought up in the tank, and which had not been outside of it since they were six days old. This, however, is far from being the case.

There are both red, yellow and grey individuals amongst them, though none of the true light grey deep-sea cod, which is very natural, as there were not any of them amongst the stock I put in. According to this I think one may assume that the colour of the cod is heritable and unvarying, which gives rise to some very important conclusions as in respect to pisciculture.

When it never happens that a red sea weed cod-fish is caught on a light sandy bottom or on the outer banks, it is not on account of its having assumed a different colour on its arrival there, but because it never quits its appointed territorial limits, viz., the broad belts of algæ round about the outer islands and rocks.

The same law applies to the light-grey deep-sea cod, as well as the cod of the fiords and zosteræ.

They certainly travel about, but only in exceptional cases leave that kind of bottom upon which they are accustomed to live, the colour of which they have assumed through generations, and which therefore

also affords them the safest home, and the most advantageous grounds on which to seek their food.

The fact, that the young are most frequently hatched far from the resort of their parents, and thus, even prior to their birth, are conveyed to quite a foreign bottom, cannot affect the assertions I have brought forward. When they begin to assume the colour they are destined to bear they will instinctively resort to the bottom where the resembling colour will afford them the best protection, and that which has been once formed by instinct, will be still more strengthened by habit.

With regard to hatching, this question is of extreme importance, in as much as it indicates the direction which ought to be followed when purchasing or obtaining fish for breeding purposes. It is neither the migratory deep-sea or sea-weed cod that one should adopt, but, on the contrary, the true fiord or zostera cod, whose migratory instincts are not much developed, and which, therefore, presents the breeder with the best guarantee for the success of his labours.»

As will be seen from this account, the chief proofs of racial distinction are:

1) that the sexual products, the roe and the milt, of the various kinds of cod vary in colour,

2) also that the fry, subsequently hatched, irrespective of the surrounding conditions under which they live, retain the colour, bodily shape, and qualities of their parents.

Of these, the first contention is of very little significance, in as much as the colour of the sexual products is dependent on the nutritive substances in the yolk or the spermatozoa, which may very well be explained from, for instance, their dependence on the nourishment of the animals or other similar conditions. It has thus long ago been proved, that substances which are deposited as nourishment in various animal cells, especially adipose cells, may, as regards their chemical composition, be dependent upon the food of the animals. For instance, in feeding starved dogs with mutton fat, it has been seen that their fat could assume the chemical composition of the mutton fat, and alter the melting

point from 20° to 40°. It is also stated that as development advances, that is to say, so soon as the yolk is used up, it loses the yellow colour of the egg of the seaweed cod, and is not so perceptible when the fry is hatched.

Of very much more interest, however, is the report, that of the individuals bred in one tank, «red, yellow and grey individuals» were found. This statement is, however, far from being based upon such accurate experiments and studies as would be requisite in framing of such wide conclusions; thus *inter alia*, it has not been proved that the colour was permanent, and the conditions in the basin alike throughout. Neither are these varieties of colour described with sufficient accuracy, or compared with the other characteristics. In order to form an opinion on these questions, we have, for instance at Jæderen, closely examined every one of the hundreds of fry of a few inches in length which were caught.

But in this instance, they were beyond the shadow of a doubt as like as they could possibly be, excepting in size (due to their being spawned at intervals during a period of several months).

There, in Jæderen, all the small fry were of exactly the same colour as that of the seaweed cod of the coast, and we have observed the same at several places on the west coast.

But if this be the case, where then is the fry of the deep sea cod?

If it were grey like its parents, we must conclude, that no fry of the deep sea cod exists along our west coast. And what then becomes of all the quantities of eggs spawned in those parts by the deep sea cod?

In Denmark, where one meets with many square miles of quite shallow water, and where the bottom is covered with green *zostera*, the fry of the cod was, literally, grassy green, and we were there told that they were all of that colour in those parts.

This certainly also agrees with a great many other zoological observations concerning the great power possessed by animals of adapting themselves to the colour of their surroundings.

Thus, Dahl observed that, in the Trondhjem Fiord, the young cod frequenting the *zostera* were greyish green in colour, while, some fathoms deeper, in the *laminaria*, they were red.

In spite of this, however, we agree with Mr. Dannevig, that this case should only be settled by experience and not by comparison; it ought to be solved by experiments or observations, but in any case we

cannot agree that one theory is more sanguine than another, respecting the development and prosperity of local races, for how sad would not be the rate of mortality that might take place, for instance at Jæderen, if of the small, inch-long, red-coloured fry, which is found there in multitudes, there only remained the few adult seaweed cod which are met with in that locality. And how should one account for the abundance of deep sea cod, if it all arose from the fry of grey coloured cod, which we, for our part, have not been able to find, and that at such a spot as the west coast of Norway.

In addition to this, not to mention our own experiences, we may refer to what so able an observer as Dr. Petersen, of Denmark, states, viz., that he has repeatedly observed that cod-fish, kept in the dark, can change colour, or at least their hue, in the course of a few hours.

It appears to us, from these grounds very improbable that any given form of the cod should correspond to races with hereditary characteristics, and they undoubtedly possess all conditions of like future possibilities; the one form may turn to that of the other.

If there be different races, then it is certainly more likely to be the masses of cod on great coastal stretches, which diverge from those of others, and, if so, the racial differences no doubt embrace other characteristics than that of the colour only. Still little or nothing is *known* on this subject.

If the circumstances are such, that our coast, taken all round, owns larger quantities of fry than, possibly, any other, why then is there such a dearth of adult fish except at that season of the year, when the migratory fish and the deep sea cod appear on our shores? This is a question difficult to answer, and it will certainly not be fully cleared up until the abiding places, throughout the year, of the migratory cod are both known, and closely studied.

That the dearth of fish in the fiords is not due to their being fished out, is evident from the above. The fisheries, on the whole, seem to have but little influence upon the cod.

We must remember how greatly the North Sea is fished, and yet the English Parliamentary Commissioners could not conclude that there was any decrease in the number of roundfish.

It is known that experiments were made in Scotland by prohibiting all trawl fishing in the Firth of Forth and St. Andrews Bay for many years.

None but the Scottish Fishery Investigators have fished there with the trawl, and their average catch of round-fish in each of the following years yielded *per haul*,

1886:	79.6
1887:	115.9
1888:	80.5
1889:	34.5
1890:	80.9
1891:	43.5
1892:	53.9
1893:	149
1894:	113

As will be seen this example cannot be brought forward as a proof of any perceptible increase in the quantity of fish (round-fish). The presence of the round-fish there has clearly been caused by other circumstances.

What are the conditions which dictate the migration of the cod in and out of the fiords with periodical regularity?

Such questions belong to the most puzzling that deep sea investigations have to solve. The conditions both of the ocean itself (currents of the sea, the nature of the various layers), and of the life of the fishes (their breeding conditions, their migratory capabilities, their desire for food and so forth) undoubtedly here bear the one upon the other.

The method which ought be adopted, would appear to be that by which one can closely study the circumstances under which the fish lives during each stage of its existence and at all times of the year, in order, through the changes in their migrations, and in the water layers that can be observed, to discover, if possible some law that guides them all.

If, in this manner, one contemplates the knowledge hitherto gained concerning the ocean and the resorts of the cod, it seems clear to us, that the fiords are not the natural abodes of the cod.

Its habitat is the 100 to 200 fathom deep beyond the coast. According to the experience of the North Atlantic Expedition, Professor Sars, and the experiences of many others, it is commonly assumed that the place where the cod may be found throughout the greater part of the year, and in the greatest abundance, is the eastern part of the North

Atlantic Ocean, on the so-called deep sea banks. Such banks are to be found, as is known about Iceland, the Faeroe Islands and the stretch from Stadt to Spitsbergen, and there enormous quantities of cod are caught in the summer and autumn. Compare that which has, previously, been stated concerning Spitsbergen, and the accounts of the English trawlers' great fishing off Iceland. Also on the North Sea Banks great quantities of cod are caught by line boats and steam trawl vessels.

From all that we know, it would appear that the cod periodically leaves those waters to approach the shore and crowd into the fiords.

It was to gain a knowlegde of these circumstances, that Hjort has, during the last few years, studied the animal life, both of the lower and higher organisms, in the fiords, and simultaneously endeavoured, through investigations of the water-layers (the Hydrography), to obtain facts by which to arrive at the knowledge of the occurrence of animals.

As will be seen in Chapter IV, which treats of the distribution of the lower animals in deep water, we have obtained a fair number of facts leading to a knowledge of the scarcer fiord animals' life, even though a great amount of research is, still, requisite to throw full light upon this condition.

In the stationary state of the water layers within the deep fiords, we found one of the reasons why the conditions necessary to existence were less favourable there than out by, and in the open sea, where our investigations indicated both an entirely different movement in the water layers, and a far greater wealth of animal life. We, therefore, assume that the sea-bottom *at great depths* is much more prodigal of life out by the open sea or at the entrance to the fiords, while, on the other hand, we often find the *shallow water* of the fiords^s abounding in fish, where it is sheltered, possesses luxuriant seaweed vegetation, and where also the young fish, at the entrance of the fiords, have these abiding place. As will be seen from Chapter IV, we regard our research as being the first step made on a field open to lengthy work in the future, and trust that the importance of the results we have already achieved, may chiefly consist in pointing out the way towards gaining, and give every hope of obtaining, good results in the future.

Many circumstances indicate that the causes leading to the migration of the fishes are very complicated. Thus it would, no doubt, be wrong to draw the conclusion that the quantity of cod in a fiord

should entirely depend upon the amount of food in the fiord. A most striking proof of the incorrectness of such an assumption was met with in the Brevik Fiord. There, during the summer of 1898, shrimps were found living at a depth of 50 to 60 fathoms in quantities previously unknown (see Chapter IV). These shrimps were tried as bait outside the fiord, at about 4 miles distance from land, and proved to be most excellent bait for cod.

In spite of this, however, hardly any cod were caught on lines inside the Brevik Fiord during the summer, and that this was not owing to the circumstance that the cod would not take the bait there [which might well be understood in waters containing such an abundant fauna] is proved by our trawling experiments.

Such conditions denote that one must not be led to believe that the migrations and habits of the fishes are dependent on one circumstance only. On contemplating these one must take the entire knowledge of the sea into consideration, and the more this is developed, the deeper will one enter into a comprehension of the life of every organism.

In the final chapter we will consider the question as to what may be the probable effect of our results upon practical research.

Chapter IX.

The Eel.

In looking through the accounts of the eel, recorded in our literature, we find but very little. It is referred to in «Norges Fiske» by Collett, and its distribution is described as extending northwards right to Magerø in Finmarken; otherwise this scattered and insignificant literature chiefly consists of literary extracts from foreign works, and no independent report on the fish, and its distribution in this country, based on individual investigations has ever appeared.

Through foreign scientists it is known that the eel is spread over almost the whole of Europe, except in the lands bordering the Black Sea. It is also found on the east coast of North America. They are known only to occur in lakes and fresh waters, and in such regions of the sea as are shallow and covered with luxuriant vegetation, more especially in the so-called eel-grass (*zostera*).

The breeding history of this fish has been quite unknown until recent years, and is not yet fully elucidated.

For centuries, the eel has been known to exist in lakes far above the sea level, the outlets of which, in the shape of falls or rapids, would seem to preclude every possibility of the fish having migrated to them, and various explanations have been suggested to account for its arrival in those parts.

As it was found, however, of almost every size in such fresh waters, it was supposed, that it also bred there; but, in spite of numerous in-

vestigations, one has never succeeded in finding ripe eels, their eggs, or quite small young in fresh water.

On the other hand, as is generally known, the Italian, Grassi, some years ago, found a great number of small transparent fish in the straits of Messina, which, it is presumed, were brought to the surface by some strong current.

These small fish were previously noted as being a singular species of the genus *leptocephalus*, but on keeping them alive in an aquarium, Grassi succeeded in proving that they developed into quite small eels, in other words that they proved to be the larvæ of the eel, and that the whole genus of *leptocephalus* was nothing but the larva of the eel species.

