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L'EXPLORATION DE LA MER

INVESTIGATIONS ON THE PLAICE

GENERAL REPORT

BY

DR. FRIEDRICH HEINCKE

I. PLAICE FISHERY AND PROTECTIVE MEASURES

PRELIMINARY BRIEF SUMMARY
OF THE MOST IMPORTANT POINTS OF THE REPORT

WITH 1 MAP AND 5 FIGURES IN TEXT

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IMPRIMERIE BIANCO LUNO

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PREFACE

The General Report on the investigations of the International Council for the study of the Sea on the plaice question will, on account of the extensive nature of the work, yet require some time to fully complete. It will probably also be necessary to take into consideration new and hitherto unpublished material, which will necessitate further delay in the completion of the work. I have therefore, at the request of the Central Council, compiled the following short resumé of the most important conclusions hitherto arrived at in the Report. It is however, impossible here to state in full detail the grounds on which these conclusions are based, or the sources from which they are obtained.

Copenhagen, 18th September 1912.

Heincke.

Simultaneously with the application of steam power to ocean fishery, in the middle of the last century, and in particular, the introduction of the otter trawl in bottom fishing in the middle of the 90's, complaints begin to arise as to the "Over-fishing" of the North Sea, especially with regard to the plaice and the haddock. It soon became a matter of experience beyond all doubt, that in the case of most of the bottom fishes, but particularly as regards the plaice, the weight and number of the fish landed from the North Sea did not by any means increase in due proportion with the number, size, and fishing power of the vessels employed. On the contrary, the actual quantity of plaice landed from the North Sea has, of late years, in spite of the continually increasing intensity of the fishing, increased but little, or not at all; moreover the landings of plaice have for several years past shown a decrease, both relative and absolute, in the number of larger and older fish, with a corresponding increase in the number of small and very small plaice. Even though the present annual quantity of plaice brought to land by the fishing vessels be equal, when measured by weight, to that of thirty or fifty years ago, it is certain that the composition of the catches is essentially different from what it formerly was. The so called large plaice, for instance, of abt. 40 cm. and upwards, have decreased from abt. 30 % of the total weight to abt. 6 %, the whole of the weight thus lost being replaced by small and very small fish. Entirely different conditions prevail on fishing grounds outside the North Sea, which are not yet so intensively worked, e. g. off the coast of Iceland, and in waters which have only of late years been fished at all, as for instance the Barents Sea, in which places the relative quantity of large plaice is much greater. The gradual alteration which has taken place in the composition of the catches of plaice landed from all parts of the North Sea must therefore apparently be regarded as a result of the increased fishing. The question now arises, whether the decrease of the large plaice in the North Sea by fishery, and the greater encroachment on the small young fish which should replace them, really indicates an actual overfishing; i. e., encroachment on the capital represented by the entire stock of plaice in the North Sea. In other words, can that portion of the stock at present removed each year by fishing, be regularly replaced by natural means, or not? This question it is as yet impossible to answer with certainty. It is, however, beyond doubt, that the great decrease in numbers of the larger plaice in the catches, and the still greater increase of small and very small fish without any augmentation of the medium size-classes, represents a *depreciation in value of the plaice as an article of consumption*, a circumstance which is only concealed by the fact that the

price of plaice, as of all sea fish, has for some years past continually increased. It is moreover evident, that the entirely useless destruction of many millions of quite young plaice, of from 12 to 18 cm. in length, which is inseparable from trawl fishing, and which takes place regularly every year in the shallower waters of the North Sea down to a depth of 40 metres, especially in the summer months, is, from an industrial point of view, an in every respect harmful and indefensible attribute of our modern Fishery in the North Sea. These young fish, which have no marketable value, are taken in the trawl, brought to the surface dead, and uselessly thrown overboard again — and this in such quantities, that they frequently represent from three to four times the whole amount of the other plaice taken in the haul — a meaningless waste of an essential part of the stock of plaice in the sea.

The need of *protective measures* to guard against such wanton destruction of the younger stages of plaice in the sea, and the necessity of some reasonable regulation of the plaice fishery as a whole, is thus so evident, that both the Governments of the countries bordering on the North Sea and their scientific advisers, as well as the fishermen themselves, have for some years past been actively considering the question of possible protective measures. In this regard it was soon agreed 1) that owing to the international character of North Sea fishing, effectual protective measures could only be brought about by means of international co-operation, and 2) that *general* protective measures, as for instance the prohibition of certain kinds of trawl fishing, either entirely or within certain areas or at certain times, or the marking out of international closed districts in the North Sea etc. would scarcely be practicable, and that it would be better to restrict any legislation on the matter to *individual* protective measures, i. e., for single species of fish and single size-classes of same; in the case of the plaice, for instance, for all young fish under a certain size (size-limit), e. g. of 25 cm. in length. Such protective measures have, as is well known, already been introduced by territorial legislation in certain of the countries bordering on the North Sea for some time, prohibiting not only the sale, but also the landing of plaice under a certain size-limit — in Germany and Belgium for instance 18 cm.; in Denmark 25.6 cm. No legal size limit exists in England, but in practice a limit of 18 to 20 cm. is by mutual agreement observed by the fishermen themselves.

It is obvious that such prohibition as to landing and sale of undersized fish must, if it is international, observe the same size-limit for all the countries bordering on the North Sea. And it is equally evident, that the real object of such international protective legislation can only be attained when such undersized plaice which may no longer be brought to land are also actually spared, i. e. either not caught at all, or, when caught, are returned alive and unscathed to the sea. Whether, and to what extent this is possible, depends partly upon the nature and method of the bottom fishing for plaice, and partly upon the height of the size-limit. Complete prevention of the capture of undersized fish would only be possible by means of very wide-meshed nets, and a very low size-limit, and would be practically unrealisable. The question is therefore, how far the undersized fish caught can be returned unharmed to the water. By the Danish method of plaice fishing, with the wide meshed "Snurrevaad", which is worked with quite short hauls, and by which almost all the Danish catches from the North Sea are taken, this will probably be possible for all the undersized plaice; also for a considerable num-

ber of the plaice taken by the German and Dutch sailing vessels, which are fitted for the capture of live fish. But in the case of the plaice fishery from larger sailing vessels and steam trawlers, the method almost exclusively employed in England, and which is responsible for by far the greatest part of all the plaice landed from the North Sea, the great majority of undersized fish taken are already dead when brought to the surface, and are in any case not capable of living when returned to the water. A legal size-limit can thus not be effective here as a protection for the undersized plaice unless the limit is set so high that it cannot pay to trawl on the grounds where they occur in greatest quantities, so that the trawlers will avoid such plaicegrounds, and themselves restrict their fishing in the interest of plaice protection.

The governments of the various countries will scarcely be inclined to impose any legal restrictions upon the fishery unless they are convinced 1) that such measures are absolutely necessary for the maintenance of a good stock of plaice, 2) that they are practicable, 3) that they really ensure the attainment of the object in view, i. e., the protection of the young plaice, and 4) that the inevitable loss which the fishing industry will suffer thereby in the first years, will soon be compensated by an improvement in the yield, especially in point of quality.

The question of proper international protective measures for the plaice is therefore a difficult and complicated one. A satisfactory solution of the same is only possible when we are in possession of exact knowledge as to the distribution of the plaice, its habits of life, its food, and its migrations. We must also know, how great a quantity of plaice, both as regards number and weight, is annually landed from the North Sea, and in what manner this quantity is composed with regard to the different age- and size-classes. Ten years ago our knowledge on these points was almost nil. Since that time however, the International Investigation of the Sea has increased and extended our knowledge to such a degree that it is now possible to seriously consider the task of arriving at a solution of the plaice question.

The "*International Investigation of the Sea*" was founded on the idea "that a rational exploitation of the sea must as far as possible rest upon a scientific basis, and that one of the main objects of the work here to be carried out is the practical improvement of the fishing industry". It has therefore from the commencement paid special attention to the question of overfishing and the imprudent destruction of young fish by present trawling methods. At the meetings of the Central Council for the International Investigation of the Sea in Hamburg in February 1904, and in Copenhagen in July 1905, resolutions were passed to the effect that the countries concerned should undertake to furnish exact and reliable details as to the extent of the destruction of undersized fish, in particular plaice, and also to supply regular fishery statistics for the purposes of a Statistical Bulletin, to be published by the Central Bureau. These latter should in particular deal with the monthly and yearly landings of the principal food-fishes at the different fishing ports, as far as possible with regard to both number and weight, and with the closest possible indication of the place of capture. For the plaice especially exact particulars were further demanded as to the composition of the landings according to the various market-classes (e. g. large, medium, small) and measurement of large samples of the landings in order to determine the composition of same from centimetre to centimetre. As a result, a very great quantity of material was collected during the following years,

consisting of fishery statistics, especially as regards the catch, and also based upon numerous weighings and measurements of food fishes, carried out at the various markets, particularly as to the plaice. Extensive international investigations were at the same time instituted with regard to the biology and especially the age, reproduction and migrations of this species. These essential additions to our knowledge led to the passing by the Central Council of the following resolution at the London Congress in June 1907, a measure which further advocated the course of dealing practically with the plaice question:

"That in drawing up the Report on their work during the years 1902—07 the Council shall have special regard to reaching a conclusion as to the desirability or otherwise, of preventing the capture of undersized plaice.

"That with this object each country interested in the North Sea plaice fisheries should furnish answers as far as possible to the following questions:

1. "Whether small plaice taken by the trawl can and, having regard to the ordinary practice prevailing in trawlers, would be returned to the sea alive;
2. "Whether any, and if so what, size limit would make it unremunerative to fish on grounds on which such fish occur in greatest abundance;
3. "Whether if excluded from such grounds by reason of the imposition of a size limit, it would be remunerative to fish elsewhere notwithstanding the imposition of the size limit."

At the next Meeting of the International Council, in July 1908 at Copenhagen, there was a partial reorganisation of the biological programme with the aim of making the results of the International Investigations as soon as possible useful to the practical fisheries, all in accordance with the wishes of the participating States. With regard to the *plaice*, the most important food-fish of the North Sea for the time being in practical regards, the following resolution was agreed to:

"With regard to the plaice, the Council believe that a very large amount of information has already been gained, but the data are at present insufficiently collated and summarized. The Council, therefore, recommend, with a view to throwing light on the points referred to in the resolution passed in London in 1907 (Procès-Verbaux VII, 1907, p. 42) that, in the first instance, a report should be furnished by each country on the whole of the work that has been done therein on this subject, and that the official delegates in each country shall to the utmost of their power be responsible for these reports being rendered to the Council not later than the 1st. February 1909; and, in the second instance, that a general Editor be appointed, who shall receive a remuneration for his incidental expenses and whose duties shall be to collate and summarize the above reports in a draft general report, which he shall furnish by a date to be fixed by the Bureau, and which after being circulated among and revised by the original collaborators, shall be discussed by the Council and shall form the basis of their corporate reply to the several Governments in regard to the plaice fishing."

This resolution of the London Meeting is concerned with the three questions referred to above, which deal with the vitality of fish caught in the trawl and the possibility of an effective size-limit. These questions are brief, yet full of meaning and requiring for their solution, which is desired by every one of the countries interested, the entire sum — weighed deliberately — of all the information, which the International Investi-

gations have so far collected with regard to the plaice, not only biological and that from the fishery statistics, but above all the full results of all those investigations which have been made on the distribution of the plaice of the North Sea according to size and age, and on the composition of the scientific hauls and the landings in the fishing ports.

Owing to the great amount of work thus demanded for the preparation of the reports of each individual country, the compilation and printing of these took more than two years, i.e. until August 1911. The following Reports on the plaice question, here arranged in chronological order of completion, have been laid in printed form before the Central Council and the General Reporter:

HOLLAND. Bericht über die holländische Schollenfischerei und über die Naturgeschichte der Scholle der südlichen Nordsee. Von Dr. H. C. REDEKE. Sent in July 1909.

DENMARK. Bericht über die dänischen Untersuchungen über die Schollenfischerei und den Schollenbestand in der östlichen Nordsee, dem Skagerak und dem nördlichen Kattegat. Von A. C. JOHANSEN. Sent in May 1910.

ENGLAND. Report on the Research work of the Board of Agriculture and Fisheries in relation to the plaice fisheries of the North Sea. Vol. I—III. Special statistics. Size and weight. 1908—1910. By WALTER S. MASTERMAN. Sent in complete September 1910. — Vol. IV. Biological statistics. Age and sex. By A. T. MASTERMAN. Part (for the year 1905/06) sent in July 1911.

BELGIUM. Contributions à l'Etude biologique et économique de la Plie. By G. GILSON. Sent in September 1910.

GERMANY. I. Über Schollen und Schollenfischerei in der südöstlichen Nordsee. Von FR. HEINCKE und H. HENKING. Sent in June 1907.

II. Die Statistik der deutschen Schollenfischerei im Nordseegebiet. Von H. HENKING. Sent in August 1911.

Scotland, Sweden and Norway have not sent in any comprehensive report in accordance with the resolution dated Copenhagen, July 1908, of their investigations with regard to the plaice.

The General Report on the Plaice Question is mainly compiled on the basis of the great amount of material contained in these individual reports. A mere summary of the results contained in these single reports would however, naturally be inadequate as a General Report; it was necessary, in order to provide a sufficient basis for practical protection measures, to give, as exhaustively as possible, a review of all the data bearing on the plaice hitherto obtained by the International Investigation. The General Report will be divided into two parts; the first, and from a practical point of view the most important, dealing with plaice fishery and the question of protective measures; the second with the biology of the plaice.

Part I, which is the first, and here the only one with which we are concerned, will deal with the following points in the order given:

- I.
 1. *The general distribution of the plaice in the North Sea and in the different parts of the North Sea.*
 2. *The subdivision of the North Sea into different areas, having regard to the distribution of the plaice and the practice of the plaice fishery.*
 3. *The scientific hauls and market samples as a means of displaying the distribution of the plaice in the North Sea and of determining the composition of the plaice stock and plaice landings.*
- II. *The amount and composition of the plaice landings and plaice stock in the North Sea and neighbouring waters.*
 1. *The amount and composition, by number, length and weight, of the quantities of plaice landed by the fishery in the different countries, in the different months and from the different areas of the North Sea. The relative amount of immature plaice in the landings.*
 2. *The amount and composition of the actual hauls made by the fishermen but not wholly landed. The composition of the hauls with regard to sex.*
 3. *The composition of the actual stock of plaice in the North Sea and its probable absolute amount. How great are we to estimate the percentage of the plaice stock, by number and weight, which is taken yearly from the North Sea by the fishery?*
- III. *Are there any signs of an actual overfishing or of an essentially increased tax on the plaice stock of the North Sea through the increased fishing?*
 1. *The decrease of the large and increase of the small plaice in the catches as probable signs of a permanent change in the composition of the stock of fish produced by the fishery*
 2. *The new and still little fished grounds outside the North Sea; Iceland, the Færoes, Barents Sea. The difference in the composition of the North Sea catches from the catches made on these new fishing grounds as a consequence of the greater fishing.*
 3. *Has a diminution occurred in the density of the plaice stock of the North Sea as a result of the fishery?*
 4. *Is the productivity of the North Sea great enough to make good the annual removal of 20, 30 or more per cent of the stock?*
- IV. *The introduction of protective measures for the plaice.*
 1. *The necessity of introducing international protective measures.*
 2. *Protective measures in the way of closing times, closed areas, or the prohibition of certain apparatus.*
 3. *Protective measures through size-limits or prohibition of landing without direct restriction of the fishery.*
 4. *Can the fish below a certain size which are caught by the different nets be returned to the sea alive and capable of living?*

- V. *Size-limits and the restrictions imposed by them on the fishery.*
1. How high must a size-limit be, in order to guarantee a real and effective protection of the undersized fish?
 2. The influence of different size-limits on the yield of the fishery in the different countries.
- VI. *The probable influence which an effective protection of undersized plaice and a more rational and more productive fishing would exercise on the maintenance of the plaice stock.*
- VII. *The desirable height of the size-limit for the plaice in the whole North Sea, to be determined by international agreement.*
- VIII. *Summary of the results.*

The following is a brief review of the most important results arrived at in the General Report in the chapters mentioned above.

I.

1. 2. The general distribution of the plaice in the North Sea and its various parts. The division of the North Sea into areas.