Thus was found the most essential key towards opening up the knowledge of the early life of the eel. It has been known — for generations — that quite small fry of the eel, 6 to 8 cms. long appeared in the spring on the sea beaches, and, often, in vast multitudes forced their way up rivers and streams, and when this is connected with Grassi's discovery, it must be, consequently, known, that the small young of the eel (*montée*) originate in the sea, and make their way to their abiding places, partly in the sea, and partly in rivers and fresh waters, where they, as the so-called «yellow eel» grow up and become big.

It has likewise been known of old, that a number of the eels occurring in fresh water, and the sea, migrated during the autumn, often in great shoals, down the rivers, and out through the fiords. But while the eels which lived quietly in the lakes were yellow in colour, with broad heads, all the migratory eels were of a silvery colour, with very large eyes and pointed heads, and were regarded as a particular species until Dr. Petersen, of Denmark, shewed that the sexual organs of the silvery eels were considerably more matured than those of any yellow eel, and, finally, through a succession of investigations, proved, that the shiny coat, the large eyes, and the pointed head were nothing more than a breeding garment, which the yellow eel gradually assumed prior to leaving the waters in which it had grown up.

By keeping the yellow eel in captivity, he obtained abundant proof that they did become glossy in appearance.

Thus the main features of the history of this fish have been discovered. From the larva (*leptocephale*), which occurs in the sea, is developed the small young of the eel, which approaches the shore. When

grown up, whether in lakes or fresh water, they assume the breeding garb, and then they return to the sea. But where the spawning takes place, where to find the eggs and the larvæ, still remains a mystery. The larva has, as previously stated, been only found at Messina, and as it is supposed to have originated from the deep waters, it may be assumed, that the spawning occurs at great depths, and that the eggs are hatched there.

Great fisheries have been, and are still based upon the migrations of the eel in most European countries.

With these foreign fisheries in view, we made, during our first cruise in

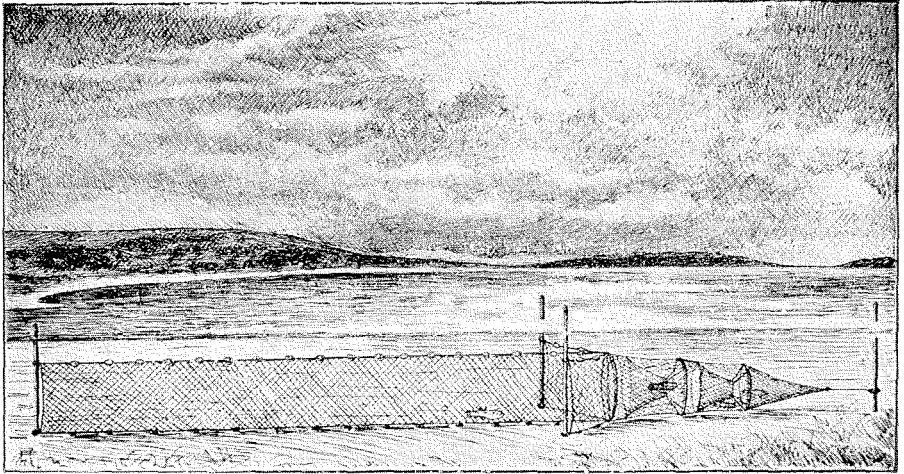


Fig. 24. Danish Eel Trap.

the Christiania Fiord, in 1897, an attempt to study, more closely, the occurrence of this fish.

On studying the map of the fiord we could draw the conclusion that the range of the fish there could not, naturally, be compared with that it possesses in Denmark, as eels are never caught so far as is known, at a greater depth than 10 fathoms. Even in the Christiania Fiord and its adjacent waters, there is thus but a very small area indeed where any great number of eels could be expected to live.

Well did we know that the eel was to be found in the fiord, and that scattered, and but little noticed fishing was carried on partly, in the winter, with traps, and partly, in the summer, with eel-pots (which, however, always need bait), and we also knew that a number were caught

in the large herring seines, which are used to catch sprats. But even the exceedingly high prices paid for eels at the Christiania fish market, sufficiently indicates how few are caught. If, from the results of the fishery, one were to form an idea of the stock in the fiord, one would assume that it was very little.

Only a glance at the statistics published (Society for Promoting the Fisheries inside Drøbak), will convince one, that from that source little or no intelligence respecting the occurrence of this fish is to be obtained. We submit an extract of the enumeration at the Christiania fishmarket.

Eels (number caught).		
	Inside Drøbak.	Outside Drøbak.
1879:	8,191	211
80:	4,306	4,750
82:	7,145	959
83:	4,919	202
87:	1,823	2,738
88:	2,930	3,515

As will be seen, this table shews an exceedingly irregular supply of eels, inasmuch as the figures for the different years appear to be entirely independent of each other, both as regards those inside as well as outside Drøbak, and this irregularity is very apparent in the figures from the outer fiord, in that the yield of 1880, for instance, was more than 20 times that of 1879, and more than 5 times as great as the following year. Such fluctuations would scarcely occur in the statistics of a profitable fishery, at least not when they concern so stationary a fish as the eel, and to draw any conclusions of its abundance from such sources would be utterly useless.

The only thing that might, with some justification, be assumed, would be that, the above-stated figures denote a great irregularity in the fishing, and that the population lacks the intelligence necessary for carrying on a rational eel-fishery.

We were greatly surprised, however, when, during the first summer, in searching the zostera covered shallow bays and creeks of the fiord with an eel ground seine, handled by Danish fishermen, we found that the fish occurred in an abundance which far exceeded anything previously experienced by Danish fishermen.

Whereever the *zostera* was met with, there were also eels, and most often in great numbers.

Of the best localities may be mentioned the Frognerkilen and the waters around the islands at Christiania, Lysaker, Sandvigen, where it was not difficult to obtain 25 to 30 eels with a small seine in quite short hauls.

The eel is also found in the little bays about Drøbak, as, for instance, the Hallangspollen, as well as near Engene in the Vest Fiord, and in Sandspollen.

At Moss, and further out, near Evje and Larkollen, there are good small areas, owning a fine *zostera* bottom, where the fish is very abundant, but the best locality which we examined on the eastern side of the fiord was the Kure Fiord, a small fiord running from near Larkollen inwards for a length of about $3\frac{1}{2}$ English miles.

It is only a few fathoms in depth, and the bottom is almost entirely covered with *zostera*; the water there teeming with fish.

On the western side, the bays about Horten are noted as good eeling places, and also about Tønsberg there are some very good, though small spots.

On Hjort's cruise in 1898, the eel was also commonly found right round to Jæderen, and places suitable for its stay, were to be met with almost everywhere in the little bays and sounds that are so numerous along our south coast.

About Fredrikstad there are, too, several localities in which the eel is to be found, of which we may specially mention the Thorsøkilen.

Dahl found the eel to be very sparingly represented in the Trondhjem Fiord, and only in a few localities.

Thus it was common at Orkedalsøren, and in Gulosen and Børsen. Also in Rissen a number of eels were to be met with, and in the inner parts of the fiord it was captured, occasionally, amongst the yield of the seine, thus in the Beitstad Fiord. Nowhere, however, could one obtain anything like the quantities of eels caught in the south, a fact which is indicated by the conditions of the deep; for from the map of the fiord it will be seen, what has already been stated by us, that the extent of the shallow water regions of the Trondhjem Fiord is exceedingly small.

In the following pages we shall give a number of examples concerning the number of eels we were able to obtain at various places.

The Christiania Fiord 1897.

August 14th, *Kjørbo* and *Næsøen*, 4 hauls, in the day time, 8 kilogrammes eels; 4 hauls same place, at night, 50 eels.

September 2nd, *Kure Fiord* (near Larkollen) 2 to 3 fathoms, several hauls, 38 eels.

September 10th, *Frognerkilen* (in twilight) 2 hauls, 50 eels.

1898.

August 31st, *Frognerkilen*, 2 hauls (in the day time), 62 eels.

Do. 31st, do. night, 35 hauls, 500 eels.

September 5th, *Thorsøkilen* near *Fredrikstad*, 1 haul with an eel drift-seine, by day, 37 eels.

September 13th, *Tønsberg* (*Trælen*), several hauls with the drift-seine yielded 5 to 12 eels *per* haul, total = 65 eels.

The coast of the Skagerrak, 1898.

August 25th, *Hovekilen near Arendal*, 5 hauls, 25 eels.

August 20th, *Lister*, several hauls, 5 eels in each haul.

July 29th, *Hafvs Fiord*, 4 hauls, 5 eels.

August 15th, *Fæøen (Haugesund)*, 1 eel pot, 1 night, 4 eels.

Extract from Dahl's Journal 1898:

June 8th, 9 the *Børs Bugten*, clay, *zostera*, stones, and sea-tangle by the beach (eel ground seine), 4 eels (of which a big one measuring 84 cms.).

July 10th, *Meja* and the *Børs Bugten*, 4 hauls, eel ground seine, 3 eels (large size).

July 13th, mouth of river *Orkla*, eel ground seine, 1 haul, 2 eels.

July 20th, *Inner Lensviken*, 4 hauls, eel ground seine, 2 eels about 50 cms.

July 21st, Inner Lensviken, 4 hauls, eel ground seine, 3 eels, 31 to 60 cms.

July 24th, Langsæter, Rissen, eelground seine, 2 eels.

August 20th, Stenviksholm, eelground seine, 3 eels, 59 to 63 cms.

August 10th, Kirknæsvaag (Beitstad Fiord), eelground seine, 3 hauls, 1 eel, 64 cms.

September 11th, Krogsvaag (Beitstad Fiord), eelground seine, 4 hauls, 1 eel, 72 cms.

We have had comparatively little opportunity of enquiring into the autumnal migration of the eel in the sea, and it has been impossible for us to form any definite opinion as to whether a great movement of the eels takes place along the shore, as is the case on the coast of Denmark. At one spot (Aasgaardstrand), we laid out an eel pot from the 4th September to the 30th November 1897, but during the whole of that period caught but 25.75 Kilos. weight of eels. The fishing was carried on only by night, and only once, during a N. W. gale, accompanied by snow, did we catch any great number, viz., 26 eels.

In the autumn of 1898, we laid out two eel pots at the same spot. They were in use from the 26th August to the 12th December, but did not catch more than about 100 eels. Of these, 26 were caught on one night, the 4th November, the weather being clear with a W.S.W. wind. The main catch, on the whole, occurred in November.

It thus appears that a sort of autumnal migration takes place in the sea, but, on the basis of the above mentioned experiments, we cannot express any opinion as to whether the eels, during migration, proceed along the coast, indicate the numbers that migrate, or whether, on the basis of their migration in the sea, a fishery might be established on our shores.

Only in a few places in our country did the people know that the glossy eel left the fresh waters during the autumn, and where such knowledge is met with people often relate that eels are to be found in such and such a lake, while mill hands, workpeople at saw mills, and such factories as are situated by such waters, tell how the machinery, in such and such a year was stopped by multitudes of eels which were packed in the water wheels or turbines. But only at very few places did the inhabi-

tants know that the eel descended the rivers each autumn, and at still fewer spots did they endeavour to derive any advantage from the migration, possibly because most of the people regard the eel as a valueless and uneatable fish.

We have been unable, hitherto, to make any extensive investigation of the fresh waters, and to give any *figures* respecting the occurrence of the eel in fresh waters would be, for the most part, impossible. We would chiefly be compelled to relate that which we heard in various localities. In almost all the fresh waters which are directly connected with the Christiania Fiord, eels are to be found. In the Sogns Vand, (Lake) for instance, they are met with, and also in the waters of the Maridal Vand. According to tradition, the old saw mill at Brække was once stopped by multitudes of eels. Bogstad Vand is also said to be full of eels. In the Vandsjø, a lake, near Moss, they occur, and it is reported that at one of the factories on the Moss river, which only has a dam across *half* the river, eels, to the value of 600 Kroner are caught during the autumn.

Many eels pass down the river which runs out from the Borre Vand, a lake, near Horten, the water power of which is used to work a factory, and quantities of them have been found on many occasions in the turbines.

It is known that several of the lakes on the south coast contain eels, and also the fresh waters of Jæderen.

In the north (nordenfjelds), much is known of the occurrence of eels in the lakes. The peasants state that they are to be found in many lakes, and especially in the inner part of the Trondhjem Fiord are the waters full of eels. The inhabitants of some of those parts fish for them during their autumnal migration in a primitive fashion. Some farms are even taxed on their right to catch eels.

In that part of the province of Trondhjem the eel appears to be far more numerous in the fresh waters than in the sea. On the west coast one hears of lakes frequented by, and even in Nordland, for instance at Senjen, it is said that eels are to be found in the mountain lakes.

It has been difficult to procure any figures relating to its occurrence, and a more thorough investigation of the stock of eels in the fresh waters would certainly be of importance.

In order to have something to start from, we have secured the right at a few places, to fish eels, during the autumn, at the outlet of lakes frequented by eels, both in the west country and in the north.

At several places in Jæderen a sort of fishery has been pursued for long during the descent of the eels. The engine for catching the eels is exceedingly primitive, consisting of a woven basket or trap, the so-called «Mærer», about 60 cms. in diameter, which is simply laid in the middle of the stream or course of the river, and which, naturally, catches but those eels which by chance do not avoid it. Proprietor after proprietor all the way down the water-courses use such an apparatus, and it is generally said, in those parts, that «oddly enough the lowest down the stream caught most». This is only natural, for those quantity of the migratory eels increases at the lower portion of the water courses owing to the number which join the river from its tributaries.

Especially in the upper portion of the Orre watershed, at Time, are these sort of engines employed. There were several mills in olden times at the mouth of the Orrevandet lake, and, during the autumn, the eels were caught in boxes. People at the spot said the catch amounted to 4 barrels. Now, that the mills have been pulled down, fishing is not carried on.

During the autumn of 1898, Hjort set an eel pot there which was looked after by the people at the spot, the catch amounting to 800 eels.

There are in the inner portion of the Trondhjem Fjord*, as already mentioned, many lakes frequented by eels, and especially about Stenkjær, and, in the waters which fall out near that town, autumnal fishing has been carried on from olden times in the mill shoots, and so-called «eel houses» which were specially built for the purpose. Many of these are, however, now decayed, and fishing is but little carried on.

At the outlet of the Lømsen, which falls into Snaasen, we rented the registered eel fishery on Ulven farm, where the apparatus consisted of a wooden box with holes in the bottom, it being placed under a mill shoot. On opening a shutter in the shoot the whole water of the river could be made to run through the eel house. The care of it, which was left to the people of the place, was, undoubtedly, badly attended to, and it was impossible to obtain any accurate information respecting the catch. There is, however, no doubt but that considerable numbers of eels were taken.

*) Our investigations, in the north, have received the most liberal support from Mr. Martens, Stenkjær, Inspector of Forests, and Mr. Chr. Homan of Christiania; also, in the south, from Mr. Consul Puntervold, jnr., Ekersund, and we, herewith, beg to express to them our grateful thanks for their kind courtesy.

When Dahl visited the place in the middle of September, 1898, he found over 50 large live eels at the farm, the result of the previous night's fishing, and the catch of the night previous to that was equally great. A number of eels lay salted in the store house. The people there said they had caught as much as a barrel of eels in one night. In 1899*), in the little river, no less than 3 hektolitres of eels were caught of a value of 100 Kroner per hektolitre.

As will be seen, we have only been able to carry out comparatively few fishing trials from which we could obtain any figures, and the statements concerning the quantity of eels that may be obtained on their descent during the autumn from our lakes, and even those figures we have been able to get, can hardly be regarded as fully reliable, that is to say that, probably, had the fishing been carried on in a rational manner, more would have been caught.

But even if the places which have been investigated are few in number, our endeavours, in our opinion, shew that eels can be caught at the outlet of our lakes; and it is also our opinion that by fishing eels in a rational manner, a very remunerative fishery might be established.

Not only could a paying eel fishery be carried on in the sea, along the shores of the south coast, provided proper engines were employed, but the fresh waters, too, might be expected to yield a not inconsiderable annual production so soon as the eyes of the people became opened to the fact that there is really money to be gained.

In the west and north, the stock of eels in the sea would probably not support any extensive fishery, but many of the fresh waters might well be expected to yield considerable quantities of eels.

We do not imagine that this short account of ours could possibly be the means of bringing about so great a fishery as, in our opinion, might be carried on for eels. In order to effect this, much more is required than written statements and facts.

It has only been our object to point out a source which is, as yet, unheeded, but which might lead to an entirely new fishery — to the establishment, in fact, of an entirely new and lucrative undertaking.

*) the fishing that year was attended to by the fishermen engaged in the investigations.

Chapter X.

The Bearing of Our Results on some Practical Questions.

In the former Chapters we have given an account of our investigations and their results. By the aid of these we shall now turn our attention towards elucidating the questions raised in the Introduction, viz., whether the waters of this country are overfished; whether any diminution in the stock of fish is perceptible, and what views, and practical methods ought to be adopted in respect to our daily fishery.

I. Overfishing.

It is impossible to imagine that any decline can take place in the stock of fish which, in any case during a great portion of its existence, belongs to the open sea. No mention has ever been made of any decrease in the yield of the bank round-fish fisheries of this country, and, which, moreover, have not been carried on for any very great length of time. The general desire, a desire which receives unanimous support, is certainly only that of enlarging them to the greatest possible extent.

The Lofoten fisheries, which have been carried on for hundreds and hundreds of years, certainly exhibited equally great variations in their yield in former days as they do now, and no proof whatever exists of any lesser abundance, now than formerly, of the cod which visit the shores of the Lofotens, and very many other parts of our coast during the spring.

There are certainly no people to be met with who believe that the shoals of coal-fish and herring have diminished in numbers, and even the Committee of the British House of Commons which, in 1893, thoroughly discussed the question of trawling, and that of a decrease in the numbers of the fish — questions which were thoroughly gone into, and enlightened by documents innumerable — could not find the *slightest* reason for presuming that the numbers of round fish in the North Sea had decreased.

The reproduction of pelagic eggs and larvæ, follows suit, and shews that even those fish which become localized when fully grown, must be said to belong to the great pales of sea concerned, in that during part of their life, as pelagic eggs and larvæ, they are quite independent of place, and are entrusted to the currents of the great oceans. As an instance of this we may mention the plaice, whose life we have already described, and to which we would refer the reader.

As we have shewn in our account of the plaice, such kinds of fish may, possibly, be fished out for a certain period, but would, probably, become replenished, provided the opportunity were given. It is thus within the power of man to regulate the amount of stock both in our country and in the North Sea. The question as to whether the fish decrease in numbers on our shores may, therefore, in respect to flat fish, be answered in the following manner. It is proved that while a decrease, due to the fishery, does take place, it has not been proved that any decrease in the numbers of young fish exists where the accumulated stock has been fished out.

We have not had an opportunity of contributing any information connected with this question, in respect to round fish, as that is one, which, in our opinion, would relate to the entire pale of sea to which the fish belong; but there appear to us to be very many reasons which tell against the presumption that, for instance, the abundance of cod in the North Sea is on the decline.

The enormous number of eggs which Hensen found, practically, everywhere in the North Sea, and which we have already referred to, does not indicate any want of germs, and that these germs should not have any opportunity of developing is highly improbable when we think of the vast quantities of fry of the round fish which we have met with, both on the south west and northern shores of Norway. And that no

great quantities of fish are produced from the stock of fry, is refuted by the great fisheries carried on both in this, and other countries adjoining the North Sea, in regard to which no decline, as previously stated, has been apparent.

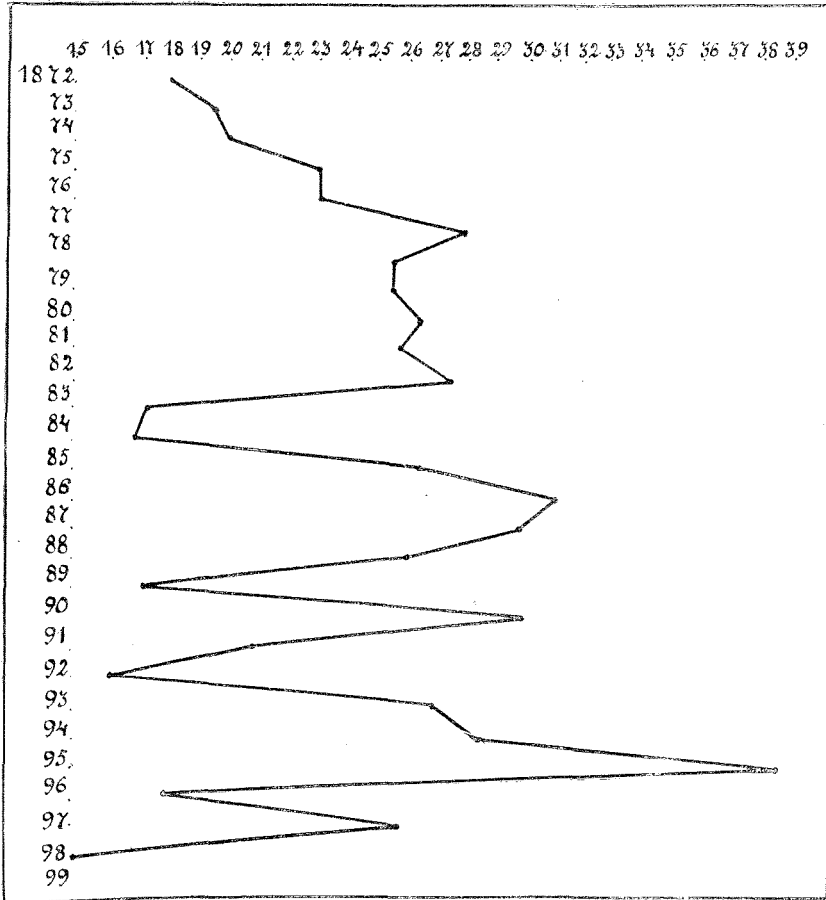


Fig. 25. The Yield (The number of cod in millions) of the Lofoten Fishery, during the years 1872, to 1898.

The accompanying diagram, representing the yield of the Lofoten fishery during the years 1873, to 1898 (Fig. 25), appears to us to be very instructive. The curves of the yield, which is denoted by lines, and represent millions, shew great variations. There are periods of excessive rises and falls in the yield. The curves make the most unaccountable leaps, and this fishery's changeability must certainly be regarded

as indicating variations in the *approach of the fish to land*, and in the labours of the fishermen themselves. The idea of overfishing cannot be entertained.

The curve has not the slightest resemblance, for instance, to those from Smølen and Frøien, framed by us in respect to the plaice, and which we must regard as typical fished out curves.

No decrease in the stock of the ocean can be proved, from this, to exist, and this is a fact which may be further strengthened by the investigations which have been carried out in Scotland, where entire fiords, and stretches of sea, have been preserved for years, without any increase of stock being perceptible. We have already mentioned those investigations in Chap. 7, under the head of «The Cod», and will refer the reader to it.

We only possess Statistical Reports concerning the daily fishery in one of our fiords, viz., the Christiania Fiord*. From the Statistical Report we have framed the following curves, representing the yield of fish from outside and inside Drøbak, during the years 1878, to 1898. The curves run nearly parallel to each other, which shews that *the quantity of fish in the inner part of the fiord, is thus not independent of that of the outer portion*, and that the great variations must be regarded more as a *variation in their approaches to the land, and not in any local stock*. It will be remembered that such approaches occur, from what we have previously stated in our article on the cod.