The extensive investigations carried out by the International Commission for the Investigation of the Sea with regard to the biology of the plaice, in particular as to its age and growth, its reproduction, and the occurrence of the different stages from the egg upwards, as well as its migrations, have given us very accurate knowledge as to its distribution and extent, which information is as valuable as it is indispensable for arriving at a correct solution of the plaice question. The following are the most essential facts thus determined:

The floating *eggs* of the plaice are spawned in the North Sea during the winter months, chiefly in January and February, and in the deeper parts of this sea, from 20 to 30 meters, principally in the southern and south-western areas. From here the pelagic fry move without exception towards the coast, and undergo there close in to land, in quite shallow water of 0 to 5 meters depth, their metamorphosis to the youngest bottom-stage, with distinct asymmetrical plaice form. From these flat coastal zones, the true home of the quite young plaice fry in its first year of life, the young plaice move, as they grow, outwards from the coast into the deeper water until, having arrived at maturity (which takes place for the males on an average at the close of the third, for females about the end of the fifth year) they reach those districts of the open sea nearest their starting point where the necessary conditions for spawning are found. This gradual seaward progress of the plaice, which extends over a number of years, is carried out by stages, and during the summer, being interrupted during the winter, when the young and still immature plaice hibernate hidden in the ground, their feeding and their growth ceasing simultaneously. Besides these regular periods of winter rest, the general seaward progress of the growing plaice is also interrupted by shorter retreating movements directed towards the land, such as that which for instance regularly takes place in the southern and south-eastern part of the North Sea in the spring months, after the close of the hibernating period, the object of which is in all probability to seek out better feeding grounds.

Those plaice which have arrived at maturity move, as a rule, during the following years, and with their further increasing size, still farther out to sea over the spawning

grounds. Correspondingly the largest and oldest plaice are found, as a rule, farthest away from land, but also these occasionally make more or less regular retrograde movements towards the coast, partly in autumn, in order to reach the spawning grounds lying nearer land, and partly in spring, after the spawning is over, in order to seek out richer feeding-grounds.

From these regular movements and migrations of the plaice in the North Sea, which stand in distinct relation to the growth and reproduction of the fish, we obtain a very characteristic form for distribution, which can be briefly expressed in the following rule, or, one might say, the following *law of distribution for the Plaice*. "*The size and age of the plaice in a definite part of the North Sea are inversely proportional to the density of their occurrence, but directly proportional to the distance of the locality from the coast, and to its depth*". That is to say: the younger and smaller the plaice, the nearer they live to the coast, and for the most part, the shallower the water in which they are found. Moreover, the younger fish being naturally more numerous than those of greater age, the greater is their density: the more so, as migrations of any extent to the open sea involve considerable spreading of the shoals. This law of distribution for the plaice is, however, not to be taken too literally. The unequal growth of fish of the same age, the interruption of the general seaward migration by hibernation and retrograde movements, crossings of direction, and various other local causes, render the rule or law, as in all similar cases, strictly applicable only to the average age and average size. Then also there appears the extremely characteristic phenomenon, that wherever plaice occur, different ages and sizes are invariably found mixed together, and this in greater degree the farther out to sea they appear. The great mass of the whole local stock at any one place is however, invariably found to consist of a single, or some few adjacent age classes. In the shallow zones of the southern North Sea, at a depth of from 10 to 25 metres, we find for instance, plaice of from the first to the fifth year of life, with a length of from 6 to 40 cm., the great majority however, being from 2 to 3 years old, and from 10 to 20 cm. long. Their density, calculated according to the number taken by an ordinary trawl in the space of an hour, may amount, on an average, to 300, varying according to time and place from 30 to several thousand. On the Dogger Bank, on the other hand, far out at sea, plaice of from 16 to 70 cm. in length, and 3 to 20 years old and upwards, are taken: the majority however, amounting to about 75 %, are more than 30 cm. long and over four years old: the density per trawling hour varies from 1 to 12, and may average from 5 to 7.

In spite, however, of the fact that the plaice of the North Sea are continually moving, migrations of very great extent, such as for instance from one side of the sea to the other, or from the southern coast to the northern deeps never, or only quite exceptionally occur, at any rate, as far as is has been possible to judge from the numerous marking experiments made. Of all the marked plaice recaptured, fully 90 % have been retaken at a distance of not more than 50 nautical miles, and 96 % at not more than 100 miles from the spot where they were set free. This bears out the supposition that there exists in all probability a considerable number of *local forms* of the plaice, which are distinguished by morphological and physiological peculiarities and inhabit different regions of the sea. In the North Sea in particular we can perhaps distinguish between two slightly, though very characteristically varying local forms, differing for instance in their

rate of growth: the "*Southern Plaice*", which is restricted to the southern and south-eastern parts of the North Sea, and which grows more slowly, being therefore, smaller at an equal given age, and the "*Northern Plaice*", found in the northern waters of the North Sea, which is a quicker-growing and larger form. The boundary between them would be a line drawn approximately from Flamborough Head on the English coast, north east round the Dogger Bank to the Liimfjord. The territory of the Southern Plaice, lying south of this line, is by far the richest plaice-ground of the North Sea, being the home of certainly 90 % of the total number of plaice in the North Sea, and forming the real seat of its plaice fishery. One of its characteristics is the wide extent of the coastal zone up to 40 metres deep. The territory of the Northern Plaice is considerably deeper than that of the Southern Plaice, and is in its western part, off the coast of North England and Scotland, distinguished by the extraordinary narrowness of the shallower coast belt up to a depth of 60 metres. The spawning grounds, for instance in the Moray Firth, and the narrow coastal zone, inhabited by the young plaice-spawn in their first year, are here very close together, and the whole life of the plaice is thus lived within a much more restricted space. As the depths of over 80 meters are already generally very poor in plaice, this also explains the much greater paucity in numbers of the stock of plaice in the northern North Sea.

The density and composition of the stock of plaice in different areas being thus extremely variable, and the nature, extent and yield of the plaice fishery correspondingly so; and as both are dependent on the depth of the fishing grounds and their distance from the coast, it is necessary, in order to give a comprehensive view of these conditions, *to suitably subdivide the North Sea into areas*. With this end in view, we have here employed the method of division of the North Sea into depth zones (Areas A, B, C, D, E, F, G) as first adopted in England, and proposed at the meeting of the Central Council in Copenhagen, July 1905, together with the geographical sub-divisions of these zones, as shown on the chart appended. This method of division, besides agreeing well with the natural conditions pertaining to the distribution of the plaice, also permits of the place of capture for the landings of plaice at the fishing-ports being located in these areas without any serious error, thus determining the exact place of origin of the landings from the individual areas of the North Sea.

If we designate all plaice under 25 cm. in length, (and under 150 grammes in weight) as "*young*" plaice, — since they include fish of the first three to four years of age — and as "*undersized*", in view of the fact that their value as an article of human consumption is only small, we can then use the term "*young-fish grounds*" to designate those fishing grounds where such plaice occur in greatest numbers, amounting for instance, to more than the half of the plaice taken in a trawl catch. These young-fish grounds are naturally, from a practical point of view, the most important in considering the plaice question: it is here that the greatest catches and at the same time the greatest destruction of young undersized plaice occur. The International Investigations have therefore paid special attention to the exact location of these young-fish grounds and the investigation of their population of plaice, as well as of other fish and plaice-food. In the southern part of the North Sea, which practically comes first in consideration of the plaice question, these young-fish grounds lie in the broad shallow coastal zones, at a depth of from 10 to 40 metres: indicated here as Areas A and B (with the exception however, of Area B₁, the Dogger Bank, which is an open sea

district, and the habitat of larger plaice). By far the greatest and densest shoals of young plaice are found in the inner, shallowest zone of the region, in Area A, especially in its sub-areas A₂, and A₃, and in the most landward parts of the somewhat deeper Area B, especially B₃ and B₄. The density of the plaice as caught with the ordinary otter trawl averages here 200 to 500 per hour, the maximum at certain spots during the summer months being 2500, with a minimum in winter of from 10 to 20. This enormous difference in the density on the same grounds for summer and winter is evidently due to the fact that the young plaice in winter hibernate hidden in the ground, and are not turned up and taken by the trawl.

3. Scientific hauls and Market-Samples as a means of displaying the distribution of the plaice in the North Sea, and determining the composition of the plaice stock and of the plaice landings.

All our conclusions as to the distribution of the different age-classes of the plaice and the composition, in point of number, of the stock of plaice in the sea and the landings of plaice at the fishing ports, are naturally based on the investigation of single *samples* taken from the great mass of fish. We distinguish between three kinds of samples:

1. *Scientific hauls, or stock-samples.*
2. *Fishery catch-samples, and*
3. *Market-samples.*

The scientific hauls are samples of plaice, drawn up from the bottom by means of scientific fishing implements of varying size and width of mesh, in such a way as to ensure the capture of all those age- and size-classes which actually live together at a given place. The scientific hauls are thus at the same time samples of the true stock there found.

The Fishery catch-samples are samples of plaice which are brought up with the ordinary fishing implements in use. Certain small plaice, of under a certain average size, determined by the width of mesh of the nets, are indeed caught by these implements, but escape again before they can be brought to the surface; these samples are therefore, in all cases where such young plaice occur, useless as true samples of the stock, and can only be regarded as *sorted samples* of same.

Market-samples are samples of those plaice which are landed by the fishermen at the ports, and brought to market. As the fishermen only rarely bring to market the whole amount of the fish caught and brought up by their nets, but as a rule throw overboard a more or less considerable number as unmarketable, these market-samples are for the most part only *sorted* fishery catch-samples. Only on such fishing grounds as for instance the deep sea areas D., where no escape of small plaice through the meshes takes place, nor any deletion by the fishermen of a portion of the catch for the sake of the market, can the market samples be considered as identical with the catch-samples, and these again as identical with stock-samples.

For general knowledge as to the biology and distribution of the plaice, the scientific hauls or stock-samples are of the greatest importance; for the purely practical con-

sideration of protective measures the fishery catch-samples and the market samples are the most important; these two last-named being indeed, in principle, of equal value. Examination of the catch-samples shows us the composition of the quantities of plaice actually caught by the fishermen, with regard to age and size, while the market-samples on the other hand, give the corresponding composition of the quantities of plaice brought to market and utilised for human consumption. From the difference between the two analyses we learn the quantities and sizes of plaice which though caught, are thrown overboard again as valueless, and thus for the most part uselessly destroyed.

The investigation of plaice samples consists in determination of the length in centimetres, the weight in grammes, sex, and age of each individual fish. And with regard to this, the following points should be borne in mind. The actual weighing can, in the case of large samples with many specimens, be omitted, being then replaced by a theoretical calculation of the weight (g) from the length (l) (full length from snout to tip of tail) the weight g (in grammes) being on an average $= \frac{l^3 k}{100}$ where k represents

a coefficient, varying somewhat according to the time of year, which can in most cases, for fresh entire plaice, without any essential error be reckoned as $= 1$. The determination of sex of the plaice is very easily made; it is, however, unfortunately seldom done in the case of market samples. The *age* of the plaice can be determined with considerable accuracy by means of the annual rings of the otoliths and of the bones; this would however, in the case of large samples, often take too much time to permit of its being calculated for each individual plaice.

Any further calculations based upon plaice samples thus dealt with will depend upon how far the composition of a sample can be regarded as equivalent to the composition of the whole quantity of plaice from which the sample was taken, or, to use the current phrase, whether the sample is *representative* of the whole. The necessary conditions for such representative value in a sample are: 1) that all the various size-classes were well mixed together in the quantity from which it was taken, 2) that the sample is not too small, and taken in such a way that no particular selection of certain sizes could occur; the last condition being the most important. Thus a sample taken, for instance, by the ordinary trawl, on a fishing ground where many small plaice of the second and third years are found, i. e. of 10—20 cm. in length, cannot be regarded as a representative sample of the stock of plaice, as the net here makes a selection, allowing the greater number of the small plaice to escape. If on the other hand, a market sample for instance, is to be regarded as representative for the composition of the landings at a certain port from a particular area in a given month, say at Grimsby from Area B₄ in June, then such market-sample must contain the various market-classes of plaice, as "large", "medium", "small", in the same relative quantities and mixed to the same extent as they appear in the total quantity of the landings.

A proper *selection* of the plaice samples to be examined is thus of decisive importance for the reliability of all our calculations bearing on the plaice question. If there is reason to suppose that a good selection of samples has been made, these can then be regarded as having a considerable representative value, the extent of which again depends upon the size of the sample, and can be determined, by means of mathematical calculation, from the composition of same.

From the analyses of the plaice samples, once with regard to length, and once with regard to the number of individuals, or total weight, for each length, we invariably obtain series of figures progressing from a minimum to a maximum — or several — and falling again to a minimum. Drawn as a graph, these series form curves with one or more highest points. These series or curves, whether representing

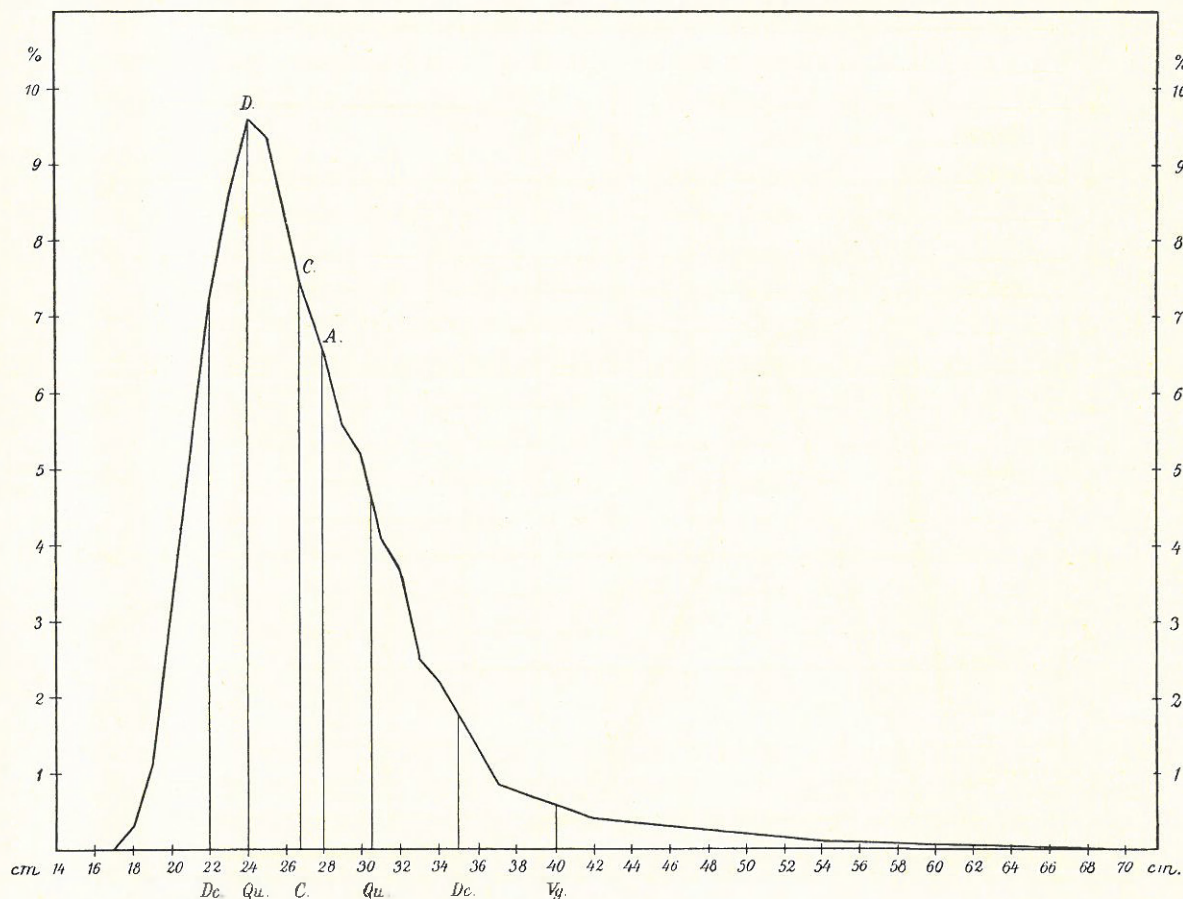


Fig. 1. Analysis by lengths of all the market-samples which have been measured in the English ports of Grimsby, Lowestoft, Ramsgate and Boston, during the period from October 1905 to the end of September 1908; altogether 4,925,698 plaice. Percentage curve.