Before any perception of a decrease of the shoals in the fiords can be formed, quite different statistics must be framed than those now obtainable. For the present we can only state that *nothing is known on this point*. An objection to this may, however be raised, in that it is very generally stated that the experience of the fishermen favours a decline. To this we may remark that, in the first place, our experiences shew that the fishermen's statements often vary at different seasons, according

*) We would remark, however, that these Reports are of but little value as they, in the first place, but give the number of fish brought in to Christiania, and, secondly, often include, under one figure, two or three small fish to make up one «countable fish». Such a method is, however, to be condemned, and is quite unsuited for the purpose of enlightening questions like those we are dealing with. Either should the number be given in «*number of individuals*», best too with their measurements, or else by their weight in *Kilogrammes*. The expression «countable fish» is far too inaccurate a term for the purposes of calculation.

to whether fish are abundant or otherwise. In the second place the annual variations shew, for instance, in the statistical Report on the Christiania Fiord, that the number falling to each fisherman is so small, that no great weight can be attached to their views concerning an increase

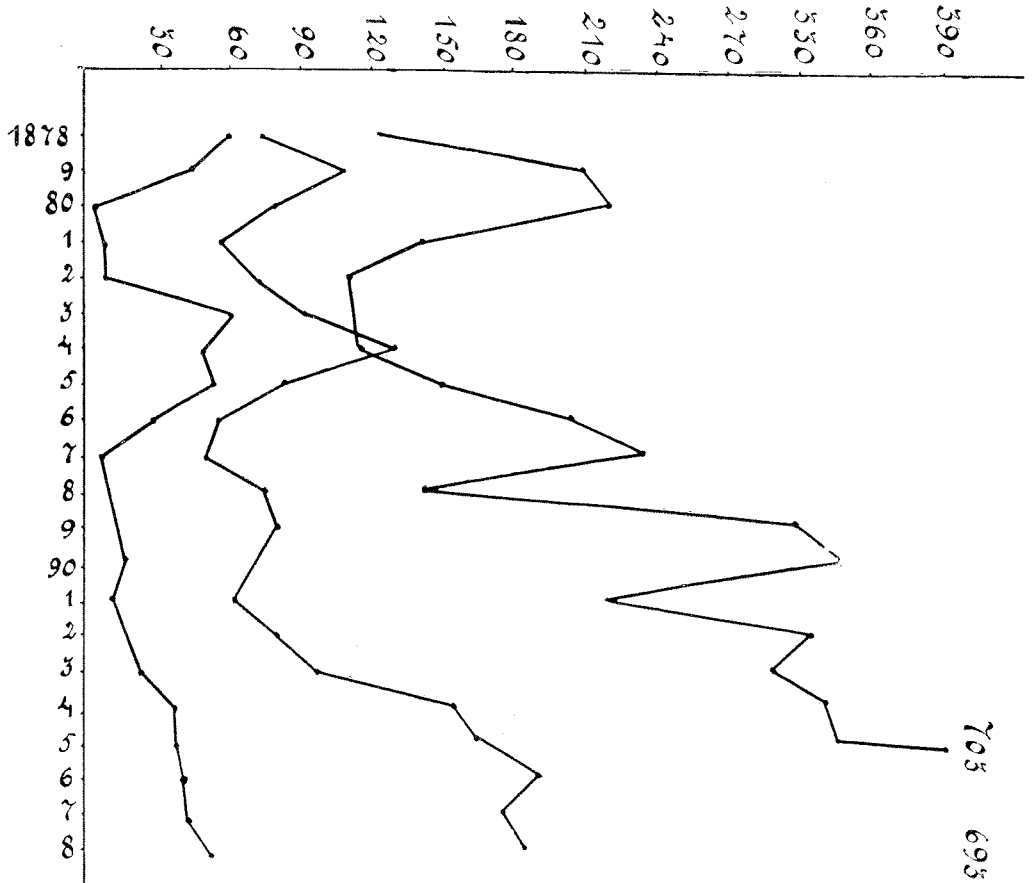


Fig. 26. Number of Cod, in Thousandths, brought to the Quays at Christiania during the years 1878, to 1898.

The lowest curves represent the numbers taken inside Drøbak
 - central -- -- -- -- outside --
 - uppermost -- -- -- imported from Sweden and Denmark.

or decrease, as it is impossible for them, under such circumstances, to notice such variations. It must, furthermore, be remarked that the yield of fish is not solely dependent on the abundance, or otherwise of fish, but also on the diligence of the fishermen, and the gear they employ.

II. Hatching.

In order to improve the supposed overfished local stock of fishes, artificial hatching has, *inter alia*, been attempted, especially of cod.

Such an industry, that of impregnating and hatching the ova of salt water fishes, is not very old. It is the result of the scientific discoveries of the last 30 years.

Whilst it has been known for ages, that fresh water fish have comparatively few, and large eggs, and that the young fish which are hatched are very large and hardy, and easily reared, as good as nothing was known of the breeding of our sea fishes some 30 years ago. It was known that most of the edible sea fishes had many, and small eggs, which, in respect to some species, could amount to several millions, but where they spawned, what the appearance of the fry was like, and where they were to be met with at different stages of life, were matters concerning which nothing was then known.

In 1864, Professor O. Sars, when in Lofoten, discovered that the eggs of the cod floated on the surface of the sea, a discovery that led to the most wide spread knowledge of the propagation of sea fishes. Owing to Sars's further investigations, and those instituted by other native and foreign scientists, who were stimulated in their efforts by Sars's discoveries, the study of the propagation of sea fishes has been eagerly carried on, and the knowledge of this, formerly so obscure a subject, was thereby greatly increased.

Sars found that one could take the ripe ova of the female fish, and impregnate it by introducing a few drops of the milt, or sperm, into the water.

By keeping the eggs in small glasses, filled with sea water, he could follow the whole course of their development, until the infantile young were hatched from the egg, and, like it, drifted about on the surface of the water where they, for a certain number of days, existed on the nourishment derived from the so-called yolk sack. When that was used up, and they became capable of eating, the death rate was great amongst those living in the small glass vessels used by Sars.

We must here point out that Sars, by these first experiments brought *the hatching of cod to as great a state of perfection as it, as an industry, has reached at present.* In saying this it is not our intention to detract from the value of technical advances made in hatching *en masse*.

Sars's discoveries and experiments in this branch of science aroused the greatest attention abroad, America being, however, the first to seriously adopt the discovery and put it to a practical test. Also in this country, owing to the results of Sars's discovery, endeavours were commenced with the object of increasing the stock of fish in those fiords of southern Norway which were reported as having been fished out. Subsequently too, the hatching of salt water fishes was commenced in England and Scotland. A considerable amount of capital, and considerable attention and forethought, has been devoted to the work of hatching, but, notwithstanding the greatest efforts spent on it for more than 20 years, *no great abundance of fry has been reared beyond the pelagic stage, despite all the practical technical labour that has been devoted towards improving the methods connected with the hatching and rearing of fishes.* Notwithstanding all the enthusiasm devoted to this cause, Sars's statement that the larvæ cannot be kept in confinement when once the yolk sack has been absorbed, has proved to be correct.

Neither at Flødevigen, nor the Hatching Establishments in America, has any success attended the attempts to rear the young of salt water fishes in any quantity, at a reasonable cost, except in their first pelagic stage whilst they still derived their nourishment from the yolk sack. If, with the means available at the present time, any attempt is made to rear the young in a further stage of development, the mortality becomes excessive, and the endeavours that have been made to improve this condition by turning them into large ponds have, from a pecuniary point of view, been most disheartening.

The best proof of the unsatisfactoriness of artificial hatching is, in our opinion, shewn by the fact that all the establishments, now at work, find it necessary to turn the young into the sea a few days after they have been hatched.

The work at Flødevigen Hatchery consists of putting several hundred millions of such fry, during the course of the spring, into the water at different spots, and in various bays on the south coast of Norway; and if one studies the accounts in the «Manual of Fish Culture» (U. S. Commission of Fish and Fisheries, 1897) relating to the hatching of salt water fishes, one will read the following concerning the hatching of cod:

«The fry is turned out as soon as practicable. If all the eggs in a

given quantity are not hatched, it is better to turn them out with the fry than to retain them until the hatching is completed».*

It is therefore best, as indicated by the method in vogue in America to turn newly hatched ova into the sea where it already swarms with fry (they are turned out at the natural spawning grounds). Evidence has been required by the authorities who have supplied funds for the purpose (and, in our opinion, properly so), to prove the value of fish hatching, and various endeavours have been made to do this

The only evidence which the supporters of hatching, at home and abroad, have had to hold to, has but consisted of arguments and calculations, the correctness of which cannot be verified, or else expressions of opinion, gathered at various spots, respecting an increase of the stock of fishes after the turning out of fry had commenced.

But not one figure or unassailable fact has been brought forward.

The want of statistical tables has partly prevented this, and besides, from the very nature of the matter, it would be very difficult to produce any reliable evidence shewing that an increase had really taken place.

A rise in the yield of fishes in the Christiania Fiord, which is shewn in the Statistical Reports, is, thus, assumed to be the result of artificial hatching.

To this we cannot agree. We have already (Fig. 26, P. 184) given the curves of the annual variations of the yield of the fishery, and described them as representing variations in the approach of the fish to the shore, and we may now point out that the curve representing the importation from Sweden and Denmark exhibits a like rise, this being a circumstance which indicates that the greater requirements of an increasing population in the capital have not been without influence. We would also call to mind our objections, on the whole, to the applicability and employment of those reports.

If the rise be due to the hatching, the increase in the number of fishes must, then, be represented throughout the whole of the Skagerrak, consequent on all the pelagic fry intended for our fiords.

The want of any sure and unassailable evidence has been felt, and even those connected with the hatcheries have acknowledged this. The authorities desired to have the young fish marked in order to find out

*) The newly hatched fry.

what became of them, but this was a demand which, naturally, could not be complied with.

The opinions of various experts on the subject have been brought forward, but all of them state that they are unable to produce any certain facts which tell in favour or otherwise of the hatching. In 1893, Capt. Dannevig brought forward a resolution proposing that an enquiry be instituted concerning these questions*, which, in the main, appears to us to be very good.

Capt. Dannevig's proposal runs: — — — «As the matter now stands, we do not know with absolute certainty whether an increase in the numbers of cod has resulted from artificial hatching or not. It is true that there is very much in favour of the supposition that an increase has occurred — yes that indicates an increase has taken place — but we nevertheless want proof positive that such is the case, we want those figures which could shew the former and the present numbers of cod».

Capt. Dannevig then proceeds to describe the manner in which he believes the desire might be accomplished. The main idea in his proposal is that, the occurrence of fry on the shores of fiords where pelagic young fish have been placed, ought to be investigated, and also the occurrence of fry in fiords where such has not been carried out, and in this way obtain figures for guidance.

«In order that we may more rapidly gain some knowledge of the matter, I propose» says Capt. Dannevig, «that a number of fiords, 4 to 6, be investigated, and that fry should be turned into every second fiord».

Previous to this, one of us, Hjort, had an opportunity of giving his opinion respecting artificial hatching generally. This will be found in Stortingspropositioner No. 1, Hovedpost VI, 1897, Communication of 23rd December, 1896, to which we take the liberty of referring the reader. In it Hjort especially points out the desirability of such investigations as proposed by Capt. Dannevig, and, after that funds had been voted for the purpose of carrying out proper fishing trials in the fiords, *similar investigations to those indicated by Capt. Dannevig have been carried out.*

Thus, during the course of our researches, it became apparent that both the fiords in which fry had been let loose (for instance the Christiania Fiord), and others where no fry had been placed (Trondhjem Fiord),

*) Printed in the Regjeringens Stortingspropositioner for 1894.

exhibited a great paucity of year's fry of cod, whilst such is to be met with in great abundance out at sea where no fry were turned out.

We have already dwelt upon the results, and formed our opinion thereon. We shall confine ourselves to referring the reader to what we have already written on the subject, as we, on our part, regard the question of the use of turning *pelagic* young into the fiords as settled.

The millions of pelagic young placed in the waters of the southern fiords cannot, according to what we have already shewn, escape a fate similar to that we have described concerning the pelagic eggs in the Christiania and Trondhjem Fiords, viz., that of drifting out to the open sea, and growing up there.

Whether, however, these millions of fry, or newly hatched eggs, increase the stock of fish in the sea to an extent corresponding to the measures employed, must be regarded as an open question, and is, in our opinion very doubtful, when we recall to mind the vast masses of impregnated eggs found, for instance, in the Skagerrak by Professor Hensen. In the month of July (26th July 1885), which is a month in which the eggs of edible fish are by no means abundant, Professor Hensen found 278 795 000 000 impregnated pelagic eggs in each 16 square geographical miles (1 square Norwegian Geographical mile) of surface; and there is no reason, whatever, for assuming that the greater part of these impregnated eggs should not reach the hatching stage, or, in other words, not arrive at a stage similar to that of the fry produced at a hatching establishment. In comparison with such figures, the quantity of pelagic fry turned out of a hatching establishment, however imposing it may appear to be, is but like a drop in the ocean.

It appears to us that what we have stated above, may give rise to the following question.

Is the work of hatching the eggs of salt water fishes to be abandoned?

Is there no possibility that the artificial production of salt water fishes may be productive of good results, in some way or other, in the future?

If, as it is carried out at present, the hatching is to be continued as a *practical and beneficial work*, the economic value of which may be regarded as settled; if, as it stands at present, it is to be continued as a business, we must warn people to have nothing to do with it, as it, like every irrational undertaking would only result in disappointment. As a business it does not pay at present.

The hatching of eggs of salt water fishes ought, as a link in the problem of the power of man to arbitrarily interfere in the economy of the ocean, in our opinion not to be given up, but it must be carried on in an entirely different manner. One must, above all, abandon every idea of immediate good results; one must not expect it to yield proofs of its advantages. It ought *pro tem.* to be looked upon as a *study*, and not the *practical result of study*.

It must be assigned to the place to which it really belongs, viz., that of *experiment*. We do not mean that experiments are to be made by *turning out fry*, but by *hatching and rearing*.

The vital question is, without doubt, to discover methods by which one can cause the myriads of tiny larvæ, which can at present be produced without any great difficulty in millions, to attain a reasonable size at a comparatively small cost.

Before leaving this question we may say that there are some kinds of fish which would be better suited to, and, possibly, afford better opportunities for experiments with this object in view, than the cod. In the chapter on the plaice we have touched upon this question, and stated that, on our coast, more fry of that fish *could* certainly live at those spots most suited to it, than is the case at present. In saying this, we intend our words to apply solely to this country. See the Chapter relative to the Plaice.

We also intimated that if the work of hatching could be perfected, so that, by its aid, the larvæ of the plaice could be kept alive beyond its pelagic stage, and reared until it settled on the bottom, a way might thus be found of increasing the stock of this species on our shores.

We may point out that it is with this object in view, Mr. H. Dannevig, at Dunbar in Scotland, has made some very promising experiments on a small scale; but even these do not entitle us, in our opinion, to believe that any number of small plaice in their early bottom stage could be artificially produced or «manufactured» for many years to come. We may, however, suggest the desirability of making similar experiments in this country, as such experiments on a small scale, which are chiefly made with the object of overcoming the technical difficulties connected with the rearing of fishes, must be regarded as of great importance, as a link in the endeavours that are being made, step by step, to obtain a knowledge of the conditions necessary for the culture of fishes in the sea.

B. Prohibition of the Use of certain Apparatus.

By prohibiting the use of various apparatus, as well as by hatching, the Authorities have aimed at increasing the stock of fish.

These prohibitions have been made, partly, on the assumption that certain engines *catch too many fish* («Tax the stock of fish too heavily»), and, partly, on the supposition that, the small fish, the fry, are destroyed by certain appliances in such vast quantities, that the remainder cannot make good the loss. It is, especially, attention to the preservation of the young that has played a great part in all the deliberations, and arrangements made for promoting the welfare of the fisheries, ever since the Commission of 1852 was appointed to deal with the question. Both in the papers, and by means of pamphlets, it has been pointed out, often in very strong colours, how certain apparatus — especially seines — in addition to their catch, destroyed great quantities of small fish, and, in consequence of these representations, there has gradually arisen, in this country, a very strong opinion against these so-called «engines of destruction».

In the Introduction it is stated, that the first result of this opinion was the promulgation of the Law of 1869, which was subsequently supplanted by the present *Law of 22nd March, 1888*, entitled «Law concerning Restrictions on the Use of Appliances employed in Sea Fishing», which prescribes that

«§ 1. Respecting Sea Fishing, the King may, on receiving a Resolution passed by the Communal Authorities — Town or Country — prohibit, until further notice, in the Place concerned, or the adjoining Districts, the use of certain Engines or Methods of catching fish, in order to prevent the destruction or diminution of the Stock of Fish.»

In conformity with this law, numerous applications have been sent in, from time to time, to the Royal Home Office, to prohibit the use of certain appliances, while numerous letters have also appeared in the public journals to the same effect.

These have called for the prohibition of
the employment of cod nets and long lines in Fladanger,
the taking of eels in traps,

the spearing of flounders (Ørland and Bjugn),
the employment of nets and long lines in the Sørffjord,
the net fishing for pollack in several Amts (Provinces),
the drift net fishing in Hallangspollen (creek near Drøbak),
the use of fine meshed fish-pots,
the employment of sea-perch nets.

Such applications have been refused on the ground that the Law chiefly aims at protecting the try, the small fish that, it is presumed, do not suffer to any great extent from such appliances.

Several Orders in Council have, however, been framed for the protection of young fish, by which, chiefly, the use of small, fine meshed seines has been prohibited in the south eastern part of Norway.

From the Order at present in force in the Smaalenenes Amt we may quote the following paragraphs.

§ 1. The use of Ground Seines*, that is to say Net-like Apparatus with or without a Purse, intended to be drawn through the water, and of less height than 11, and less length than 75 metres, is at all times prohibited. During the period from the 1st October to the 31st May, the use of Seines of larger dimensions is also prohibited, provided they are intended to catch ground fish. On the other hand such Seines may be used at all times for the purpose of catching Gregarious Fish, provided the Catch takes place where the Shoals appear, or on the generally known and frequented Autumn Herring Grounds (deep fishing grounds), and that the fishermen notify their intention to the Fishery Inspector.»

§ 2. No Seine (large seine) must be hauled to the shore.

Discussions for, or against the use of these apparatus, have, to a very considerable extent been confined to ordinary expressions of opinion. Thus one side states that the supplies of the ocean are inexhaustible, «take all you can get out of it»; while the other side points out that such a view would lead to the ruin of the fisheries, and that it may be described as an immoral act to destroy «thousands of of infantile fry». During this discussion, which has been carried on not without conside-

*) In an article written by Hjort, which appeared in «The Scotsman», the word «Grundvad» was erroneously translated «Trawl», which we greatly regret. We, however, considered this to be too trivial a mistake to need a rectification, and are astonished that this has aroused some displeasure.

rable fervour, very few *observations of the fishing*, itself, have been made. It has even been impossible for us to find a single written description of *any certain haul of fish*, or even a single report that one or other haul yielded so and so many fry of any description of edible fish.

If the work, instituted to discover the correct view on which to base practical measures for the improvement of our fisheries, is to raise itself beyond that of a heated struggle in which party interests are alone concerned, it must, above all, be founded on unassailable facts, and we shall, consequently, before stating our opinion, give a few figures from our fishery experiments.

Seines. The small, prohibited seines were originally constructed for catching eels or small herrings. Prior to the publication of the prohibition, many such small so-called «two men's seine», or «eel nets», of a length of about 50 metres, were to be found in eastern Norway. The Commission of 1852, stated that there were 50 such nets in the Christiania and Langesund Fiords. On the 15th March, 1888, from the evidence of 26 persons, chiefly seine fishermen, taken in Eidanger, it appeared that there were then 50 seines in that parish. The catch consisted partly of eels, trout, small herrings and sillocks, and the business was said to bring in 600 to 1000 Kroner *per annum*, to the owners. Of the fishes mentioned, the eels was certainly the most valuable, together with the small herrings which were sold and used as bait.

The seines belonging to such fishermen corresponded in all respects to the eel *ground seine* described by us in Chapter II, the yield of which (the catch) may, therefore, be looked upon as typical of *ground seine fishings*. The little herring seine, the catch of which was observed by Hjort at the Hvaløerne, differs somewhat, but not greatly, from the eel ground seine. In Chapter III and VI, mention is made of our fishing for fry with the eel ground seine, and we stated there that the smallest fry were not to be met with in our fiords *during the summer*. At the same time that we found stretches in the south eastern part of Norway where eels might be advantageously caught in seines, we found that the seines only caught the so called *zostera* fishes, but no fry of edible sorts. We shall here again give a number of examples of the yield of eels and fry from hauls of the seine.

Summer.

South Eastern Norway.

- 1) 14th Aug. Kjørbo, 5 hauls, 16 pounds of eels. No fry.
- 2) 14th, 15th Aug. Kjørbo, 4 hauls, 50 eels, 2 trout (12¹/₂, 14¹/₂ inches in length). No fry.
- 3) 24th Aug. Drøbak, 2 hauls, 12 eels, 110 whiting of the 2nd year.
- 4) 2nd Sept. Kure Fiord, 5 to 6 hauls, 38 eels, some few whiting, 1 large cod.
- 5) 3rd Sept. Eløen, 1 haul, 10 eels, 20 young whiting of the 2nd year, 1 cod, the year's fry, 1 cod, young of the previous year. 23 plaice, under 9 inches. 3 trout (9.10 and 11 inches in length).
- 6) 10th Sept. Piperviksbryggen, large herring seine, 1 cod of the second year.
- 7) 10th Sept. Frognerkilen, 2 hauls, 50 eels, no small cod, 2 trout (weight, about ¹/₄ Kilo).
- 8) 24th Aug. Hovekilen, Arendal, numerous hauls, 10 eels, not a single cod.
- 9) 25th Aug. Hovekilen, Arendal, 5 hauls, 25 eels, 5 cod (20 to 27 cms. in length).
- 10) 31st Aug. Frognerkilen, 2 hauls, 62 eels. 2 cod (smallest stage of the year). 4 cod (24 to 27 cms. in length).
- 11) 31st Aug.—1st Sept., Frognerkilen, 35 hauls, 7 cod (7.5 to 11.5 cms. in length), 23 cod (19.5 to 43 cms. in length).
- 12) 6th Sept. Thorsøkilen, Drift net, 37 eels, no. fry.
- 13) 7th Sept. Vadholmen, Hvaler, no eels, 26 whiting (10 to 30 cms.), 4 cod (10 to 13 cms. in length), 1 cod (37 cms. in length).

14) 8th Sept. Holtekilen, Hvaler, 3 hauls, 6 eels, 7 cod of first and second years, a few whiting.

15) 15th Sept. Viksfiord, Fredriksværn, a few hauls, a few eels in each haul, no small cod.

In addition to these, our own hauls, which naturally are just as much to be depended upon as the illegal hauls of the fishermen, Hjort has also observed, in the neighbourhood of Fredriksstad, a number of the (illegal) hauls of the seine, made by the fisherman. In consequence of these we give the following extract from Hjort's Journal:

«East side of the river near Fredriksstad, south of Øren 5th and 6th September.

The flat land at Øren near Fredriksstad continues as a very shallow bank, 1 to 3 fathoms below the surface of the water, in a southerly direction, broken by some slightly deeper furrows and ridges. The bank, below one fathom is covered with fresh water vegetation. Beyond the bank the bottom is bare, except for patches of zosteria here and there on the slope leading down to the 20 fathom deep channel between the bank and Kragerøen (see Fig. 27).

1) Numerous hauls with the hand ground seine. Examination shewed that great portions of the bank were covered with stones, so that only a few parts were suitable for seining purposes. These parts are marked by the fishermen with posts. From some hauls there we obtained 8 perch, 6 roach, 33 flounders (1 to 3, the remainder 9 to 28 cms. in length).

2) The same day I observed fishing carried on with a «two men's herring seine» during the evening after dark. One man in one haul got 9 eels, another 8, besides perch, gwyniad, bream, roach and swelts (fresh water fishes, the upper few metres consisting of quite fresh water from the river Glommen). No fry, either of whiting or cod.