D Mode or greatest density, C Median, A Arithmetic average. Qu, Dc, Vg quartiles, deciles and vigintiles.

the actual absolute numbers, or given in relative (percentual) figures, might for our purposes be advantageously made the subject of mathematical discussion, from which we could learn something more about their properties, and thus employ them further in our calculations. With this end in view, we mark off upon such curves a number of characteristic points, the positions of which represent certain important figure-values. Such

principal values are: (Fig. 1). 1) *The maximum of the curve, or the mode (D.)* i. e., those length-classes of the plaice to which the greatest number of individuals belong, 2) the *arithmetic average (A.)* or medium length of all the plaice represented by a curve, 3) the *median (C.)* or central value; that length-value above and below which lie the half of all the plaice (in single values) and the ordinate of which divides

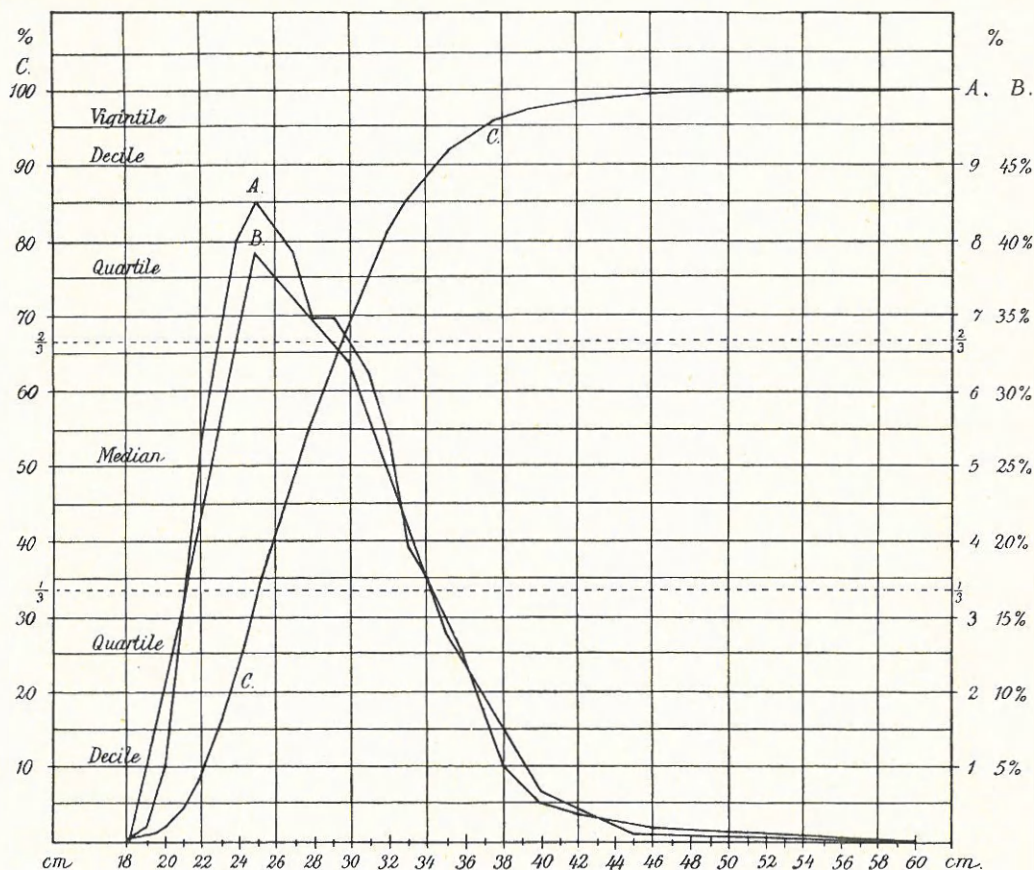


Fig. 2. Analysis by lengths of 34,209 plaice from Area B₂, measured in English ports in June of the three years 1906—1908. A. ordinary curve with the numbers for each single centimetre; B. smoothed curve with the numbers for each 5 centimetres; C. summation or integral curve. Percentage curves.

the whole area of the curve into two equal sections. Other important principal values are the two *Quartiles (Qu)* which lie above and below the median, at a distance of 25 % of the whole series from this, and between the ordinates of which one half of the whole area of the curve is enclosed; also the two *Deciles (Dc.)* lying each 40 %, and the two *vigintiles*, lying each 45 % respectively from the median.

The graphical representation of a series of measurements of a plaice sample can also

be given by other methods than the usual one above explained. In many cases it is advisable to employ the so-called *smoothed* curve: this is obtained by taking, not the single values for each centimetre of length as ordinates, but the sum of a series of adjoining single values, for instance for each 5 cm. This is done for instance comparatively, in Fig. 2. By means of such smoothed curves many casual irregularities of the original curve are deleted. Another form by which a series of measurements can be represented, and one which is of especial importance for our purposes, is the *summation or integral curve* shown in Fig. 2. In this case, the ordinates corresponding to the single centimetre lengths of the abscissa are not the single values appertaining to each length, but the *sums of single values*, and give, for each centimetre, the sum of the single figures appertaining to this and to all smaller centimetre lengths. If such a summation curve be drawn, as here, as a percentage curve, it is possible to read from it immediately what percentage of the whole quantity of plaice samples lie above or below a certain length, e. g., for our practical purposes, above or below a certain size-limit, of say 25 cm.

II.

1. The amount and composition, by number, length and weight, of the quantities of plaice landed by the fishery in the different countries in the different months from the different areas of the North Sea. The relative quantities of young, undersized plaice in the landings.

The first condition necessary for a successful solution of the practical plaice question is to know, as exactly as possible, how great are the annual landings of plaice from the North Sea, and their composition according to the different age- and size-classes.

With regard to the size of the landings, we are, thanks to the improved market and catch statistics of late years, fairly well informed. Thus the quantity of plaice landed in 1908 from first-class fishing vessels amounted to about 48 million kg. in round numbers; distributed among the various countries in the following absolute and percentual figures.

in England . .	31,028,437 kg.	=	64.20 %
- Holland . .	7,637,751	=	16.00 %
- Germany . .	3,625,703	=	7.60 %
- Denmark . .	2,995,299	=	6.20 %
- Scotland . .	1,824,839	=	3.80 %
- Belgium . .	1,055,449	=	2.20 %
	<hr/>		
	48,167,478	=	100.00 %

The quantity of the plaice landings varies thus very considerably in the different countries bordering on the North Sea, by far the greatest number going to England, which alone brings almost two thirds of the whole plaice production of the North Sea to market.

The composition of the plaice landings (in size-classes from centimetre to centimetre: this being the real basis for our calculations, and not the composition according to the ordinary market classes, «large», «medium», «small», which are very variable terms) can only be ascertained through methodical weighings and measurements of market samples. This composition must appear more or less different for the various countries. It depends on: 1) the usual legal or generally accepted size-limit adopted by the fishery, below which no plaice, or very few, are brought to land. This size limit is variable: in Germany 18 cm., in England 18 to 20 cm., in Denmark 25.6 cm. 2) the regional extent of the fishery, whether for instance carried on in all parts of the North Sea, as in the case of England, or chiefly in the northern, as Scotland, or southern part as with Holland: from the northern North Sea are naturally landed relatively more large plaice, from the southern parts relatively more small fish. 3) the yearly course of the fishery; whether the plaice fishery of a country is carried on in all months of the year and in all the regions of its fishing territory with equal or varying intensity: the latter is the general rule, and the different countries vary considerably in this respect. Where for instance much fishing is done in summer in the shallower coastal regions, a greater number of small plaice are landed than where the winter fishery in the south and the summer fishing in the deeper northern areas also play a part.

Market measurements of sufficient accuracy, i. e., taken by scientific methods, have been carried out in most of the countries, but only during the last few years, and even then not always in sufficient extent to ensure accurate calculations. From that country which takes by far the greatest part of all the landings of plaice from the North Sea, i. e., England, we have fortunately market measurements for three consecutive years (1906, 1907, 1908) which have been so extensively and methodically carried out, as to give a very reliable picture of the English landings, both for the whole year and for the single months, and from the various areas of the North Sea. As the English plaice fishery extends over almost all the areas of the North Sea, and is carried on at all seasons of the year, it is reasonable to suppose that the composition of the yearly landings of plaice in England may be regarded as equivalent, without any very serious error, to that of the total landings of all countries. The German market measurements for the year 1909, likewise carried out according to an excellent method, confirm this supposition, as also certain Danish and Dutch market measurements. We can thus say that we have a good and reliable knowledge as to the composition of fully 80% of the weight of all the plaice landed yearly from the North Sea.

Most of the determinations of weight in connection with the market measurements, or failing these, the calculations as to weight arrived at theoretically from the length of the plaice measured, also warrant, as far as the samples in question can be considered as of representative value, the drawing of conclusions, from the weight of plaice landings given in the market statistics, as to the average weight of the individual plaice, and thus as to the total number of fish in the landings. In this manner we can for instance estimate the total landings of plaice from the North Sea in

the year 1908 in round numbers at a total weight of 48 million kg. and 200 million plaice.

The English Landings of plaice.

Our conclusions as to the composition of these landings are founded on methodical calculations based upon the measurements of about 4,925,000 plaice, a weight of about 1,220,000 kg. carried out during a period of three years, from October 1905 to October 1908, at the most important English fishing ports, i. e., Grimsby, Lowestoft and Boston. It is reasonable to suppose that the composition of the landings at these three ports is, with some slight modification, representative of the total of the English landings during the period named. The weight of these total landings for the period 1905—1908 amounted to about 87,850,000 kg. Of this weight the percentage measured was thus 1.3.

The methods by which these extensive market measurements are carried out and subsequently dealt with cannot be here discussed, but will be exhaustively treated in the General Report itself. The discussion of the English market measurements and their results forms the *most important part of the General Report*, and furnishes the principal basis for our conclusions as to the composition of the landings of plaice from the North Sea, which sufficiently indicates the importance and effectiveness of various international size-limits. The English market measurements take as their starting point the landings already divided according to the usual market-classes, and the measured samples are thus samples of such market-classes. These samples can, by proper selection, be made representative of the composition of the market classes from which they are taken, and by the methodical addition of different samples, series of measurements can be obtained which are representative of the whole of the unsorted landings for the individual ports, months, areas, and for the whole of the North Sea. Results have shown, that we have by this means arrived at a good and serviceable knowledge of the composition of the English landings of plaice.

A complete and accurate picture of the composition of the landings is only to be obtained from the figures arranged in tabular form from cm. to cm., and the graphical representations (curves) based thereon. A number of such tables are reproduced in the General Report; it will here suffice to give some of the most important of the principal values of these series of figures, especially that of greatest density and the median, total number and total weight, average weight of the plaice, and a series of so-called summation-values, taken from the summation or integral curve, which show what percentage in number and weight of the whole fall above or below a given length. A combination of these values will as a rule suffice to characterize the landings.

With regard to the English plaice fishery, the following explanatory remarks may be of service. The English plaice fishery extends over almost the whole of the North Sea, the greatest yield however being drawn from Areas B₃, C₂ and B₄. 80% of the total weight of plaice landed is brought in by steamer, and only 20% by sailing vessels. These sailing vessels, most of which are from Lowestoft, and fish in Areas C₃ and B₃, are chiefly beam-trawlers, but have however, no receptacle for storing plaice alive, and bring no live fish to market. Plaice fishery is the chief part

of the fishing done by these sailing vessels from Lowestoft, if not the only kind of fishing they carry on. In the case of the steamers, plaice fishing ranks as a rule below other kinds of fishery; there are however, at some ports, especially London, small steamers which fish in summer from time to time *for plaice alone*, and that in the regions of the young fish grounds, viz; Areas A₂, A₃, B₃ and B₄.

The composition of the English landings is to a certain extent determined downwards by a size-limit, which, though not legally enforced, is yet observed in practice, of 18—20 cm. Plaice below this size are therefore rarely found in the landings. Plaice under 25 cm. long (i. e., up to 24 cm. inclusive) will in the following be designated as "*undersized*". Plaice under 29 cm. (i. e., up to 28 cm. inclusive) will be called "*small*", as being in number and weight more or less practically identical with the market class termed "*small*" in most English ports. Similarly plaice over 35 cm. long can be called "*large*."

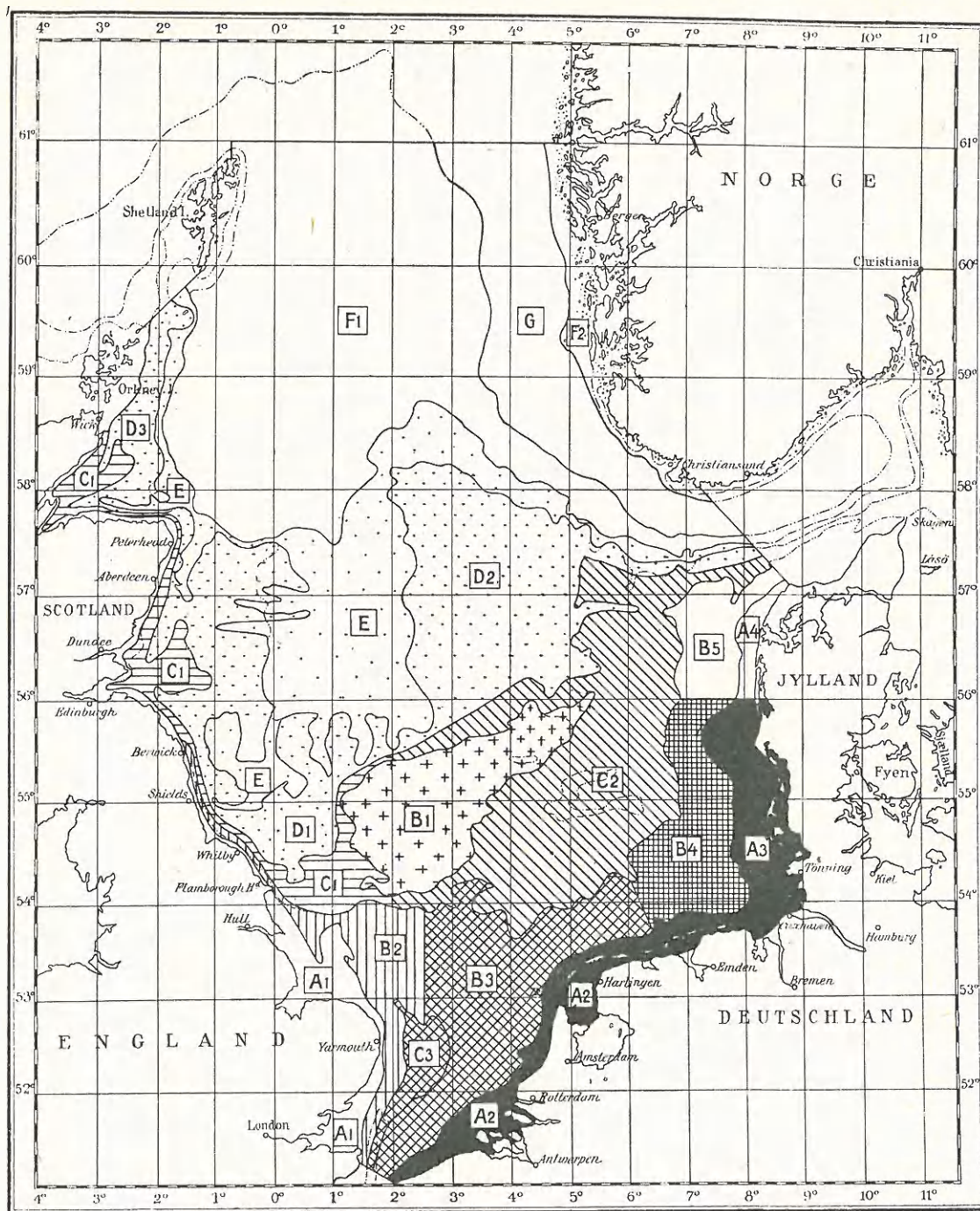
a. The Landings from the different Areas.

The following Table 1 gives a comparative view of the average annual quantity and composition of the English landings of plaice from the North Sea, calculated for the period of measurement 1905/08.