3) On the 6th, at 6 o'clock in the morning, observed the same two fishermen who had been fishing all night. One had get 22 eels, the other 12, and of the above named fish so many that the one boat-boat brought in 10 Kroner, the other 7 Kroner 50 Øre. Observed some hauls. No fry either of whiting or cod. Both boats had altogether 9 cod of the following length: 40, 40, 28, 49, 32, 56, 51, 34, 38 cms. Noticed that eels were only fished for at high water, that is to say when the salt water covers the bank».

On the 8th September at Rom, Hvaler, Hjort observed, at 5 o'clock in the morning, some fishermen fishing with small, fine meshed two to four men's herring seines of a length of 20 to 30 fathoms. The seine only contained small herring, small whiting and sticklebacks. The small

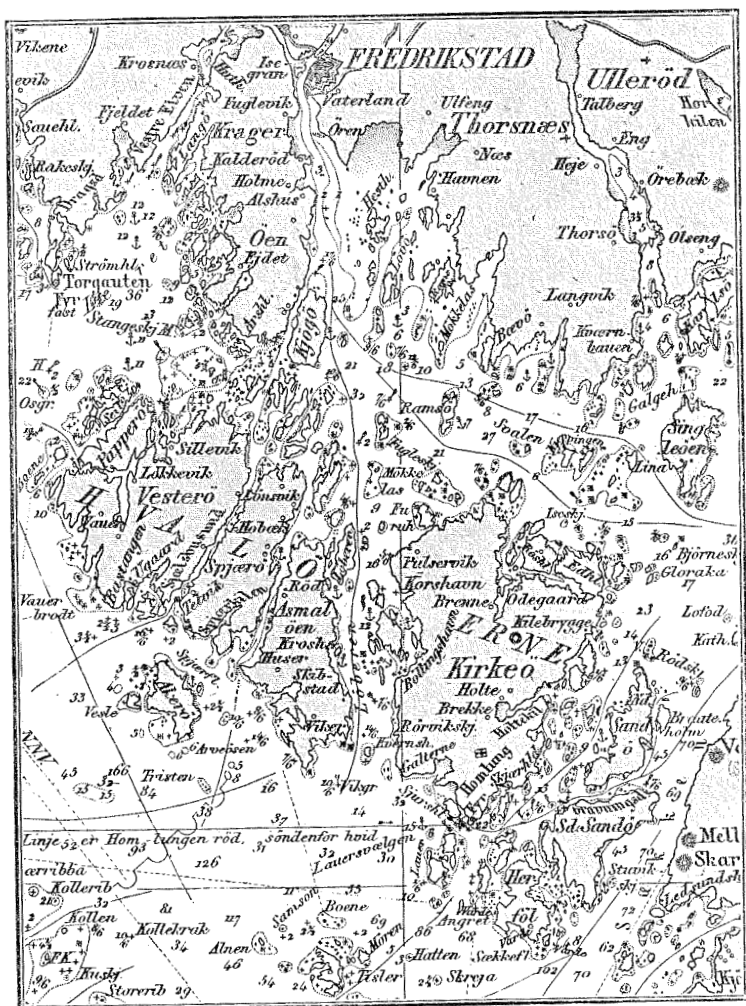


Fig. 27. Chart of the Waters in the neighbourhood of Fredrikstad and Hvaler.

herring were sold to various expectant line fishermen, who could not proceed seawards with their lines until they got the herrings for bait.

The same day he observed line fishers, hauling their long lines (1600 hooks per boat) in 80 fathoms of water, off Torbjørnskjær, near

Hvaler. They were in Hvaler smacks, with the boats belonging to them, and used the small herrings, caught that morning at Rom, as bait.

One of them caught on 1600 hooks:

Two score or so large haddock (about 40 cms. in length).

Several large ling, up to 130 cms. in length.

About 20 dog fish (a species of shark).

Several hag fish.

15 large cod, about 80 cms. in length.

Some — » 40 — » —

» — » 30 — » —



Fig. 28. Line fishers off Hvaler (See also Fig. 21, p. 95, depicting the same men with their smack).

If we therefore compare the experiences described in Chapters 3, 5 and 6 with the above one may say: —

i. East Country (Eastward of Lindesnæs).

During the Summer very little fry is caught by the eel ground seines and the small herring seines either in the sea or the fiords. It was almost impossible to obtain the fry of cod, even if specially sought for.

We moreover found that the best waters for eels were just those in which the fewest cod fry were to be met with. It cannot possibly be considered that any destruction of fry, worth mentioning, can occur from June to September (both months included) during the eel fishery*.

In the *Autumn and Winter*, on the other hand, more fry are caught in the seines, thus at Drøbak in October, a series of hauls yielded altogether 150 cod (8 to 22 cms., most 8 to 13 cms. in length): in October, one haul off the land of Hurum yielded 147 cod, from 6½ to 11 cms. in length; in February, four hauls yielded 11 small cod (6 to 30 cms. in length); also during the same month five hauls yielded 50 cod (9 to 12 cms. in length). Even at those seasons the destruction of fry is far less than formerly imagined, and then (see Chap. 6) there are no eels to be caught. The net fishing does not then pay, and, moreover, for a long time the seining grounds are covered with ice.

2. The West Country and North Country.

The youngest year classes of round fish are met with in abundance during the *summer*, only off the sea coast, and may there be caught by the hundred at each haul of the seine. During the same season numbers of year and a half old round fish may be netted in the fiords. Of such small fish, about half are too small so serve as food, whilst the other half may be used (the so called «frying fish», which are caught chiefly on hooks and lines). In comparison with the enormous coast line, the conditions of the bottom only allow of seining over a very small surface.

In the autumn and winter great numbers of the smallest fry of round fishes may be caught, both inside the fiords, and beyond the island belt.

(Concerning our views on the laws respecting seining, see Section C of this Chapter).

Trawls. Of Trawls we recognise two sorts, viz., the fine meshed (Danish Eel Drift seine, the Otter Trawl used by us) and the English Beam and Otter Trawl. Of these the *fine meshed trawl* was originally employed

*) The former statements respecting the destruction of fry wholesale, during eel fishing, can only be explained as having arisen from want of personal observation, or else, a superficial examination of the catch. Most probably the idea has arisen from the zostera fishes having been mistaken for the fry of edible fishes.

in *fishing eels*, and both in Denmark and Germany great fisheries, bringing in millions of Kroner, are carried on with it, or a very similar appliance. The fine meshed trawl takes the fry just as well as the eel ground seine. Every kind of apparatus that can catch eels, can also catch fry.

In order to understand the question of damage done by trawling in our land, it must be remembered that large stretches of even, flat ground, without stones, are necessary for trawling purposes. If our sea charts are closely examined, it will be seen that such flats, devoid of stones are only to be met with in *deep water*. We venture to say that it would hardly be possible to find sixteen square miles (one Norwegian square geographical mile) of trawling ground in the whole of Norway at a depth less than 10 fathoms, in any case such grounds are unknown to us, and are not to be met with in the waters that have been subjected to our researches. As, moreover, both flat and round fish, with few exceptions, are entirely absent beyond a depth of 10 fathoms, the fine meshed trawl and drift net may be said to be quite harmless engines so far as the fry in this country is concerned. We believe that this apparatus will be of great importance to Norway in the future, as it will lead to a, possibly, very paying deep sea shrimp fishery at depths of 50 to 60 fathoms. The future benefit of the appliance will, in this country, doubtless depend upon the attention paid to cleanliness and care in the treatment of the shrimps by the people. As warnings have even been published against this deep water fishery, we may state (although it ought to be quite unnecessary to oppose such opinions — warnings clearly based on ignorance —) that Hjort witnessed 300 to 400 hauls of the trawl in the Langesund-Brevik Fiord, in which not one specimen of the smallest of fry of round fish was taken. Only a small whiting was caught now and then, seldom more than one in a haul, most often none. Naturally, of flat fish fry, not one of the common shallow water flounders was taken. Of some special deep water flounders, small young were caught, as well as some of the fry which form the rarities of our collection. We have been credited with the great discovery of lobster fry, 1 to 2 inches in length! When one knows that over 30 different varieties of shrimps are to be found in this country, such mistaken identity can be excused (see Chap. IV).

The *English Trawl*, with its wide meshes is still more innocent of the charge of destroying the fry. The English Trawl was invented for

the plaice and sole fisheries on the banks of the North Sea, and is most effectively employed at depths varying from 10 to 30 fathoms in the North Sea. There are very few such depths in this country, and no trawling for those species of fish, worth mentioning could be carried on.

If the English trawl is used in this country, the trawling will be for round fish, and possibly for some kinds of deep sea flounders (*Pleuronectes cynoglossus*). In any case, however, trawling would have to be carried on at very great depths and at a great distance from the coast of Norway on our so-called «ocean banks», and would thus not prove dangerous to the *fry* of the common edible species of flounders (see section C).

Traps. Of traps there are chiefly three kinds in use, viz., Cod, eel, and shrimp traps. They are all more or less alike, the difference mainly consisting in the different sizes of mesh (see Fig. 24).

According to Dreschel's Report on the Salt Water Fisheries of Denmark, a work which we recommend to every student of fishing, the dimensions of the different kinds of traps are as follows:

	Cod Traps	Eel Traps	Shrimp Traps
Length of the trap in working order	16 feet	12 feet	10 feet
Diameter of the foremost « space	4 «	2½—3 «	4 to 6 «
« « « back « «	2 »	1 foot	1½ « 1 foot
Number of meshes per ell (2 feet) in the foremost portion	12 to 14	36 «	60 « 64
« « « « « « « « back «	14 « 15	42 «	65 « 75
« « « « « « « « row	12	25 to 30	52 « 55
The length of the row in in working order	60 feet	60 feet	70 « 80 feet
Price of the net in trap and row	7 kroner	18 kroner	40 kroner
« , additional, for putting it up	5 «	18 «	12 «
Materials, as a rule twine ^{12/9}	cotton twist	cotton twist	cotton twist.

As it will be seen the Cod Traps are wide meshed, the Eel and Shrimp Traps very fine meshed. At the Biological Station, Drøbak, simultaneous trials have been made at different seasons with traps, and experience has shewn that the more wide meshed and bigger the trap is, the greater the number of cod caught. It is thus in the interests of the fishermen themselves to use wide meshed traps for cod. On the

other hand, fine meshed traps are necessary for catching eels and shrimps, and in them small cod will invariably be found, often too small for food. But such traps can only be extensively employed in the south eastern parts of Norway, and, chiefly, during summer, as it is only then that eels and shrimps can be caught in traps.

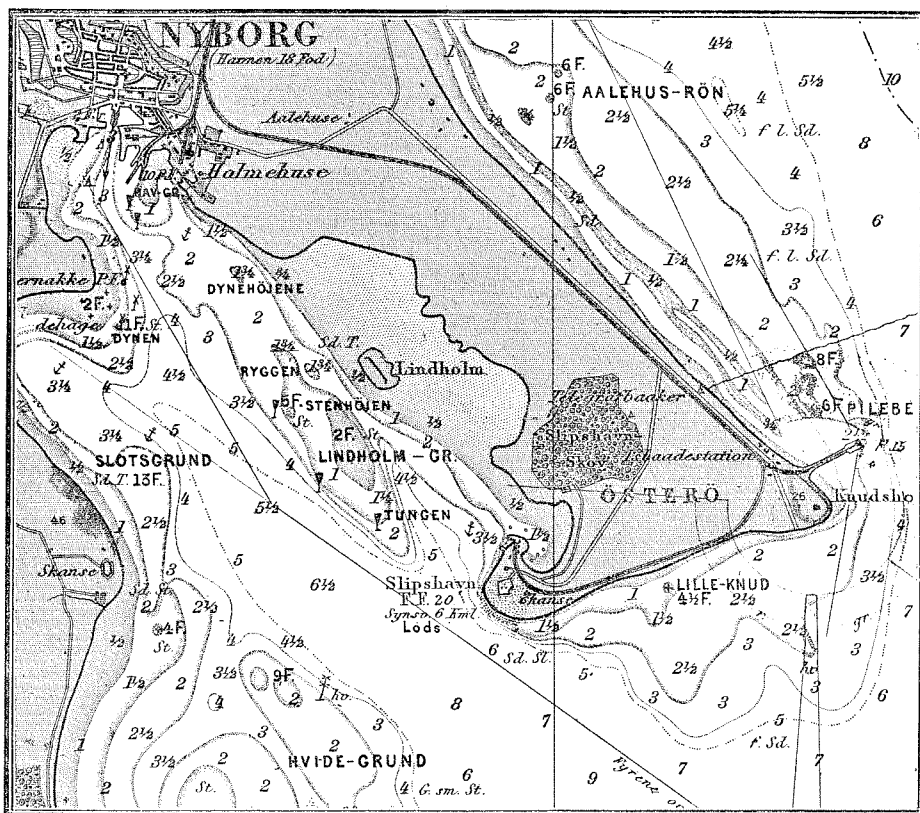


Fig. 29. Chart of Nyborg Fiord, Great Belt, Denmark.