Tab. 1. *English Market-Measurements 1905/08. Landings from the different areas.*

Area	1905/08 Yearly landings		1903/08 estimated weight per plaice kg.	1905/08 Range in length of plaice measured cm.	1905/08 Interval of		Probable percentage of the total number below:								Percentage of "small"	Catch of steam- trawlers per day of voyage kg.
	kg.	estimated number			mode	median	23 cm.	25 cm.	26 cm.	29 cm.	31 cm.	36 cm.	51 cm.			
	1000	1000														
A ₃	2165	14,091	0.153	16—45	24	24	26	55	68	95	97	99	100	86	492	
B ₄	4090	21,656	0.189	16—71	24	25	20	43	55	84	92	99	99.8	76	294	
B ₃	6845	33,294	0.206	15—71	24	26	20	39	48	68	78	94	99.1	42	263	
C ₃	2153	9,408	0.229	17—69	25	26	17	37	48	67	77	93	99.9	31	287	
B ₂	3280	12,197	0.269	17—67	26	28	9	24	32	55	66	87	99.8	27	164	
C ₂	6082	16,671	0.365	17—76	28	29	5	15	20	41	54	78	98.4	25	116	
C ₁	1003	1,893	0.529	20—69	30	32	2	6	10	30	43	68	95.2	9	89	
B ₁	2034	2,229	0.865	18—70	32	41	2	5	8	15	20	30	85.0	3	66	
D ₁₊₂	910	970	0.812	20—70	48	41	0.3	0.8	1	6	11	25	88.3	4	33	
E	166	204	0.811	26—66	50	48	—	—	—	—	—	—	—	6	17	
Total	28,728	112,613	0.255	15—76												

This table shows, that the quantity and size of the plaice taken by English fishery vary greatly according to the different sub-districts or areas of the North Sea. The greater part of the plaice, more than the half, in weight and number, of the whole of the landings, comes from the three areas, B₃, B₄ and C₂. Of the "*undersized*" plaice,



Plaice %
 below 25 cm > 50 % = 40—50 % = 30—40 % = 20—30 % = 10—20 % = 5—10 % = 5—10 % = 0—1 %.
 above 25 cm 1 % = 1—2 % = 5—10 % = 10—20 % = 20—30 % = 30—40 % = 60—70 % = 75 %.

Fig. 3. *English Market-Measurements 1905/08.* Relative quantities (in percentage of the total number) of small "undersized" plaice below 25 cm. and of large, mature plaice over 35 cm. in the English landings from the different areas of the North Sea.

The blank areas have not been investigated.

i. e., those under 25 cm., which amount in number to about one-third of the total quantity of all the landings, no less than 77 % are taken from the three areas A_3 , B_3 and B_4 . Of the large plaice (over 35 cm. long) which make up about 10 % of the total number of fish in the English landings, nearly three fourths are drawn from Areas B_3 , C_1 , C_1 , D and E and only about one-fourth from the southern areas C_3 , B_3 , B_4 and A_3 . This varying composition of the landings from the different areas is also entirely in agreement with the general law of distribution of the plaice in the North Sea, according to which the size and age of the plaice in a given district of the North Sea are inversely proportional to the density of their occurrence, and directly proportional to the distance of the ground from the coast, and its depth. Fig. 3 here appended gives a clear view, in chart form, of the relative quantities of undersized plaice (under 25 cm.) and large plaice (over 35 cm.) in the landings from the various parts of the North Sea.

The areas can be divided into three groups, according to the size of the plaice and the composition of the landings.

1. *The four areas A_3 , B_4 , B_3 and C_3 form, (with A_2), the southern, most landward plaice zone of the North Sea.* From here are drawn the greatest quantity, in number and weight, viz., yearly about 15 million kg. and 75 million fish, of an average weight of 200 gr. The value of greatest density of the plaice measured is from 24 to 25 cm. the median from 24 to 26 cm. More than *one-third* of all the plaice (37 to 55 %) are under 25 cm. long and can thus be designated as "undersized" plaice, more than *two-thirds* (67 to 95 %) are under 29 cm. and can be called "small" plaice. The "large" plaice, i. e., those over 35 cm. long, amount to less than 8 % (7 to 1 %), the very largest and oldest, i. e., over 50 cm. long, (mostly over 10 years old) less than 1 %. This zone is thus the district of small and undersized plaice. As shown by the scientific catches, great quantities of plaice are caught here, which, falling below the legal or practically accepted size-limit of 18 cm., are thrown away, and never reach the market. This then, is the region, where the useless destruction of enormous quantities of young, immature, undersized plaice, is continually carried on.

2. *The two areas B_2 and C_2 form the medium plaice zone of the North Sea.* Although in point of space almost as large as the first, this zone yields annually only about 9 million kg. and only 29 million fish, these being however, for the most part larger plaice, with an average weight of about 300 gr. The greatest density of the plaice lies from 26 to 28 cm., the median from 28 to 29 cm. Only about one-fifth of all the plaice are under 25 cm. long, and scarcely half under 29 cm. Large plaice, i. e. over 35 cm. make up about 10 to 20 %; very large and old, over 50 cm. about 1 to 2 %. The useless destruction of small, unmarketable plaice is here extremely restricted, and occurs only in certain parts of B_2 . The question of protective measures here therefore, no longer applies.

3. *The areas C_1 , B_1 , D_1 , D_2 and E form the extreme northern plaice zone of the North Sea.* In point of extent about as large as the first two combined, this zone is represented in the landings with an annual yield of only 4 million kg. and 5 million fish; these being, however, large plaice with an average weight of about 800 gr. The number of undersized plaice (under 25 cm.) here amounts to only 0 to 6 %; that of the "small" (under 29 cm.) at the outside three tenths of the total. The "large" plaice

make up 25 to 70 %, the very large fish 5 to 15 %. Very small plaice under 18 cm. are, according to the scientific catches, practically never caught now in this zone; only in C₁ can a few now and then appear in the trawl. The question of protective measures is no longer of any importance for this zone.

Within each of the three plaice zones of the North Sea the various subdivisions, the areas themselves, again show points of difference, the size of the plaice and the percentage of the different size-classes being dependent on the depth of the region and its distance from the coast.

b. The English landings for the various months from the whole of the North Sea.

Investigation shows, that the size and composition of the landings vary not only according to the areas of the North Sea, but also, though in lesser degree, according to the months. And these monthly variations are found both within one and the same area, and for the North Sea as a whole. These variations are partly accounted for by the fact, that the intensity of the fishery and its extent over the different areas are not the same in all months (seasons), and partly due to the fact that the distribution, density, and composition of the shoals on the ground are not always and everywhere the same, but vary, as a result of the complicated movements of the plaice population in the North Sea, according to month and season. Thus the English fishery for instance, finds its greatest yield in Areas A₃, B₄ and B₃, in the Southern North Sea, in early Summer, during June and July: in the northern areas on the other hand, in late summer and early autumn, during August and September. On the other hand, while in all other areas the winter catches, i. e., those of January and February, are the smallest, and the catches made in summer the largest, the reverse is the case in Area C₃. By far the greatest yield of plaice occurs here in January and February, which is in all probability due to the fact that in this area and a part of B₃ lies one of the *principal spawning places*, where great numbers of spawning fish collect in the spawning months of January and February. In the composition of the catches we find, and this, moreover, chiefly in the southern coastal regions of the North Sea, a very remarkable difference between the winter months (December to February) and the spring and summer months, (March to July) the percentage in winter of large plaice, over 35 cm. being much higher. This is no doubt due to the fact that the small plaice hibernate hidden in the ground, and thus escape being caught by the trawl.

The following table (Tab. 2) and the graphical representation of same (Fig. 4) giving the size and composition of the English landings from the whole of the North Sea, divided according to months, present a good view of these monthly variations.

From these it will be clearly seen, that the largest landings of plaice fall in the spring and summer months, the smallest in the winter months: between summer and winter there is also a slight increase in the quantities landed, viz, from September to November. And here it is of particular interest to note, that the percentage in weight of the market-class «small» in the landings increases and decreases regularly with the absolute quantity of the latter, as also the percentage in number of the «small» plaice

(under 29 cm. in length). In other words: «*The size and quantity of the monthly plaice landings is dependent on the quantity of small plaice.*» The most small plaice are however taken during the months of spring and early summer, and naturally, in the shallower waters of the southern North Sea.

Table 2. *English Market-Measurements and Landings for the period 1905/08, according to months.*

- a. Monthly percentage of the different sizes in the total landings, by number.
 - b. Monthly percentage of the different market-classes in the total landings, by weight.
 - c. Quantity of the landings, in 1000 kg. All for the whole North Sea.
- (calculated from "Plaice Fisheries", Vol. I, Table VII, Vol. II, Tables VI and XLVI).

Month	a. % of the total number below cm:							b. % of the landings in kg.		Total of the landings 1000 kg.
	23	25	26	29	31	36	51	large + medium + others	small	
November.....	14	34	45	68	79	91	98.6	60	40	9,049
December.....	13	35	46	65	76	90	98.9	70	30	6,313
January.....	12	25	33	56	68	87	98.6	77	23	5,802
February.....	17	32	39	58	69	86	98.3	76	24	4,540
March.....	21	42	51	72	81	92	99.1	77	23	4,853
April.....	22	42	51	72	82	94	99.5	65	35	6,212
May.....	22	42	52	75	83	94	99.2	49	51	8,834
June.....	19	39	49	70	81	93	99.2	40	60	10,301
July.....	14	29	38	59	70	91	99.5	52	48	10,134
August.....	11	25	34	57	70	90	99.5	65	35	9,157
September.....	13	31	45	63	76	92	99.6	64	36	8,890
October.....	15	37	48	72	82	93	99.3	64	36	9,879
Yearly total	17	35	44	66	77	91				

Fig. 4 represents these three summaries graphically.

These characteristic monthly variations in the landings are not without some importance for the practical plaice question. We are now in a position to accurately determine, at any rate, with regard to the English fishery, not only in what regions of the North Sea, i. e., on what fishing grounds, the greatest quantities of small and undersized plaice are destroyed by the trawl, but also at what season of the year this takes place. The fishing grounds in question lie in the areas A₂, A₃, B₄ and B₃, the season being the months from April to August. We can with some degree of certainty estimate the number of undersized plaice (i. e., under 25 cm. long) landed from these fishing grounds during the months named, at 50 % of the total quantity of the landings, and that of the so-called small plaice, under 29 cm., at about 75 % or, in respect of weight, about 29 % and 52 % respectively. As the total weight of the English plaice

landings from these areas during these months is estimated at about 8 million kg. per annum, it follows that about 2.5 million kg. of undersized, and about 4 million kg. of small plaice are destroyed every year; in actual numbers about 23 and 27 million fish. Even these figures do not however represent the full extent of the

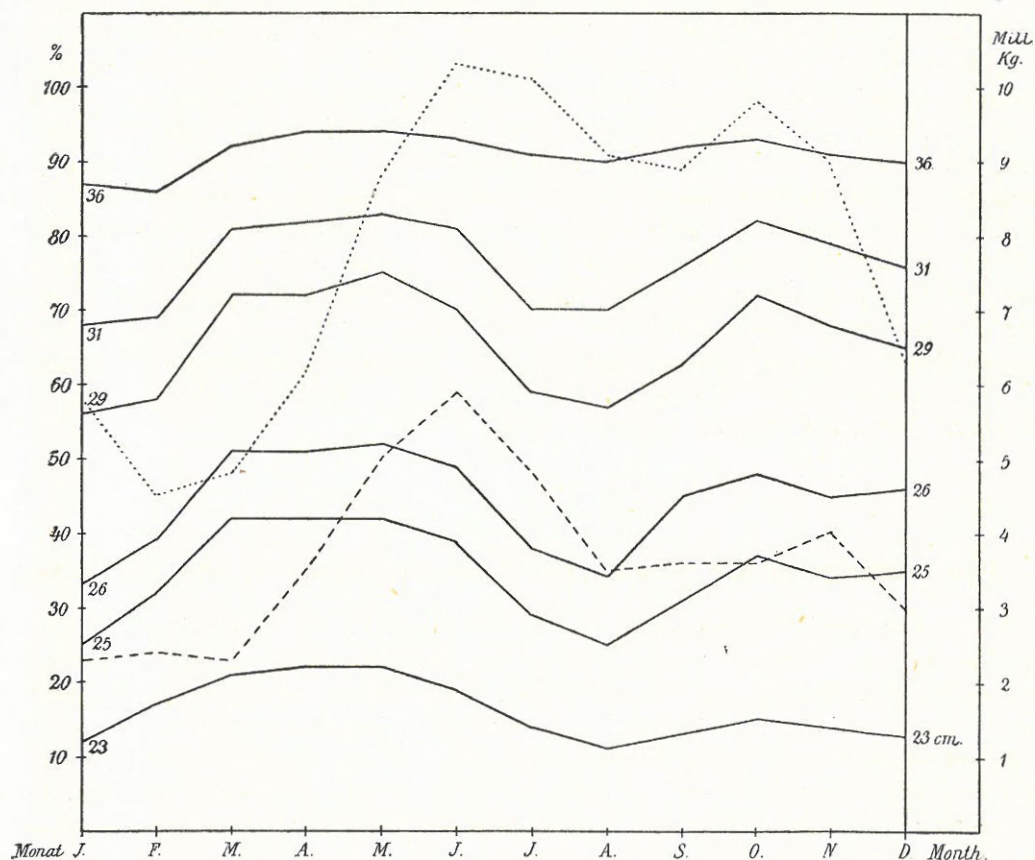


Fig. 4. English Market-Measurements 1905/08.

- a. ————— Percentage by number below 23, 25, 26, 29, 31 and 36 cm. in the total measurements for the three years; by months.
- b. — — — — — Percentage by weight of the market-class "small" in the total landings of the three years; by months.
- c. Total landings in million kg.; by months.

destruction of young undersized plaice; we have still to add those very small fish which are taken on the young fish grounds by the trawls, and brought to the surface, but not brought to land, being thrown overboard again as valueless. As will be further shown later on, these very small plaice thus uselessly destroyed, amount in number, during the summer months, to twice or four times the whole of the rest of

the catch. We arrive thus at the estimate, that every year about 140 million young plaice are taken by English fishing boats in the young-fish areas during the summer months alone, i. e., from April to August, and of these about 20 million of the largest fish are brought to market, while 120 million small and very small fish are uselessly destroyed. It is obvious, that it would be of the greatest practical value if we could succeed in putting a stop to such ruinous plaice fishery in the spring and summer months by means of an international size-limit or any other effectual protective measures.

In late autumn and winter, from November to March, the plaice landings from the southern North Sea are, (with the exception of Area C₃) not only absolutely considerably smaller, but also far poorer in small and richer in large plaice. Most of all, however, the comparison of scientific hauls with market samples from the young-fish grounds shows, that only a relatively quite small quantity of very small plaice are caught here in winter by the trawl and uselessly destroyed, scarcely one fourth of the total market catch; which is nothing in comparison with twice or four times the market catch in the summer. The great mass of the small and very small plaice are here, on account of their hibernating in the ground, almost without importance for the trawl fishery, and the winter catches of the shallower coastal areas resemble therefore in their composition the catches of the deeper regions farther out at sea. *The destruction of undersized plaice is therefore considerably less in winter, and the useless destruction of same extremely small.*

c. The landings of the whole year from the whole of the North Sea.

If we consider the whole North Sea, to the extent to which it is fished by English boats, as one single district, and combine all the monthly landings from this district, we arrive at the total landings for the whole year. Knowledge on this point is of particular value to the practical plaice question. The extensive English market measurements for the period of three years from October 1905/1908 give us a picture of the composition of these yearly landings which has proved, owing to the methodical checking, to be very reliable. And it appears from this, that the landings of the three consecutive years differ neither in quantity nor in composition. In spite of various slight differences in the extent and working of the plaice fishery in these three years, they have had no noticeable influence on the composition of the landings, rather, in all probability, an equalisation has been the result: nor is there any evidence of increase or decrease of the various size-classes during this period.

The graphical (Fig. 5) representation of the landings for the year 1906/07 might serve as a clear view of the composition of the annual landings of plaice from first class English vessels in the North Sea during the years from October 1905/08. In this figure is shown, along the abscissa under each length in cm. also the corresponding average *age* for this length-class, the figures being based upon numerous investigations with regard to age. The brief description of the composition given thereunder states, for the most part, the mean values from the two annual series 1906/07 and 1907/08.

The average yearly landings by weight amount to 29 million kg., by number 112.5

million plaice from 15 to 76 cm. in length and from 37 to 4477 g. in weight. The average length of all plaice landed is about 29 cm., the average weight calculated empirically (from weighings of partly cleaned, partly entire fish) 258 g., calculated theoretically ($k = l$) 271 g.; the former is 0.952 of the latter.

The interval with the highest number of specimens (mode or D) is 25 cm. The part of the series below this length (ascending arm of the curve) is subject to a market-selection; that is, of the small plaice actually caught up to a length of 24 cm. not the whole catch but only a portion is landed; on the other hand — apart from chance loss — all the plaice caught above 25 cm. in length are brought to market. The plaice only partly landed up to and including those at 24 cm. in length, which we may conveniently call "undersized" plaice, have an average age of 2, 3 to $3\frac{1}{2}$ years. The quantities of these brought to market compose about $\frac{1}{3}$ rd (32%) of the number and about $\frac{1}{7}$ th (14%) of the weight of the total landings. The percentage of undersized plaice discarded by the market-selection increases, the smaller the plaice are and in a very rapid manner. Thus, the plaice below 23 cm. (up to and including 22 cm.) compose only 14% by number, only 5% by weight of the landings, those below 20 cm. (up to and including 19 cm.) only 1% and 0.2%; those below 18 cm. only 0.01% by number and 0.0015% by weight of all landings. 18 cm. is the size-limit used consciously in practice, though not imposed by law, and we can see how the first-class vessels keep well above it. Of the 112.5 million plaice landed only 11,250 approximately are below this size-limit. The plaice below 29 cm. in length have been called here generally "small" plaice; this has been done, after examination had shown, that the quantity of these plaice by number and weight in our measurement series (about 63% and 40%) agree well with the corresponding quantities in the landings; though the market-class "small" admittedly contains a number of plaice which are larger than 28 cm., yet their number is fairly well counterbalanced by the number of plaice below 29 cm., which are included in the market-class "medium". In the same way, we may call the plaice over 35 cm. "large", the plaice between 29 and 35 cm. in length thus forming the group "medium". The proportions of these three groups small, medium and large are, by number, 63 : 27 : 10; by weight 37 : 32 : 31; or, again, by number 7 : 3 : 1; by weight almost 1 : 1 : 1. The "small" plaice are on an average 2 to 4 years old, the "medium" 4 to 5 years, the "large" 5 to 25 and more years. Among the small plaice almost all the males, but very few females are mature; among the medium all the males and about $\frac{1}{3}$ rd of the females, among the large almost all the females also.

The length above and below which 50% of the number of all plaice in the English landings lie, i. e. the *central or median value of the number series*, is 27 cm. The two lengths, between which half the number of all plaice lie, i. e. the two quartiles, are 24 and 31 cm. This interval is thus the predominant range of the series; it contains plaice at an average age of $3\frac{1}{2}$ to 4 years; 10% of these are undersized, 40% small and 10% medium plaice.

The length, above and below which 50% of all the plaice by weight lie, i. e. the *median or central value of the weight series*, is 31 cm.; the corresponding quartiles about 26.5 and 38.5 cm.; between these lie 50% of all plaice by weight; they form the predominant range of the weight series, including abt. 15% of small, 30% of medium and 5% of large.

Extremely characteristic of the composition of the landings from the individual size-classes is the manner in which the number of plaice — from the value of greatest density of the series, 25 cm. — decrease with size and age. The decrease is very rapid, but not regular, differing in power for the different age- and size-classes. Some idea of this can be obtained from the following series, which indicates the percentage

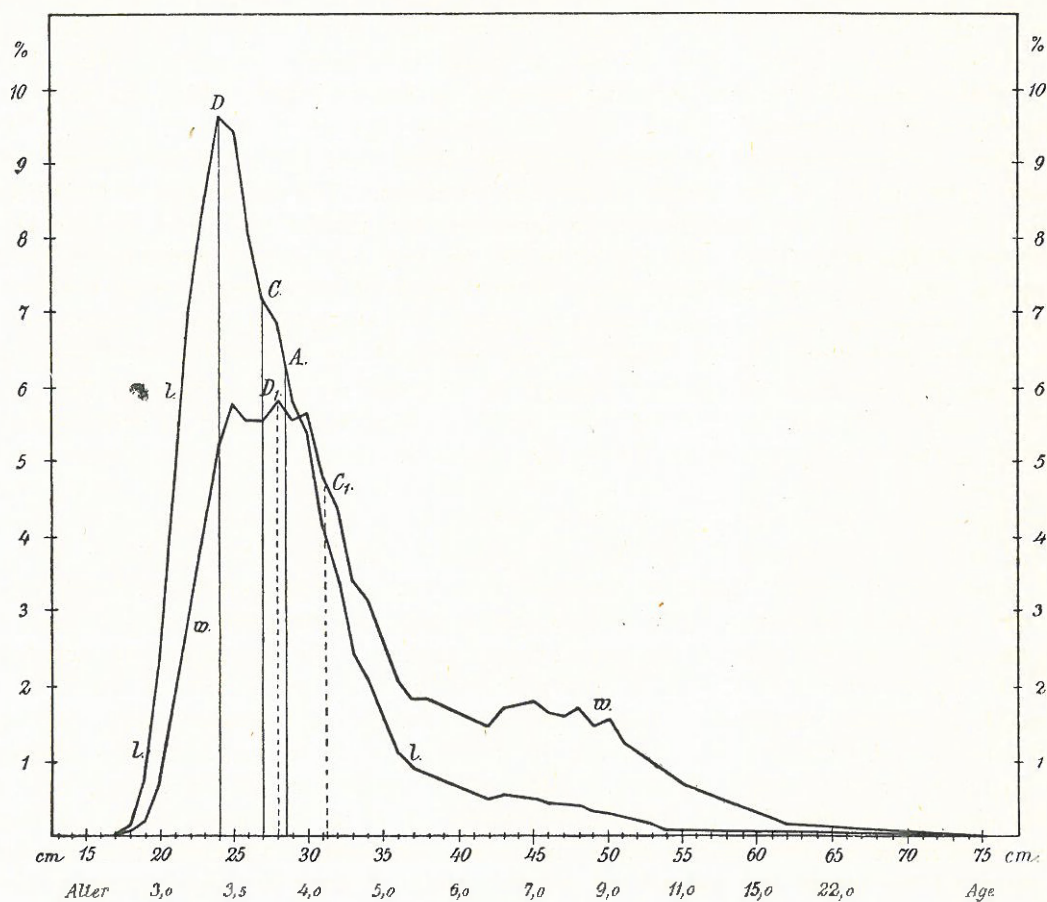


Fig. 5. *English Market-Measurements*. 11th Year, October 1906/07. Analysis by length and weight of all plaice measured in English ports (1,775,658). *l* length curve; *w* weight curve. — Percentage curves.

D Mode, C Median, A Arithmetic average of *l*

D₁ — C₁ — of *w*

in a landing of such plaice as exceed a certain length in cm. and have passed a certain average age.

Thus:

over cm. long	25	—	30	—	35	—	40	—	45	—
more than years	3.5	—	4	—	5	—	6	—	7	—
Percent of total	59	—	25	—	10	—	5	—	3	—

over cm. long.	50	—	55	—	60	—	65	—	70
more than years.	9	—	11	—	15	—	22	—	—
Percent of total	1	—	0.3	—	0.1	—	0.01	—	0.0005

It is certainly a point of interest and of great value for a correct view of the plaice question, when we learn from this series, that only 25 % of the plaice in the English landings from the whole of the North sea exceed an average age of 4 years, only 10% being more than 5 years old, i. e. the earliest age at which the majority of female plaice reach full maturity. Only 5 % are over 6 years old, only 1 % more than 9 years. The oldest plaice in the North Sea reach, however, an age of more than 20 years, sometimes even over 30.

If we review the information at hand with regard to the composition of the English plaice landings from the North Sea, from the point of view of the practical plaice question, we see that the capture of small and undersized plaice still plays a great part in the English fishery. About one third of the total number, or one seventh of the total weight of the landings are undersized plaice under 25 cm., while 63 % in number and 40 % in weight are small plaice under 29 cm. long. As the most prominent sizes can be noted plaice of 24 to 38 cm.; between these lie almost $\frac{3}{4}$ of the total number, or $\frac{2}{3}$ of the total weight of all the landings. Expressed in commercial terms: *The small and medium sized plaice constitute the most important and determining factor of the English plaice fishery in the North Sea.*

Landings of plaice in Germany.

The German plaice fishery in the North Sea ranks only third or fourth in point of extent and yield. The yield amounts in weight (see p. 15) to only about 7 % of the whole plaice production of the North Sea, as against 64 % in England and 16 % in Holland: the yield of the Danish fishery is about equal to that of the German.

Market measurements with a view to determining the size and composition of the landings were instituted in Germany as early as 1904 and 1905, but were not carried out to any great extent, or on scientific principles, until 1909. These German market measurements are, as reliable indications of the composition of the landings, at least as valuable as the English measurements, if not more so, being equal to these in relative extent, i. e., in the number of measurements in proportion to the quantity of the landings. We are also, thanks to the equally high methodical value of the English and German market measurements, in a position to make useful and instructive comparisons between the results of both, the more so, as the German measurements are also divided according to months and areas.

The German plaice fishery in the North Sea extends over a much smaller district than the English, and differs also considerably from same with regard to the methods employed. Its field is chiefly the so-called southern and south-eastern North Sea, i. e. the areas A₃, B₄, C₂, B₅, together with small portions of B₃ and B₁. The total yield of the German plaice fishery can as an average for the 5 years 1905/09 be estimated at about 3,400,000 kg. per annum, of which about 2,485,000 kg. or 73 % are drawn from the North Sea (exclusive of Skagerak). Of these again 2,438,000 are

If we compare these German total landings for the whole year with the English figures corresponding, we see at once that they have a much lower average weight, and are much richer in small, and poorer in large plaice than the English. Thus for instance, the "undersized" plaice (under 25 cm.) amount to 47 % of the number, and 31 % of the weight in the German landings; in the English only 32 % and 14 %. The "small" plaice (under 29 cm.) make up in Germany 85 % of the number and 68 % of the weight, in England only 63 % and 37 %. The large plaice (over 35 cm.) represent, on the other hand, only 3 % of the number, and 10 % of the weight of the German landings, as against 10 % and 31 % in the English. This remarkable difference is very simply explained by the fact, that the German plaice fishery carried on in those areas, viz. B₂, C₁, B₁, D and E, — in which most large plaice appear, is, in contrast to that of England, little or nothing, being for instance, in the areas B₁, D and E so insignificant, that the small number of plaice which are landed from here, and which are not included in the above table, would scarcely affect any alteration at all therein. On the other hand, the great relative importance of the plaice fishing done by German sailing-vessels, and the fact that this falls almost exclusively in the coastal areas A₂ and B₄ lowers the average size of the plaice in the landings considerably. But even if we compare only the German steamer landings with the English, a great difference is still to be seen.

A strong, though naturally not complete resemblance is to be noticed between the total of the German landings from the southern North Sea and the English landings from Area B₄, the composition of which is likewise here set forth for comparison. England lands from this area more than one and a half times the total quantity of the German landings (about 21½ as against 13¾ million fish). The percentages in numbers of the "undersized" and "small" English plaice from B₄ (43 % and 84 %) are almost the same as for the German plaice from the south-eastern North Sea (47 % and 85 %). Thus the certain number of large plaice taken by the German fishery from Areas C₂ and B₅ is compensated by the quantity of the small plaice taken from Area A₂.

Seen from this standpoint, and especially in order to check the reliability of the methods employed for determining the composition of the landings, it is valuable to compare the English and German steamer landings from the same area B₄. This is possible, owing to the fact that extensive German market measurements are also at hand from this area.

Landings from Area B ₄	Total Quantity		Average weight in grammes	Percentage in number under cm:						cm. Interval of	
	Weight in kg.	Number		23	25	26	29	31	36	Mode D	Median C
1. English. Period 1905/08	4,090,000	21,656,000	189	20	43	55	84	92	99	24	25
2. German. 1909. . .	300,013	1,833,635	163	17	42	56	84	93	98	25	25

The similarity between these English and German steamer landings is remarkably strong, with the exception of the average weights, which are very different; this is however, of but slight importance, as we have here to deal with empirically determined weights, which are arrived at in different ways and not by any uniform method. As the English and German steam trawlers (English sailing vessels do not fish in Area B₄) employ exactly the same methods of fishing, and especially as they observe the same legal or accepted size-limit of 18 and 20 cm. respectively and as moreover, the correct noting of the catch in this area is very reliable, we can regard this agreement of the English and German plaice landings from this area in point of composition, as a proof of the reliability of the measuring methods employed, and of the representative character of the market samples measured, and therefore also as a proof of the reliability of all our conclusions as to the composition of the landings in general.

A further similarity between the results of the English and German market measurements from Area B₄, and one which also proves, in this respect, the reliability of the methods of investigation, is the remarkable likeness between the composition of the monthly landings in both countries, these having been investigated in Germany as well as in England. In both cases we find, in Area B₄, the heavy decrease in winter in the number of small, undersized plaice in the landings, and the corresponding increase in the number of large fish; then the sudden reappearance of the small plaice in March; further, a second smaller minimum of the small plaice in August, and a second smaller maximum in the autumn.

In the case of the steamer landings from Area C₂, the similarity in the composition is not so great as in B₄. The English landings here seem to contain many more large plaice than the German; this is, however, in all probability simply due to the fact, that the German steamers mostly fish the south-eastern parts of this very extensive area, adjacent to B₄, while the English keep rather to the western and northern parts, which are probably richer in large plaice. The difference might also in part be due to the fact that the English landings are here stated as for the three years 1905/08, and the German for 1909.

Of great importance to the practical plaice question is the very considerable difference in the composition of the German steamer and sailing ship landings. The sailing ship landings contain much smaller plaice than the steamer landings; the former show no less than 65 % in number and 52 % in weight of "undersized" plaice, as against 30 % and 16 % in the case of the latter, and correspondingly 96 % and 86 % "small" plaice, as against 73 % and 52 %. These great differences are easy to understand, as the German plaice fishery from sailing vessels is almost entirely restricted to the areas A₃ and B₄, which, in comparison with the grounds of the steamers, which lie much farther out at sea, might almost be called shore fishery. As sailing ships and steamers land about the same annual quantity of plaice, the yearly destruction by sailing vessels of young, undersized plaice is absolutely greater than that of the steamers; for the year 1909 about 4,500,000 fish as against 2,100,000, i. e. more than double: or, reckoned in weight, 504,000 kg. as against 237,000 kg. As the great majority of the plaice taken by the sailing vessels are brought to market alive, and as these live plaice fetch a much higher market price, (about 50 pfg. per kg.) than the small steamer plaice, which are always brought in dead, (about 25 pfg. per kg.), the sailing vessels utilise

their landings of undersized fish to much better effect than the steamers; they earn from these about 250,000 Mark annually, as against abt. 60,000 Mark for the steamers. A size-limit prohibiting the landing, and thus the utilisation of small undersized fish would therefore naturally prejudice the takings of the sailing vessels far more than of the steamers. If fixed, for instance, at 25 cm. it would cost the sailing vessels the half of their earnings from plaice fishing, the steamers one sixth at the outside. This would moreover, be in the case of the former a still greater loss, since the plaice is for them the most important item of their fishery, and represents, both in weight and value, the greatest part of their annual yield, while in the case of the great majority of steamers this fish plays only an unimportant part, and ranks in point of yield far below the sum of their other trawling fishery.

Our knowledge as to the composition of the German landings of plaice from the North Sea, as obtained from the market measurements for the single year 1909, leaves still the question open, as to whether this composition has remained the same for a long period of years, or whether it perhaps differed essentially in any other earlier year. As far back as the years 1904 and 1905 market measurements and weighings were carried out at German ports, although these were not nearly so extensive, nor so methodically correct, as those of the year 1909. These measurements for 1904/05 show a larger average of weight of the plaice in the German landings than in 1909 and thus naturally also a considerably different composition of the same, the percentage of young, undersized plaice in 1909 being higher than that of 1904/05. If these investigations are entirely reliable — which is not yet quite certain, — it is still open to doubt whether such differences in the composition of the plaice landings are merely the result of variations in the localisation of the fishery — which might for instance one year be carried on nearer the coast, and in another at greater distance therefrom, etc. — or whether it is really a question of actual alteration in the stock of fish, so that, for instance the year 1909 shows depreciation of the fish stock, as against 1904/05, resulting from a relative increase in the number of smaller plaice and diminution of the proportion of larger fish.