No blame has been attached to the wide meshed traps, nets, lines, leistering &c. &c. in respect to the destruction of fry, but they are accused of taking *too many large fish*.

To this question we shall return later on.

Before proceeding to discuss the principles of the relations of the Law to the fisheries, we shall look into a few *examples* respecting how much is caught in other lands and how the fish is caught.

Denmark. In October, last year, Hjort proceeded to Denmark in order to find out, from personal observation, the number of appliances used there. From his Diary we may quote the following: Nyborg, on the Great Belt, October, 1898. In the fiord, which is 1½ miles long and about 1 mile in width, eel traps, cod traps, eel drift nets, trout traps and herring seines are used in fishing.

On the stretch of shore between Knudshoved and Slipshavn (1 mile), when sailing in the cutter belonging to the Danish Biological Station, I observed 140 eel traps; between Slipshavn and Nyborg (about 1½ miles) 160 eel traps, and about as many on the western shore, besides very many (probably more) cod traps. Witnessed the drawing up of eel traps. In several of these, numerous small cod, especially of the year and a half old cod. Eel fishing carried on throughout the entire summer, and, with eel drift nets, even up to nigh Christmas. Of these 7 or 8 are continually shot from boats in the fiord. Was on board one boat and witnessed several hauls. Catch, eels and, occasionally small cod (1½ years old). Saw cod trap fishers return home. One man owned 150 cod traps, another 50. Thirty of these, which had been exposed to stormy weather for 10 days yielded 350 cod (notwithstanding the stormy weather and that the traps were filled with zosteria by the storm). The cod are sent to Christiania. Four smacks take turns in sailing thither. The cod traps are set, some on the shallows by the shore (less than 2 fathoms; the depth is given in Fig. 29, in metres), near the channels, others on the banks in the Great Belt.

In addition, fishing is carried on with large herring seines for small herrings, to be used as bait. There are also many trout traps, in which a number of trout are taken, when, during autumn, they come in towards fresh water to spawn — «According to report, about 10 000 eel traps are set round Fyn». The Danish Fishery Statistical Report for 1895 gives the number of apparatus used in the Lim Fiord.

Number of <i>Herring seines</i>	51.
— » Herring ground-nets	256.
— » — vertical »	116.
— » <i>Eel seines</i>	449.
— » Eel traps	1 686.
— » » « («vadeglibe»)	678.

Number of Eel hooks (lines)	147.
— » other eel catching engines («aalestænger»)	2 585.
— » so-called «Plumpstænger»	468.
— » Plaice seines	365.
— » Flounder nets	11 154.
— » Cod traps	2 636.
— » Cod nets	9 469.
— » Cod long-lines	315.
— » Lobster pots	1 750.
— » Shrimp traps	1 204.
— » other Shrimping engines («rægeglibe»)	421.
<hr/>	
Total number of apparatus	33 748.

The value of these appliances is 380 687 Kroner, and the take of 1895, was of an estimated value of 1 280 739 Kroner, divided as follows:

Herring fishery	68 577 Kroner
Eel —	538 052 —
Flounder —	300 280 —
Cod —	212 580 —
Shrimp —	129 345 —
Other fisheries	31 905 —

From the above figures some idea will be formed of the enormous number of engines employed in Denmark; and it will be seen that the fiords, from 2 to 5 fathoms, at most, in depth, with quite level bottoms, are being constantly searched with seines and drift nets, and that, consequently, the take of small fish in Denmark must be very great. When from those waters cod can be shipped abroad, even to a land of fish like Norway, it will be seen, better than in any other way, that *the stock of fish there is not entirely local*. It was formerly stated that not a single cod was to be found in the Lim Fiord prior to the year 1825, and that the fishery there arose as the natural conditions of the fiord became altered. Now cod representing a value of 200 000 Kroner are caught there yearly — some say «notwithstanding the numerous apparatus», others «on account of the many appliances».

From Lancashire in England (see Note, P. 142) we may give an example of how a fishery can last, notwithstanding the most enormous destruction of fry*.

Fig. 30, shews us the waters between Ireland in the west, Scotland in the north, Lancashire in the east, and Wales in the south. These waters which form the so-called Irish Sea, cover, in their eastern portion,

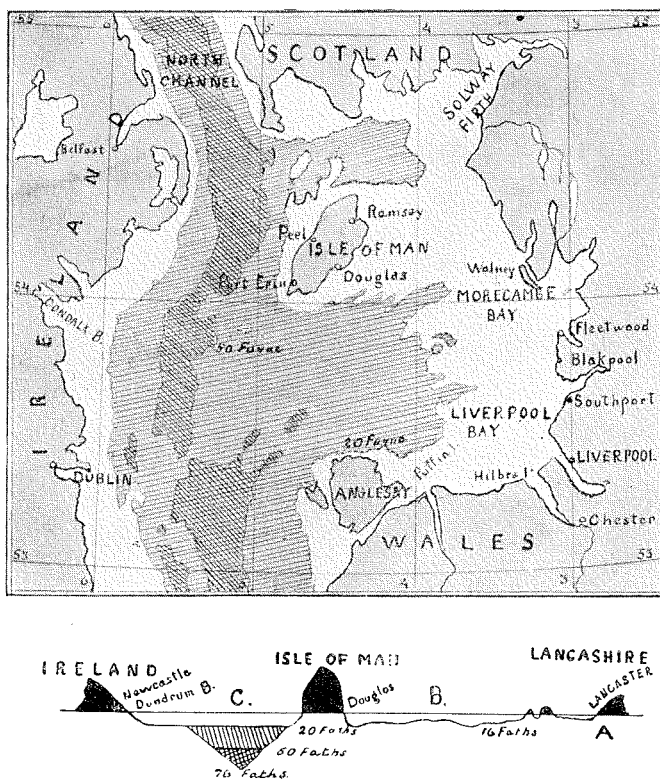


Fig. 30. Chart of the Irish Sea, with Depths, and Section of Depths.

a very large, shallow bank above the 20 fathom line (as shewn in Fig. 30, without hachure), which is 80 to 90 miles long (from N. to S.) and about 40 miles in width. To the westward of the Isle of man there is a deep furrow, up to 70 fathoms deep. The relative depths will very clearly be seen on the section, at the foot of the chart, from Ireland, past the Isle of Man to Lancashire.

*) A very large portion of the fry naturally survives its capture.

The latter are, for instance, our common shore or strand shrimp, of which three varieties are the most important, viz., *Palæmon Fabricii* (which is caught in numbers, for instance, at Sandvigen near Christiania), the *Crangon Vulgaris* (the «Horse Shrimp») and a special west coast species (*Pandalus annulicornis*). In Lancashire the catch chiefly consists of

Crangon vulgaris (shrimps), and
Pandalus annulicornis (prawns).

Fig. 31 is a chart of the neighbourhood of Liverpool. The word «shrimping» denotes those spots where shrimp fishing takes place. As

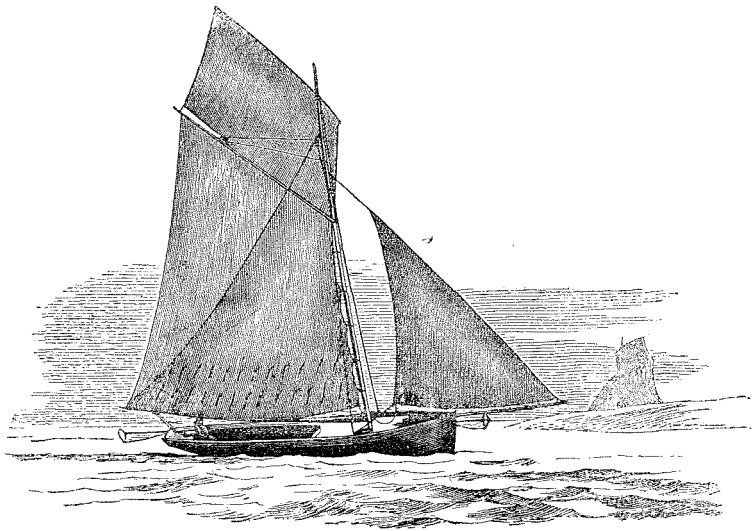


Fig. 32. A Morecambe Bay Shrimp Trawler.

will be seen the fishery is carried on between the sandbanks, which, at low water, are exposed, and, at high water, are covered by the sea, thus in shallow water.

In the channels there are vast quantities of shrimps, which are caught by means of a little beam trawl (15 to 25 feet in width) with a fine meshed net (half an inch from knot to knot), from half decked boats of about 5 to 6 tons. In 1896, there were said to be 400 such boats at work, and this shrimp trawling has existed for a great length of time. Holdsworth, in his «Deep Sea Fishing», 1874, states that it is a very ancient fishery. In 1896, it was estimated to bring in about 1 000 000 Kroner.

During this trawl fishery on the level, shallow sands, quite enormous numbers of fry of various kinds of flat fish are caught. One can, in this instance, rightly talk of thousands and tens of thousands of small fish in a haul.

From the notes of the Chief Inspector of the Lancashire Fisheries we may quote some examples of the number of fry that may be caught in a haul. The hauls were made with a small beam trawl of a width of 21 feet. The catch consisted chiefly of soles, plaice, dabs, whiting cod and skate.

Date	Time occupied in trawling	Shrimps Quarts	Young of edible fish	Number of other shrimp trawlers on the spot during the trawling
27th September, 1893	1 hour 30 mts.	32	11 032	12
8th June, 1894	1 « —	3	2 325	42
21st August, 1894	1 « 15 «	15	5 672	31
23 August, 1894	1 « 10 «	10	4 391	33
4th September, 1894	1 « —	64	2 339	21

Some other hauls from grounds on which trawling was prohibited, may be given. A trawl of a width of 25 feet was used.

Date	Time occupied in trawling	Shrimps, Quarts	Flat Fish	Round Fish
7th November	30 mts.	5 ¹ / ₂	6 117	81
28th December	40 «	22 ¹ / ₂	20 772	117
2nd January	45 «	6	8 356	156
14th November	43 «	3 ¹ / ₄	1 373	2
28th December	40 «	10 ¹ / ₄	5 215	6
2nd January	45 «	14	2 017	10

The Flat Fish consisted of soles, plaice and dabs of an average size of 3 inches; the Round Fish were whiting, cod, and herring of an average length of a trifle under 4 inches.

As great numbers of the fry, thus caught, die, quite an enormous destruction of fry occurs. *Imagine 20 772 flat fish caught during the course of 40 minutes, and that one such trawler makes many such hauls during the course of one day! Fancy too, that there are no less than 400 trawlers, and that there have been as many, so far as we can discover from the literature on the subject, for at least 50 years.*

There are two sides from which to view this matter, both of them being equally instructive.

1. *Such a destruction of fry has been tolerated for 50 years because no means dared be taken to stop an undertaking yielding an annual return of 1 000 000 Kroner.* The only measures taken by the Authorities have been the closing of those grounds where the greatest wealth of fry was to be met with, and, at present an attempt is being made to introduce a modification of the trawl, in which [the ground rope is raised a few inches up, so that it does not touch the bottom. With such an apparatus the destruction of fry is reduced somewhat, as will be seen from the results of the hauls effected by it.