Landings of plaice in Holland.

The Dutch plaice landings from the North Sea are of some importance; amounting to about 7.5 million kg. annually, i. e. about one-fourth of the English landings, and more than that proportion of the landings of other countries bordering on the North Sea. The value of these Dutch landings can be estimated at about 720,000 Gulden, and amounts to about 20 or 25 % of the total value of the Dutch trawl fishery in the North Sea.

The Dutch plaice fishery is, like the German, divided between steamers using the otter trawl, and sailing vessels, which fish with the beam trawl. The steamers fish for the most part farther out at sea, in Areas A₂, B₃, B₄, B₁ and C₃, chiefly however in Areas B₃ and B₁ (Dogger Bank). The port used by most of the steamers is Ymuiden. The sailing ships are divided into two classes; large vessels, similar to the English smacks, sailing chiefly from Scheveningen and Katwijk an Zee, and working the grounds that lie farther out at sea, and a number of small shore fishing vessels, which

work nearer land, their principal port being Helder: these last are always provided with a receptacle (Bünn) for storage of live fish. The larger sailing vessels fish in the areas A₂ and B₂, the small ships probably only in A₂. It is impossible to determine exactly the relative value of the yields of steamers and sailing ships; at a rough estimate, the steamers take in all probability at least 75 % of all the landings, leaving only 25 % to the sailing vessels.

Holland has up to the present no size-limit, legal or accepted. Thus a considerably larger number of young undersized plaice are landed in this country and utilised for human consumption than elsewhere, especially by the small sailing vessels, which work chiefly in the area A₂. In the Dutch market, plaice are at present divided into four market-classes: "large", "medium", "small I" and "small II" the approximate average weights of the plaice being 1260, 690, 290, and 120 grammes. The last-named smallest market-class "small II" which average about 8 fish to the kilogramme, and measure from 11 to 37 cm., most of them between 20 and 26 cm., form the great majority of all the Dutch plaice landings from the North Sea, and amount to about 75 % to 80 % of the catch of the steamers and larger sailing ships, and more than 90 % of that of the shore fishing vessels.

The Dutch market measurements being less methodically and relatively less extensively carried out than the English and German, it is impossible to give any thoroughly reliable picture of the composition of the Dutch landings of plaice from cm. to cm. either as regards the whole of that part of the North Sea worked by Dutch fishermen, or for the separate areas. We can however, with some degree of reliability, calculate the composition of the landings at the principal port, Ymuiden, which takes the catches of nearly all the steamers and a part of that of the large sailing vessels, as shown for the year 1906.

Table 4. Calculated composition of the landings of plaice from the North Sea at the Port of Ymuiden, in 1906.

Landings	Total of Landings		Average weight in grammes	Percentage of total number (<i>n</i>) and of total weight (<i>w</i>) under cm:								Range cm.	cm. Interval of	
	Weight in kg.	Estimated number			23	25	26	29	31	36	51		Mode D	Median C
1906 At Port of Ymuiden, from Steamers and Sailing vessels	5,733,740	40,764,500	146	<i>n.</i>	43	66	75	92	97	99.1	99.97	11—71	22	23
				<i>w.</i>	27	49	59	82	90	96	99.7		24	25

If the landings of the small sailing vessels fishing near the coast were added to this calculation, and the composition of the total of the Dutch landings thus approxi-

mately arrived at, then the relative quantities of small undersized plaice would certainly be somewhat higher than that shown in the above table. The average weight would also show a decrease, and probably sink to 140 gr. or even lower. If we take, for instance, 140 gr. as the average weight of all plaice landed at Dutch ports in 1906 from the North Sea, then the number of fish which should correspond to a total weight of about 7.5 million kg. would be about 53.6 million. In England, during the period from October 1905/08 about 31.7 million kg. of plaice were landed, with an average weight of 264 gr., equal to 116.3 million fish. The Dutch landings thus amounted in weight to about 24 % of the English, but 46 % of the number. The German plaice landings for the year 1909 amounted to 2.45 million kg., or 13.86 million fish with an average weight of 177 gr. which is equal to 33 % of the weight, and 26 % of the number, of the Dutch landings.

The Dutch market measurements do not permit of any calculation as to possible monthly variations in the composition of the landings; it is however, very probable that such variations exist, being no doubt similar to those found in the English and German landings. This is almost exactly correct as far as concerns the absolute quantity of the landings in kilogrammes. With the Dutch, as in the case of the English and German landings from the southern parts of the North Sea, the maximum falls in Spring, especially in May, the minimum in Winter (January and February) with a smaller slight minimum in July and August.

If we subtract from the Dutch landings those undersized plaice which in Germany may not be, and are not brought to land on account of the legal size-limit of 18 cm. i. e. the greater part of the plaice below this size, and a corresponding quantity of larger fish of 20 cm. and more, they will then appear very similar to the German. *There is then, scarcely any difference between the Dutch and the German plaice fishery as regards the fish caught, but only as regards fish brought to land.* This should in particular also apply to the plaice fishery of the sailing vessels of both countries, the Dutch working Areas A₂ and B₃, while the German ships fish in A₃ and B₄. The stock of plaice in the western district of A₂/B₃ is obviously similar to that of the more easterly A₃/B₄ especially as regards the occurrence of young undersized plaice, and this to such a degree that the two districts may in this respect be classed as equal.

From the statistics at hand, and the market measurements which have been carried out, it is impossible to determine whether any essential difference has taken place between the different years of a period for instance such as the years from 1903 to 1907 in the composition of the Dutch landings of plaice from the North Sea: this is however, scarcely probable. The lack of such essential difference would prove that the relation of the yield of the steamer fishing to that of the sailing vessels, as well as the extent, in area worked, of both classes of fishing have remained unaltered.

Landings of plaice in Belgium.

The Belgian plaice fishery in the North Sea is similar, as regards its manner of working and territorial extent, to that of Holland, the steamers however, using the otter-trawl, fish farther north and west than do the Dutch; almost all over the North Sea. The large and small sailing vessels work almost the same grounds as in Holland, especially the areas

A₂ and B₃. In point of extent and yield the Belgian plaice fishery is the smallest in the region of the North Sea, and furnishes annually only a little over 2% of its whole plaice production, amounting in 1907 to about 1,100,000 kg. Almost the whole of this quantity of plaice is landed at *Ostend*, and the market statistics from this port are thus representative of the whole of the Belgian North Sea fishery. These market statistics from Ostend have been since 1904 more thoroughly and methodically carried out. The total quantity of plaice landed in Ostend from the North Sea for the period of five years from 1904/08 amounted to 7,027,344 kg. of which 2,964,271 kg. were taken by steamers and 4,063,073 kg. by sailing vessels. This gives, as the average of the five years, 1,405,469 kg., or 592,854 kg. by steamer and 812,615 kg. by sailing ship. The total value of these landings of plaice for the five years 1904/08 is calculated as 1,276,952 Fcs. for the sailing vessels and 666,834 Fcs. for the steamers, or 1,943,786 Fcs. in all, the average annual value being 255,390 Fcs. and 133,367 Fcs. or 388,757 Fcs. in all. Thus the yield of the sailing ships in Belgium is, in contrast to Holland, greater than that of the steamers. This has, however, not always been the case, as the steamers had, until 1906, a higher yield than the sailing vessels. In 1906 however, the positions were suddenly reversed. The real cause of this alteration was the fact that the fishing steamers in 1906 began to forsake the coastal grounds of the southern North Sea, and transferred their field of operations to its more northerly waters. The absolute and relative quantities of small plaice landed by the steamers were thereby considerably reduced, and the absolute quantity of their landings also decreased, while the average weight per fish rose (from abt. 270 gr. in 1904 to 325 gr. in 1908). The sailing ships that worked the coastal grounds had now more weight in the market, with their great catches of small plaice, and at the same time the relative quantity of the market-class "small" in their landings continually increased.

The very small number of methodical market measurements in Belgium do not unfortunately permit of any exact calculations as to the composition of the landings at Ostend from cm. to cm. The only way in which we can arrive at any computation of the total weight and total number of plaice in the landings is by means of determination of the average weight and average contents (in number) of a basket — which is the usual market measure in Ostend — as to the various market classes. Nor can such calculations make any claim to accuracy except as referring to the total of the landings for the whole year from the whole of the North Sea.

A legal size-limit of 18 cm. exists in Belgium; the composition of the landings is thus influenced by this limit.

The market class "small" is here a very uncertain and variable size and includes, at any rate, in the steamer landings, larger plaice than in those of the sailing ships. On the steamers this class is probably about the same as that which in England is called "small" and its extent is practically covered by the number and weight of our "small" plaice, i. e., those measuring under 29 cm.; probably, however it is somewhat larger. In the landings of the sailing ships at Ostend the class called "small" corresponds nearly to what we call "undersized" plaice, i. e., those under 25 cm. long.

If we now compare, as far as this can be done from the few values at hand, the Belgian landings of plaice with those of other countries, we find that the total quantity of the landings for the years 1904/08 both from steamers and sailing ships, are probably

Table 5. Estimated weights and numbers of the landings of plaice at Ostend for the years 1904, 1906, 1908 and in total for the 5 years 1904 to 1908.

Year	Vessel	Weight in kg.	Percentage of market-class "small"	Number	Percentage of market-class "small"	Average weight per fish	Year
1904	Steam	1,045,700	68	3,923,260	79	267	1904
	Sail	754,833	32	4,449,585	50	170	
	Total	1,800,533	53	8,372,845	64	215	
1906	Steam	385,799	48	1,314,774	61	293	1906
	Sail	680,795	35	4,010,882	55	170	
	Total	1,066,594	40	5,325,656	57	200	
1908	Steam	242,278	39	752,545	54	322	1908
	Sail	898,930	53	6,283,049	70	143	
	Total	1,141,208	50	7,035,594	68	162	
1904 / 1908	Steam	2,964,271	53	10,364,047	67	286	1904 / 1908
	Sail	4,063,073	45	25,394,598	59	160	
	Total	7,027,344	46	35,758,645	62	197	

similar in point of composition to the English landings from Area B₃, the steamer landings alone being similar to the English catches from B₂, and the landings from sailing ships alone like those from A₃. This was to be expected. If we compare the Belgian landings for 1908 with the German for 1909, we find a great similarity between the sailing ship landings of the two countries, while the Belgian steamer landings contain considerably larger plaice than the German. Any comparison between Belgium and Holland is rendered very difficult owing to the non-existence of a size-limit in the latter country, and also on account of the insufficient market measurements on both sides. We may however, with more or less certainty presume that the composition of the Dutch and Belgian landings from sailing ships, fishing exclusively in the southern coastal regions, is, making allowance for the quite small plaice, which are unmarketable in Belgium, the same, and very similar to that of the German sailing ships. It is characteristic of these landings from sailing vessels, that even with a size-limit of 18 cm. we yet find 50 % and more of the plaice landed measuring under 25 cm.

From this point of view it should be noted that the results of the catch statistics

and the market measurements give no reason to suppose that either relatively or absolutely more young undersized plaice are destroyed in the eastern, German parts of the southern North Sea, i. e., Areas A_3 and B_4 , than in the western parts off the coasts of Belgium and the Netherlands, in Areas A_2 and B_3 .

Landings of Plaice in Denmark.

The Danish plaice fishery, the average total yield of which amounts to about 10 million kilogrammes, has its principal fishing grounds, not in the North Sea, but in the Skagerrak, Kattegat, Belt Sea and the Baltic, which alone yield about 6.5 million kg., leaving only about 3.5 million kg. to the true North Sea, which is approximately the amount of the German plaice fishery in the North Sea.

The chief port for the Danish plaice fishery in the North Sea is *Esbjerg*, on the west coast of Jutland. The fishing vessels sailing from this port are, with the exception of some very few steamers and a number of small shore fishing vessels, chiefly decked cutters, which work the areas A_3 , B_4 , A_4 , B_5 and C_2 , fishing all the year round with the exception of January and February, mostly in early summer and autumn. These cutters are fitted for storage of live fish, and bring their catches to market alive. They invariably use the "Snurrevaad", which has been generally adopted on the west coast of Jutland since 1892. Although the fact that the Danish plaice fishery differs essentially from that of other lands is in part due to the character of the nets used, this is still more owing to the fact that a legal size-limit of 25.6 cm. for plaice has existed for a number of years, and is strictly enforced. The composition of the landings is naturally considerably influenced by this, as regards its lower limits, and is thus very different from that of the landings in England, Germany, Belgium, and especially in Holland. And finally, the plaice landed in Denmark are sorted in quite a different way to that of most of the other countries. The live plaice landed are reckoned by the score, and the total weight of the landing is calculated only from the weight of each score. Different sorts are mostly classed only according to the weight per score.

Extensive market measurements of live plaice landed in *Esbjerg* from the North Sea have been carried out for the years 1904, 1905 and 1906. During these three years 23,902 fish caught with the "Snurrevaad" and of 22 to 45 cm. in length, were measured. In spite of the relatively very small number of these measurements — amounting annually to only 0.03 or 0.08% of the total catch — they are nevertheless in all probability to be regarded as having good representative value. On the basis of these measurements we get the following probable composition of the total landings in *Esbjerg* for the three years 1904/06.

The picture given by this composition of the Danish landings of plaice is totally different from that of the landings in other countries. No immediate comparison with these is here possible; they can only be compared as far as concerns those portions of the different landings which lie above the value of greatest density, and are thus unaffected by the selection owing to size-limit, etc. This value of greatest density, or boundary value between curves of selection and the curves of the true catch is represented in the Danish landings by the length of 26 cm. We see from such comparison, that the Danish landings from the North Sea are very similar to the German, (steamers

Table 6. Composition of the landings of plaice by cutters from the North Sea at the port of Esbjerg for the three years 1904 to 1906.

Year	Total of landings		Average weight in grammes	Percentage of total number (<i>n</i>) and of total weight (<i>w</i>) under cm:								Range in cm.	Cm Interval of	
	Weight in kg.	Estimated number			23	25	26	29	31	36	51		Mode D.	Median C.
1904				<i>n.</i>	0.5	3.5	16	70	88	99	100	22—45	26	27
—1906	9,598,798	41,916,149	229	<i>w.</i>	0.002	2.4	9	59	81	98	100		27	28

The principal values of the total-series for number (*n*) and weight (*w*) are as follows:

	D.	Q.	M.	Q.	D.	V.
cm. <i>n</i>	25.53	26.47	27.70	28.47	31.38	32.64
cm. <i>w</i>	25.89	26.86	28.35	30.30	32.43	33.88

and sailing ships combined) both as regards the average weight of the plaice, and the composition according to the various size-classes. There is this slight difference however, that the Danish plaice are somewhat smaller, and that the very large fish of over 45 cm. are entirely wanting. The latter is however probably only apparent, inasmuch as these large plaice, though not found in the samples measured, may still have been present in the actual landings in certain quantities: it may also partly be due to the fact that the winter catches, of January and February, which in Germany contain especially large plaice, do not occur at all in Denmark. Hence we arrive at the further conclusion, that the German and Danish plaice landings from the North Sea are, as regards the original catch taken out at sea, of the same composition, and only differ as a result of the selection exercised by the different size-limits. This original similarity is also to be expected, since the German and Danish fishery is carried out in the same regions of the North Sea, i. e., its south-eastern parts.

The Danish plaice landings from the North Sea thus render it possible to approximately determine what alteration would take place in the German landings from the south-eastern North Sea if the legal size-limit in Germany were raised from 18 cm. to 25.6 cm. This calculation shows that in such case, about 50 % of the number, and 40 % of the weight of the plaice in the German landings could not be landed. And the average weight of the plaice would increase from 160 gr. in the landings with a size-limit of 18 cm. to 233 gr. with the higher size-limit, or, roughly, from 4 kg. per score to 5 kg. per score. This increase in the size and weight would in Denmark, according to JOHANSEN effect an increase in price of from about 35 pfg. per kilo to 46 pfg. Part of the loss in number and weight would thus be compensated by the increased market value: while the weight decreased from 100 to 60, the value of the catch would fall only from 100 to 80.

The Danish plaice landed from the south eastern North Sea are certainly a far better and more regular article of consumption than the corresponding German landings. The average weight of the fish is nearly half a pound (233 gr.) as against 160 gr. in

Germany, and the average length 28 cm. Half the total number of plaice lie between the lengths of abt. 26 and 28 cm. and half the weight between 27 and 30 cm., whereas the corresponding figures for the German landings are abt. 22 to 27 cm. and 24 to 30 cm.

The Danish plaice landings from the *Skagerrak*, which are mostly brought in to Frederikshavn, and are likewise subject to the size limit of 25.6, are, on an average, composed of larger plaice than those from the North Sea. The size-limits are, according to the measurements for the years 1904/07, 24 to 70 with an average length of 33 to 34 cm. and an average weight of abt. 380 gr. The maximum, or value of greatest density of the measurement series, is at 32 cm., the median at 33 cm. Plaice under 29 cm., the so-called small plaice, here amount to only 10 % in number of the total, as against 70 % in the North Sea landings.

The Danish plaice landed from the Northern and Middle *Kattegat* are also larger than those from the North Sea, but considerably smaller than those from the *Skagerrak*. They measure from 23 to over 60 cm., with an average length of 29 to 31 cm., and an average weight of 280 gr. In the landings from the northern *Kattegat* about 42 % are "small" plaice under 29 cm. long. The average quantity of the landings from the *Skagerrak* and the Northern and Middle *Kattegat* (in Frederikshavn) amounts to about 3.5 million kg. i. e., as much as the landings from the North Sea in Esbjerg.

Landings of plaice in Scotland.

The quantity of plaice taken by Scotland from the North Sea ranks, in point of weight, below that of all other states bordering on that water, with the sole exception of Belgium: it amounted in 1908 to only about 1,825,000 kg. or about one-seventeenth of the English landings, and only a quarter of the Dutch, or half the German yield. The *value* of the plaice landed in Scotland is however relatively very considerable, exceeding that of Germany and Denmark, approaching that of Holland, and amounting to one-eleventh of the value of the English landings. This is due to the fact that the Scottish plaice fishery in the North Sea is carried on almost exclusively in its northern waters, and thus yields fish of a greater average weight, the market value of which is considerably higher per kilogramme than that of the small plaice landed from the southern North Sea. The great majority of plaice landed in Scotland are taken by the trawl, a smaller quantity being caught by means of lines. The trawlers are for the most part steamers, but include a smaller number of sailing vessels.

The chief port for the plaice landings from the North Sea is *Aberdeen*, which takes about 50 % of the total quantity. The Scottish plaice fishing grounds in the North Sea extend from Lat. 61° N. southward to the Dogger Bank, and eastward to Long. 8° E. The catch statistics for Aberdeen divide the grounds as follows: *Northern Grounds*, north of Lat. 59° N. which include the greater part of Areas F and G, and part of D₃ according to the international division of the North Sea; the *East Coast Grounds*, directly off the coast of Scotland from the Orkneys to the Firth of Forth, chiefly Areas C₁, D₁ and parts of E, the *Middle Grounds*, being the greater part of Areas D₂, E and parts of F, and finally the *Southern Grounds*, or Areas C₂, B₅, and parts of B₁ and B₄. Of these

the Northern Grounds furnish about 54 %, the East Coast Grounds 28 %, the Middle Grounds 11 % and the Southern Grounds 7 % of the total weight of the plaice landed in Aberdeen.

Since the year 1907 a great number of weighings and measurements of plaice have been carried out in *Aberdeen*. As however only a small part of the results of these measurements have yet been published, we are unable to gather any satisfactory knowledge as to the composition of the Scottish plaice landings. We can however give an estimate of the approximate weight and number of plaice annually landed at Aberdeen for the four regions referred to and for the whole district.

Table 7. *Estimated weights and numbers of plaice landed in Aberdeen from the North Sea. (Average of the three years 1905 to 1907).*

District		Landings arranged in market classes			Total landing	Average weight in kilos	Percentage of market classes			Percentage of the district to the whole
		large	medium	small			large	medium	small	
I. Northern Grounds	kg. no.	90,267 37,611	298,083 354,861	24,517 72,109	412,867 464,581	0.888	22 8	72 76	6 16	75 72
II. East Coast Grounds	kg. no.	15,383 8,226	171,767 272,630	24,017 70,638	211,167 351,494	0.601	7 2	81 78	12 20	13 16
III. Middle Grounds	kg. no.	8,833 3,997	74,450 86,570	1,633 3,983	84,916 94,550	0.898	10 4	88 92	2 4	7 7
IV. Southern Grounds	kg. no.	6,300 2,739	39,983 54,166	4,133 16,052	50,417 72,957	0.691	13 4	79 74	8 22	5 5
North Sea	kg. no.	120,783 52,573	584,283 768,227	54,300 162,782	759,366 983,582	0.772	16 5	77 78	7 17	
Average weight of market classes		0.2297	0.760	0.334						

From this we see, firstly, that the market classification in Aberdeen is quite different to that employed at the English fishing ports: the average weight and average length of the plaice are considerably higher for all three market classes — large, medium and small — in Aberdeen than in England. The "small" class in Aberdeen for instance, corresponds more or less exactly to the Grimsby "medium". Such small

fish as those which constitute the Grimsby "small" plaice are rarely seen in Aberdeen; only occasionally, as in the autumn from 1905 to 1909 do some small steam trawlers fish dense shoals of small plaice in their third and fourth years quite near the East Coast; fish which could be classed as "young fish" or undersized plaice. These small plaice are then designated "extra small". In the second place we see, that the average weight of the plaice in all four of the regions as here defined, is very high, equalled only in the English landings by that of the areas C₁, B₁, D and E. The East Coast Grounds have the lowest average weight: 600 gr. per fish, which corresponds fairly exactly with the average weight obtained by the English measurements for Area C₁ — the area which practically corresponds to the region of the East Coast Grounds. On the Southern, or rather South Eastern Grounds, the average is higher, about 700 gr. and lies approximately equidistant between the average weights of the English landings from C₁ (abt. 530 gr.) and from B₁, D and E (abt. 830 gr.). These Southern Grounds include chiefly the northern parts of the areas C₂ and B₁, with small parts of B₅ and B₄. And correspondingly, the size of the plaice from these waters is considerably lower than that of the fish from the Dogger Bank. The Middle and Northern Grounds have the highest average weight of nearly 900 gr. These grounds include the areas D₂, D₃, E, F and G; the English plaice from these areas are however smaller on an average, probably owing to the fact that the Scottish catches are generally taken in more northerly waters than the English hauls.

Although it is not yet possible to satisfactorily apportion the Scottish landings from the North Sea to the various international areas, we can yet state with certainty that the composition of these is similar to that of the English landings from the northern North Sea with the particular modification however that the Scottish plaice are somewhat larger still than the English.

Thirdly, we see from the table, that the composition of the Scottish landings of plaice is mainly determined by the Aberdeen market-class "medium". This class includes plaice of from 23 to 70 cm. in length, having an average weight of abt. 760 gr. and amounts, in these four regions alone, to about 72 % to 88 % of the weight, and 74 % to 92 % of the number. This determining influence of the "medium" class is further shown by the fact that the average weight of the total landings of plaice from the North Sea in Aberdeen is almost the same (abt. 770 gr.) as that of the "medium" class, (760 gr.). According to the Aberdeen market measurements, the median of the "medium" class is at about 41 cm., and, as the total landings from the North Sea show abt. 78 % medium, 5 % large and 17 % small, i. e. more small than large, the median of the total landings must be reckoned at something under 41 cm., probably about 38 cm. Such a median we find in the English landings approximately from the areas B₁ and D. This permits us perhaps to suppose, that the total landings from the North Sea in Aberdeen are similar in composition to those of the areas B₁ and D. Thus the number of "undersized" plaice, under 25 cm. would not exceed 5 % at the outside, probably not more than 1 % or 2 % and that of the "small" plaice, under 29 cm. probably only 4 % or 6 % of the total quantity.

It is thus clear, that the question of the destruction of young undersized plaice and protective measures to prevent same are of no importance as regards the Scottish fishery when compared with the fishery in the southern North Sea.

Table 8. *Size and composition of the annual landings of plaice in all countries from the North Sea.*

Country	Quantity of plaice landed		Average weight in grammes	Of which under 25 cm. long			
	kg.	number		Percent		absolute	
				kg.	no.	kg.	number
England	29,000,000	112,500,000	259	14	32	4,060,000	36,000,000
Germany	2,480,000	14,000,000	177	31	47	768,800	6,580,000
Holland	7,500,000	53,600,000	140	49	66	3,675,000	35,376,000
Belgium	1,400,000	7,150,000	196	21	39	294,009	2,788,000
Denmark	3,200,000	13,967,000	229	2.4	3.5	76,700	488,700
Scotland	1,800,000	2,331,000	772	0.6	3	5,400	69,900
	45,380,000	203,548,000	223	20	40	8,879,900	81,302,600

This table, which will, I trust, express without serious error the actual conditions, shows the present total annual landings from the North Sea at roughly 203 million plaice, which, with an average weight per fish of 223 gr., gives a total weight of about 45 million kilogrammes. About 40% of this number, and 20 % of the weight, are plaice under 25 cm. long, and less than 166 gr. — or $\frac{1}{6}$ th of a kilo — in single weight. The quantity of so called "large" plaice, of over 35 cm. long, can be estimated roughly at 6 % of the total number and 20 % of the total weight. The medium sized plaice of from 25 to 35 cm. will thus make up 54 % of the number and 60 % of the weight. The average age of a North Sea plaice of 25 cm. long can be estimated at $3\frac{1}{2}$ years; that of a plaice of 35 cm. at 5 years. From this it follows that only 6 % of all the North Sea plaice landed have reached an average age of over 5 years; 54 % are between $3\frac{1}{2}$ and 5 years old, and 40 % under $3\frac{1}{2}$ years old.

2. Size and composition of the catches actually made by the fishing vessels, but not brought to land complete.

The analyses of the actual catches of the trawling vessels — steamers and sailing ships — clearly show that the composition of the catch samples from most North Sea waters is different from that of the market samples. The catch-samples, or actual catches, contain as a rule a certain number of small plaice, which, on account of their small market value, or owing to the existence of a size-limit, are picked out by the fishermen and thrown overboard again. The relative quantity of these rejected fish in proportion to the market catch actually landed, varies greatly, according to the situation of the ground, and the time of year. It is naturally greatest where the most small plaice of little value are found, i. e., in the southern areas of the North Sea on the so-called

"young fish grounds", and there again greatest at such times as the densest shoals of these young plaice occur.

In order to obtain a more or less correct idea as to the actual quantity of young undersized plaice which are annually destroyed in the North Sea, it is necessary to compare the analyses of the scientific hauls with those of the market samples from the same water, and the same period of the year. These investigations have now been carried out to a certain, though not yet sufficient, extent.

It appears, that when a catch sample, by means of rejection of the small plaice of less value, becomes a market sample, the individual numbers of both will be inversely proportional to those percentages of same which were not affected by the selection. The portion not affected by the selection will consist of those parts of the measurement series which lie at or above the value of *greatest density* or *dividing value*, it being taken for granted, that the fishermen accept all plaice of this size and upwards, rejecting only those of smaller size.

By means of such a calculation we obtain the following figures, which show how many times greater was the rejected, unused portion of the actual catch than the portion landed and consumed (the latter being taken as 100). The value of greatest density or dividing value of the market samples in the areas with which we are here concerned, lies a rule between 24 and 25 cm. often still lower. It is obvious, that the number of rejected plaice will, *cæteris paribus*, be higher, the higher the dividing value lies. The height of this is again naturally to a great extent determined by the height of the legal or practically accepted size-limit. The figures here given are calculated from German and English investigations, and are thus subject to the influence of a size-limit of 18 to 20 cm.

Proportional relation of the number of rejected plaice to that of the fish landed, in a trawler catch.

Area	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Month
	100	100	100	100	100	100	100	100	100	100	100	100	Fish landed
A ₃			64	200	100	190	2400						Fish rejected
B ₄	12		112			250	250	250	450	180	13		
B ₃			41		35	360			550				
C ₃							41		25				

We see, that in the southern coastal areas A₃ (and in any case also A₂) B₄ and B₃, in the summer months from June to September, the number of plaice rejected and thrown away (most of them being from 10 to 20 cm. long) is generally from *twice to five times* as great as that of the plaice actually landed: it can, in exceptional cases, be twenty times as great, or more. In the winter months the number of rejected under-

sized plaice is very small, or nil, and the actual trawling catches contain at this time very few such fish, as these are then hibernating, and are not taken by the trawl. In Area C₂ the rejection is of very little importance, as the small plaice are very rarely seen here at all; in B₂ and C₃ it is somewhat more considerable; it occurs also in C₁, but can, for all the other areas, be regarded as nil.

At a rough estimate we can reckon, that in the areas A₂, A₃, B₄ and B₃, *from twice to three times* — at least twice — as many fish are annually rejected from the trawling catches, on account of this market selection, and for the most part uselessly destroyed, as there are landed. This means, for the whole of the North Sea, the useless destruction of about 300 million undersized plaice between 10 and 24 cm. long. The total number of plaice landed from the North Sea by first class vessels has been estimated at roughly 203 million yearly, of which 81 million measure under 25 cm. The total number of North Sea plaice actually caught in the trawl is thus to be reckoned at about 503 million per annum, ranging in length from 10 to 70 cm. Of these 300 + 81 or 381 million, amounting to 76% of the total number caught, are undersized plaice under 25 cm. in length, and from 1 to 3½ years old. Of these however, only about 16% are landed and turned to use, about 60% being uselessly destroyed. Of these 503 million fish, only about 12 million, or a little over 2%, are plaice over 35 cm. long, over 450 grammes in weight, and over 5 years old.

Composition of the hauls with regard to sex.

The male plaice are smaller than females of the same age, and are more numerous, in the first four years of life, than the females. In the first year of life the proportion of males to females appears to be abt. 60 : 40, in the following years the relative number of females increases, and from the 5th year of life they are more numerous than the males, and this the more according as the length of body increases. The very largest plaice are invariably female. In all probability, the males do not reach so great an age as the females. From this it is evident that the coefficient of mortality is greater among the males than among the females.

The males being more frequent in the first years than the females, but more rare later on in life, there must be a certain length at which both sexes are equally numerous. For the southern North Sea, taken as a whole, we can consider 24 cm. as being approximately the length in question, i. e., of all the plaice of 24 cm. in length in the southern North Sea, half are male and half female. In order to arrive at reliable figures, we must of course suppose that males and females were found, in the samples investigated, properly mixed together in the true proportion corresponding to each size. It appears however, that this is not the case, either with regard to time or place. In winter, especially in the spawning months from December to January, and on the spawning grounds for instance of C₃, the males are invariably more numerous in the landings, and still more so in the actual catches: they make up about 80% or more of the total catch. This has doubtless some connection with the fact that females under 35 cm. long are, in the southern coastal areas, as a rule not yet mature, while all males under 35 cm. have reached maturity; the greater part of the former hibernate,

but the small males which have reached maturity do not hibernate, and are thus caught in the nets. Owing to this superiority in numbers of the males, and the lack of small female plaice, the point of intersection of the male and female curves of frequency is raised considerably, and lies, as a rule, far above 25 cm. In the summer catches on the other hand, the females almost invariably outnumber the males, (by as much as 70% or more), and in particular we notice, that many small female plaice make their appearance in the nets, also in the southern areas. Thus the point of intersection of the curves is lowered considerably as against the winter, and lies for the most part between 20 and 24 cm. in the coastal areas; somewhat higher in the deeper waters.