Date	Time occupied in trawling	Shrimps Quarts	Fry of edible fishes
12th May	$\frac{3}{4}$ hour	2	136
20th «	1 «	3	228
23rd «	1 «	4	202
6th June	1 «	3	88
21st July	1 «	6	956
14th September	1 «	4	303
18th «	1 «	5	801
2nd October	1 $\frac{1}{2}$ hours	6	724
16th «	1 $\frac{1}{2}$ hour	7	1 129
2nd November	1 «	6	527
4th December	1 «	3	215
13th «	1 «	3	296

As will be seen, this future appliance (in any case it was such in 1896, and we do not know that any changes in the apparatus employed have been made since then) catches up to 1 129 small fish, while the take of shrimps only amounted to 7 quarts.

2. In the second place, in the Lancashire shrimp trawling one has an example of how a really remunerative fishery can, at the same time,

prove destructive to small fish; but the most astonishing part of the whole phenomenon appears to us to be the circumstance that *notwithstanding the fishing has been carried on by 400 trawlers throughout the course of 50 years, such vast quantities of fry are still present. The shrimp trawling in Lancashire is, therefore, in our eyes, one of the most striking examples, if not of the ocean's inexhaustibility, then of its wealth.*

Similar and numerous examples from other places and lands might be given, and descriptions are published concerning the East Coast of England, Germany &c. &c., but we confine ourselves to describing what we have seen for ourselves.

The facts above given from both Norway and Foreign Lands will, we presume, serve as the basis for reflections concerning: —

C. What ought there to be done, and what principles ought to be followed in order to preserve the stock of fish?

In the previous section we endeavoured to reply to the question «What injury do the various fishing appliances do to the fry of edible fishes in this country?» In proceeding to discuss the question as to what practical measures ought to be adopted by the Authorities respecting the fishery industry, we are compelled to regard it from various points, and not solely with the question of the destruction of the fry before us. The basis of a practical proposal must be a thorough knowledge of the whole enterprise, a knowledge which can only be gained from *special investigations* of the various waters, their natural history; the life of the fishes and, above all, it must not be constructed on theoretical speculations.

From the results we arrived at concerning the history of the life of fishes, it appeared that we came to the conclusion that most fish, producing pelagic spawn, must be considered as belonging to one tribe common to the whole coast. From this it appears, on the one hand, that protection of the fry at one spot will be for the good of the entire coast or a very great portion of it, but, on the other hand, too, that the destruction of fry at one little spot can be remedied or made up from some

other place. *If apparatus which destroy fry are to be prohibited, then the prohibition must, first and foremost, be applied to those parts of the coast where the fry occurs in greatest profusion, and not where it is most scarce.* It is necessary, first and foremost, then to preserve those places which form the true home of the fry, and where its occurrence is enormous. In this country, however, — on account of the doctrine of species of fish being confined to one locality — it has been thought that the fry, especially must be preserved *where it is most scarce, in order that it may become more abundant.* In this there, however, lies a great overestimation of human ability to influence the amplitude of the stock of fishes. As we have already seen, it is the natural conditions which cause the fry to be less numerous at one place than at another, and not human beings. This is proved *inter alia* from the fact that, in the Christiania Fiord, one so destitute of fry, in which the use of seines has been prohibited for many years (since 1893), there has been no increase of the *youngest* year's classes during summer.

If fry-destroying apparatus are to be forbidden in Norway, during summer, the prohibition should apply to the sea coast, where, in a single haul, one can obtain hundreds of young fish. *On the other hand, there is no reason why the use of seines in the eastern part of the country, and its fiords, should be prohibited, so far as the fry is concerned.* If one compares the few small cod we have taken in our seine during summer, with the conditions existing on the west coast, or with the trawling in Lancashire*, this must be apparent to everybody.

Are there any other circumstances which makes the prohibition of seine fishing desirable at that season of the year? It has been stated that seining destroys the plants (the sea weed), and the lower animals. That this cannot be of any great consequence, appears to us to be clear, when the Danish biologist, D. Petersen, in such an eel seining land as Denmark, notwithstanding his great experience on the subject, has not been able to use this as a handle for such an assumption. In a statement made to the Danish Minister of Agriculture he says «I never could make sure that the seine fishery, as carried on in the Lim Fiord, caused any great

*) We must call the attention of the reader to the fact, that we do not consider ourselves entitled to express any opinion on the conditions prevailing in Lancashire, and that we have only mentioned them as a contrast to those existing in Norway.

damage to the vegetable and animal life on the bottom, notwithstanding that I have seen it carried on under very many conditions, and have, personally, carried it on at biological stations for the very purpose of discovering whether it caused appreciable injury, or not». His declaration, therefore, supports the continuance of a similarly free state of things to that existing in Denmark; and have they not great experience on these matters in that country?

Our conclusion is therefore, firstly, the following: *In the eastern parts of Norway no physical grounds exist for prohibiting the use of seines during summer, but, on the other hand, a good deal of injury might be done by the seine on the west coast at that season.*

We now proceed to the question whether other conditions in connection with the fisheries are present which would warrant the prohibition of seining during the summer.

We may, therefore, mention that the introduction of small seines would certainly arouse considerable strife, and strife of the kind that always takes place when a new apparatus is introduced, as those who fish with more primitive appliances raise the cry that they can't catch anything. The latter idea would, however, be really quite an unfounded one, as it cannot be imagined that the seines could possibly deprive the other fishermen of any part of their gains, because the catch would, mainly, consist of eels, which, *during summer*, remain stationary. On the other hand, a strife of an unpleasant character would undoubtedly occur, between the fishermen and land proprietors, as the latter — supported by our Courts of Justice — claim absolute possession of all the seining places in the south east part of Norway, a circumstance which makes a paying eel fishery far more difficult in this country than in Denmark, where the rights of the owners of property can only affect *fixed engines*. That such a strife would, however, be smoothed over after a time, is apparent from the experience already gained in the Langesund Fiord where, from the evidence taken in the parish of Eidanger respecting the fishing that formerly took place, and to which we have already referred, it appears that a very lucrative seine fishery was carried on, the fishermen paying for the hire of the seining grounds.

The prospect of such a strife, the discussion of which, however, lies beyond the scope of this work, will, therefore, hardly counterbalance the object of forming a new and paying summer fishery in the south

east of Norway, one, too, that can cause no injury to the stock of fish. While referring the reader to Chap. IX (The Eel), we may state that we believe such an eel fishery would be one of great importance, *and such an eel fishery can, from natural causes, only be carried on during the period when fry are not found in the fiords of the east coast, viz., during the summer. In the autumn and winter, seining eels does not pay, because the eel then hides itself at the bottom, and cannot be caught in the seines.*

If has further appeared from our researches that the resorts frequented by the eel, are never the same as the habitat of the fry. While it is presumed that eel fishing would pay very well during the summer on the east coast, such would not be the case on the west coast, mainly on account of the conditions of the bottom. Out on the shores of the open sea, where the fry are to be met with, there are no eel grounds. There could be no object in attempting to establish an eel fishery with seines in such parts.

The small seines employed on the west coast, were, therefore, never used as eel nets, but were applied to the purpose of catching small herrings, codlings, and small coalfish. We cannot express any opinion on the important questions as to what extent such a fishery may be carried on, what is the size of the fry destroyed by it, and what importance it is to our population. We find an opinion all the less necessary, as we are aware that these questions have not occupied the attention of the people, as was the case with the eel nets on the east coast. The questions ought, however, to receive the greatest attention, and a most careful description of the natural conditions, and fisheries, ought *to be written*, this being a task which we hope, at some future time, will occupy our attention. In respect to the conditions of the east coast during autumn and winter, we may add, as already stated, that, at those periods, quite large quantities of fry may be caught in the seines, even though not quite so great as stated in exaggerated reports. At such seasons, too, seining becomes unprofitable, as the eel fishery is closed, and the capture of small fish can hardly be remunerative.

Whilst the previously mentioned seines were *fine meshed*, and used close to the shore, most of the other kinds of network appliances, such as trawls and drag-nets, can only be employed here, in deep water, and most of them (with the exception of the deep water shrimp trawl) are wide meshed. These are not destructive, therefore, to the fry. If the

trawl in the North Sea destroys great numbers of small fish, it is because there are there trawling grounds in 10 to 20 fathoms of water, while such are entirely wanting in Norway. We have, as is known, many great banks situated off our shores, but they, as a rule, all lie at a greater depth (50 to 100 fathoms) than those of the North Sea, and from what is known of the North Sea, for instance that the plaice is very seldom found at a greater depth than 30 fathoms, it must be presumed that the conditions on our banks are quite different. What they are like, what fish live there &c. &c. must be decided by future investigations.

There is, for instance, still a question which nobody can answer, viz., what apparatus is best for fishing there. Whether, for instance, the trawl would prove to be serviceable and paying, no one knows. In all probability this is improbable.

When legislative measures affecting our coastal waters are to be framed in respect to the trawl, drag-nets &c. &c., it is not consideration for the preservation of the stock of fish that should lead to future restrictions on the use of such appliances, but regard to the existing fishery with other appliances. It is, thus, a positive fact that the trawl can absolutely destroy the long lines. During Hjort's trawling experiments in our fiords, it happened, unfortunately, on several occasions, that the lines were injured. That compensation must be made for such damage in cases where long line fishing is a paying and old business appears to be clear. But in the *long run* it will assuredly happen that, in the struggle between two such opposite apparatus, the one possessed of the greatest vitality, that is to say the better of the two, will oust the other, and cause it to disappear — to the great advantage of the fishermen themselves. In October, in the Langesund—Brevik Fiord, it was almost impossible to trawl, because of the trawl getting foul of one or another set line. But as the catch on such long lines was exceptionally poor, and trawling for shrimps was very paying, the conditions became changed, and, at present, 10 trawlers sweep the fiord daily in every direction.

It is, naturally, to the fishermen's own advantage that the best apparatus, which brings in most to its owner, comes off the winner, but it is a different matter when consideration for an older, business is permitted to dictate regulations for its protection «until further notice».

It would surely be most correct to allow each apparatus, in open

competition, to prove its superiority or otherwise. But this cannot be discussed *in a general way*, neither do we desire to launch into any discussion respecting the special advantages of such appliances, owing to want of independent experience. We take the same standpoint in respect to all apparatus formed for taking *salmon* and *trout*. A study of such appliances is being made by one of us, Dahl, and we do not wish to publish any of the results arrived at until we regard the problems before us as solved. Only by such action can our work be of value. We will only state that, in all the hauls of the seine made by Hjort in the south of Norway, not one salmon was caught, and but very few trout. Dahl's investigations are being carried out in the Trondhjem Fiord.

We desire to confine ourselves to having indicated the prevailing conditions, and to pointing out the preliminary labours which will be needed in order to lead to rational legislation respecting our sea fisheries. Such preparatory work has been carried out on a great scale in other countries, by studying the biology of fishes. Our own investigations have, hitherto, but been able to cope with the beginning of such a task, and we have, therefore, on the whole, restricted ourselves on the one side to describing, in detail, those few points concerning which we considered we had arrived at certain conclusions (like the east coast seine fishery), and, on the other, to indicating the course of future labours.

Explanation of the Maps.

I. Chart of Depths in the Skagerrak

(From Pettersson and Ekman).

The Curves denote the Depth in Metres.

II. Charts of Depths in the Christiania Fiord.

The Curves denote the Depth in Fathoms.

10 thus indicates 10 Fathoms = about 20 Metres.

- A. Dark Brown Colour represents Depths less than 10 Fathoms (20 Metres).
- » Light Brown Colour represents Depths between 10 and 30 Fathoms (20 to 60 Metres).
- » Light Blue Colour represents Depths between 30 and 100 Fathoms (60 to 200 Metres).
- » Dark Blue Colour represents Depths exceeding 100 Fathoms (200 Metres).

III. Chart of Depths in the Trondhjem Fiord.

The Curves denote the Depth in Metres.

- A. Dark Brown Colour represents Depths less than 60 Metres.
 - » Light Blue » » » between 60 and 200 Metres.
 - » Dark Blue » » » exceeding 200 Metres.
-