The true numerical proportion can only be arrived at by comparison of the sexes in all places and at all times. In the southern North Sea we get abt. 50% male and 50% female for all the scientific trawl catches together, or, after deducting the small plaice of under 20 cm. in length, abt. 48% male and 52% female. In the German plaice landings for 1909, which are subject to the influence of a size-limit of 18 cm., of about 260,000 plaice 44% were male and 56% female. The true proportion in the English and German landings probably lies in the middle, and amounts to 46 : 54. If we add to the landings of plaice from the Southern North Sea the large numbers of fish which are rejected from the catches, which measure, for the most part, less than 18 cm., down to 10 cm., then the proportion of 46 : 54 of males to females would naturally be so considerably altered in favour of the males, that these would certainly become the more numerous. In the northern North Sea, as far as investigations are at hand from these waters, the proportion is in all probability different from that of the southern North Sea, at any rate, in the Scottish fiords, particularly in the Moray Firth. Of about 67,000 plaice from scientific catches, ranging in length from 10 to over 80 cm., 53% were male and 47% female; in the Moray Firth alone 54 and 46%. Of the Moray Firth plaice from 10 to 17 cm. in length 58% were male, and 42% female, which corresponds approximately to the proportion of the same sizes in the southern North Sea. Of the Moray Firth plaice of 18 cm. and upwards, on the other hand, 54% were male and 46% female, or considerably more males than in the southern North Sea. Still greater and more remarkable is the difference in the position of the point of intersection of the sex curves; this lies, for the southern North Sea, approximately between 20 and 28 cm., and for the whole at 24 cm., whereas the length of intersection in the Scottish fiords is about 37 cm.

These local variations in the numerical proportion of the sexes are in all probability of some importance as regards the question of overfishing.

3. The composition of the actual stock of plaice in the North Sea, and its probable absolute amount. How great are we to estimate the percentage of the plaice stock, by number and weight, which is taken yearly from the North Sea by the fishery?

It need hardly be said that it is of the utmost importance for a solution of the practical plaice question to have at least an approximate idea of the composition of the actual stock of plaice in the North Sea and the absolute size of same.

As regards the composition of the stock, this can only be arrived at by investigation of the so-called stock samples. These are catches made with such nets as are furnished with sufficiently small meshes as to ensure the capture of every size of plaice which is to be found at a certain spot. According to the experience gained from our scientific catches with various kinds of nets, the ordinary trawl is here sufficient for the purpose as far as regards the most of the central and all the northern areas of the North Sea: in the southern coastal areas on the other hand, nets of narrower mesh are required. Another question is, whether such stock samples, while satisfactory as regards the nets, can be considered as *representative* of the local stock of the place of capture at the time made; i. e. whether the various sizes are as thoroughly mixed in the sample as on the sea floor. On this point we can unfortunately say nothing as yet. Moreover, it must be borne in mind that the stock of plaice in the North Sea means the population of the whole of the North Sea, and not only that of a certain part. The stock of a certain ground (local stock) varies greatly according to the law of distribution of the plaice, and differs also at different times. In order therefore, to obtain series of measurements which can be regarded as more or less representative of the actual stock, it is necessary to take numerous samples from all parts of the North Sea and at all times of the year; these being, moreover, more numerous at such places and times, as the density of the plaice is greater. In other words, the samples taken from the different parts of the North Sea and at different times, must be proportional in size to the local and periodical density of the plaice. This is a demand which it is unfortunately impossible to satisfy at present: it could only be done by purely scientific catches, methodically distributed throughout the whole of the North Sea, and this could only be realised to a certain extent, for the bottom of the North Sea is in places so stony that it is impossible to use a trawl at all, although we cannot say that no plaice are to be found there, especially since the results of line fishing prove the contrary.

In the face of these extraordinary, and at present insurmountable difficulties, we are obliged for the present to remain content with a knowledge of the composition of the plaice stock in the North Sea which can only be considered as partially satisfactory, and in particular, it is impossible, until we have carried out more thorough investigations and employ better methods, to say anything with certainty as to the composition of the *younger* portion of the stock of plaice, (up to 25 cm. in length). We must be content to determine something about the *older* portion of the stock over 25 cm. And here we can in the first place be certain, that the stock-, catch- and market-samples of plaice of 25 cm. and upwards are equal in point of composition. The plaice landed in England from the North Sea (market samples) are evidently catches which fulfil, for the most part, the conditions 1) that the catches be numerous, and taken from all parts of the North Sea and at all times of the year, 2) that they be as far as possible proportional to the density of the local and periodical stock of plaice — since the fishery, pursued as a means of livelihood, would naturally fish the individual grounds in any sea as far as possible in proportion to the richness of the stock of fish.

The English market measurements will thus furnish us with the best possible knowledge at present obtainable as to the composition of the stock of plaice in the North Sea, (or rather, in the southern and central parts thereof, as far as these can be fished with the trawl). For several reasons however, the midsummer measurement series (i. e.

from July and August), rather than those for the whole year, will give us the best relative view of the stock of plaice in the North Sea; the various parts of the North Sea being at this time of year more or less equally fished by English vessels. There is however, no essential difference between the composition of the landings for the whole year and these summer landings. In this way the descending part of the curve of the English landings (see Fig. 1) should give us a picture, very inaccurate, no doubt, but to some degree approximate, of the composition of the stock of plaice in the North Sea, as far as concerns such parts thereof as can be fished with the trawl, and excluding the northern North Sea. In any case, we have at present no better.

As regards the probable *absolute size of the plaice stock* in the North Sea, various means may be considered as possible in order to arrive at an approximately accurate knowledge of same. In any case, it is here a question of determining the so-called *fishery coefficient*, i. e., that fraction of the plaice stock annually removed by fishing from the North Sea. The various methods here adopted are as follows:

1. The method of determining, by quantitative catches with the vertical net, the number of drifting *plaice eggs* annually spawned in the North Sea. From the number of eggs annually spawned by the female plaice we arrive at the number of females, and from the number of mature females we can again, with the help of the composition of the plaice stock with regard to males and females of various sizes and degrees of maturity, (which is presumed to be known) arrive at the absolute number of plaice of a given length which are annually to be found in the North Sea. This method, which has been employed by HENSEN, appears theoretically feasible, but presents in practice so many and serious difficulties, that no positive results of real value have as yet been obtained.

2. *Determination of the fishing coefficient by means of marked plaice.* The experiments with marked plaice, which have been extensively carried out in the North Sea since 1902, can be compared to experiments made with a ballot-box, containing a very large number of white balls and a very small number of black (or marked) all mixed together. If the latter are equally distributed among the white balls, and many lots of balls then taken at random from the box, the proportion between the white and black balls shown by the average of all the samples will be same as the proportion in the total contents of the box. In other words, the white balls drawn will stand in the same proportion to all the white, as the black balls drawn to all the black. The total of white balls here represents the entire plaice stock of the North Sea, the number of white balls drawn answering to the number of plaice caught each year, while the total number of black balls corresponds to the number of marked plaice set free at the beginning of the year, the black balls drawn representing those recaptured at the end of that period. The former divided into the latter gives the percentage of marked plaice recaptured in the course of a year, and this again is equal to the percentage of all those plaice in the North Sea which can be taken by the trawl, which are caught in the course of a year: this is the *fishing coefficient*.

Experiment has shown, that of about 27,000 marked plaice set free during the years 1902 to 1908 in the North Sea, about 6,000 plaice, or roughly 22 %, were recaptured within a year of their liberation. Thus the average fishing coefficient in the North Sea for the years 1902 to 1908 can be taken as 0.22.

The value of this fishing coefficient, obtained from the marking experiments of all

countries, is only qualified. It would be greater, the more numerous were the marked plaice liberated, and especially, the better these were distributed over the whole of the North Sea, and that in a way corresponding to the local and periodical density of the plaice stock. This has however, only to a certain extent been the case: the greatest number of marked plaice were, it is true, set free in those areas having the greatest density of plaice population, i. e., in the southern shore areas, but this was done, for the most part, in large numbers only at certain points in a very large district, and in quantities which were infinitesimal when compared with the great mass of the plaice stock; moreover, they were often liberated at places and times at which a very intensive fishery was being carried on. The regular distribution of the marked plaice throughout the North Sea, as demanded by the nature of the experiment, and so necessary for obtaining reliable average values, thus suffered considerably. It is probable that in most cases, and especially where large numbers of plaice have been liberated at once at a certain spot, they have been found, when recaptured, in too great relative density. This would make the fishing coefficient appear higher than it really is, and the figures 0.22 are in this respect probably *too high*. On the other hand, there are a whole series of circumstances which can and will reduce the fishing coefficient to below the normal value: first of all the fact, that a certain number of marked plaice, although recaptured, are not delivered up as recaptured fish, and do not appear in the list of marked fish retaken; also, as can be shown, a marked fish may sometimes lose its mark, and finally, a certain percentage of the marked plaice liberated die sooner or later in the course of the first year, without being caught; their death being no doubt to some extent due to the fact that they have suffered somewhat from being taken in the trawl in the first instance, and have less vitality when set free. The loss thus caused among the liberated plaice by these circumstances which prevent their recapture must be regarded as considerable; it is even probable that the coefficient of mortality is greater than the percentage of fish recaptured. It is certain, that from this point of view the fishing coefficient of 0.22 must be regarded as *a minimum*, and will in reality be higher; how much, it is difficult to say. I am of opinion that the average fishing coefficient of the North Sea, i. e., for the entire stock of plaice, can be presumed to lie between the limits 0.20 and 0.40, with the most probable value 0.30 or 0.33. It must however be borne in mind, that this fishing coefficient only applies to those sizes of fish which are caught by the ordinary trawl, and as used for the marking experiments, i. e., from abt. 12 cm. long and upwards.

3. *Determination of the so-called catch coefficient of the ordinary trawl*, i. e., that percentage of the plaice actually to be found on any part of the sea-floor, which is taken by a single haul of the net over that ground. This investigation is a modification of the determination of the annual fishing coefficient of the North Sea. A large number of marked plaice are distributed, as equally as possible, over a small, measured and limited plaice-ground (of from one to two nautical square miles in extent), i. e., mixed with the plaice already present on the ground. The experimental ground is then immediately fished by a steamer using the ordinary trawl, moving at the rate of speed usual for fishing vessels, and working the ground, as equally as possible, in a series of hauls. Presuming that the trawl here fishes each hour an approximately equal area of the sea-floor (area of normal trawling hour) we can then calculate the proportion of the

area covered in a single haul to the whole of the experimental ground, and thus also the proportion of the plaice actually caught to those which should be present in the area fished. This proportion is then, according to the analogy of the well-known ballot-box experiment, the desired *catch-coefficient* for single hauls. According to the few experiments which have been carried out in this direction (in Germany near Heligoland) the coefficient of the ordinary trawl appears to be on an average about 0.25. It must however be borne in mind that the difficulties in the way of obtaining reliable average values by means of these experiments are manifold and serious, and we must reckon with at least as wide a margin to either side as in the case of the fishing coefficient calculated from the marking experiments.

If it were possible to determine how often, on an average, each single area of workable ground in the North Sea is fished by the trawl; whether once, twice or more often, we should then have a means of calculating, from the catch-coefficient of single hauls, a coefficient for the whole of the fishery. It is however, unfortunately impossible as yet to calculate the extent of the fishing of the North Sea grounds with any degree of reliability. The remarkable similarity between the size of the catch and fishing coefficients would seem to suggest that each piece of practicable fishing ground in the North Sea is *only once* fished by the net in the course of a year; since this would give a catch coefficient equal to the fishing coefficient. On the other hand, the enormous number of first class trawlers now working the North Sea, and which may probably be reckoned as fully 2,000, and the great number of trawling hours they represent per annum, tend to show that each part of the North Sea is fished *more than once* a year by the net, possibly twice or even more often. In such case the fishing coefficient would be higher than the catch coefficient. Closer investigations upon this point are very much to be desired; in the meantime I am inclined to suppose that the fishing coefficient is probably higher than the catch coefficient, but not more than twice as high.

4. *Determination of the coefficient of mortality of the plaice stock.* This coefficient of mortality is to be considered as represented by that percentage of the stock of plaice which dies each year. By "dying" is here understood, being caught, eaten, dying of illness, or by any other natural means. The coefficient of mortality will thus in any case be higher than the fishing coefficient, and its height will always form the maximum limit of the latter. The coefficient of mortality of the stock could be calculated, if the composition in point of number of same, as regards plaice of the different age-classes, were known. Supposing that the size of the whole stock, and its composition, remain unaltered for several years in succession, then as many plaice must die each year as there are annually born. For a portion of the stock, e. g., for a series of successive age-classes, the coefficient of mortality corresponds to the percentual number of the first of these age-classes; if, for instance, the plaice in their fifth year amount to 47 % of all the plaice over 4 years old in the whole stock, then the coefficient of mortality of these plaice over 4 years old is 0.47. According to the explanation given on p. 45, we still lack the greater part of the knowledge as to the composition of the plaice stock, which is necessary for such calculations; we can only estimate it approximately for the classes of over 25 cm. long and over 3½ years old, and this, for the present, only on the basis of the English market measurements. From these we have the coefficient of mortality just quoted, 0.47 for plaice over four years old. For that part of the stock which includes plaice

over 5 years old, i. e., fish over 35 cm. long, or the so-called "large" plaice, we get a coefficient of mortality of 0.43, for plaice of over 6 years old (over 40 cm. long) likewise 0.43. It is, unfortunately, impossible to make further estimates of any degree of reliability, our knowledge as to the composition of the stock being insufficient. And in particular, it is unfortunately impossible at present to estimate the coefficient of mortality of that part of the plaice stock which includes fish of about 12 cm. long, or from the completion of the second year of life; those which are taken by the ordinary trawl, and upon which the fishing coefficient thus depends. We can only, with the aid of the composition of the scientific hauls, get an approximate idea as to the height of the coefficient of mortality for plaice of 20 cm. and upwards, i. e., plaice of an average age of over three years, or all plaice from the beginning of the fourth year upwards. This coefficient of mortality I estimate at about 0.70. It may be considered as certain that the coefficient of mortality for that part of the stock which is subject to trawl fishery, and which falls between the limits stated above, from the third year of life upwards, is considerably higher than 0.70, perhaps 0.80 or even more.

These few possible determinations of the coefficient of mortality prove however, with certainty, that the coefficient is higher, the more fish of the younger age-classes are contained in the part in question of the stock; in other words, the small plaice under four years old have a considerably higher mortality than the older fish. This can to a certain extent be due to the fact that the small plaice have more enemies than the larger fish, partly to the fact that they are fished with greater relative intensity, or to both causes. The first reason appears to be sufficiently obvious, and is very probably the case; the second is possible, but not yet supported by results of marking experiments. In any case, the more or less reliable approximate coefficients of mortality obtained can be regarded as the *maximum* possible fishing coefficient for the same age-classes of the stock. We can thus probably say with certainty that the fishing coefficient for the stock of plaice over four years old is in any case less than 0.47, and for plaice over three years old less than 0.70, for fish over two years of age less than 0.80. It is however at present quite impossible to say how much less; we do not know in what proportion the plaice which die a so-called natural death stand to those which are destroyed by man, nor which of the two classes is the greater. As long as we know nothing positive on this point, we may be allowed to consider both as equal. We thus obtain, for the stock of plaice over two years old (12 cm. long) which are to be considered from a fishing point of view, a fishing coefficient of 0.40, calculated from the coefficient of mortality 0.80.

The various methods here employed for obtaining a reliable fishing coefficient, and thus arriving at some calculation of the true size of the stock of plaice in the North Sea give us, for the present, the following results:

The North Sea trawl fishery is concerned with that part of the stock of plaice which includes fish of two years old and upwards (about 12 cm.). Of this portion of the stock between 20 and 40 % in number are probably taken each year by the trawl; on an average perhaps 30 or 33 %. This total trawling catch of North Sea plaice of 12 cm. and upwards we have already (see p. 43) estimated at 503 millions, of which about 203 million fish are brought to market. The total stock, in those parts of the North Sea which can be fished by the trawl, of plaice of the same sizes, i. e., from the

third year upwards, would thus amount to from 1257 to 2515 millions; probably, (with a fishing coefficient of 0.33) 1509 million fish. If we calculate the plaice-fishing area of the North Sea at roughly 300,000 sq. km. (a somewhat uncertain estimate) we get an average of 5,000 plaice for each sq. km. area in the North Sea. If we estimate the average area fished by a trawler in an hour at roughly 100,000 sq. m., we get ten trawling hours per sq. km., which gives 500 plaice per trawling hour area, or 5 per 1000 sq. m. or one plaice per 200 sq. m. Supposing the fishing coefficient to be 0.40, we should then get 420 plaice to the trawling hour area, or 4.2 per 1000 sq. m. or one plaice per 240 sq. m. As the research steamers have, in the shore areas during summer, taken up to 2,500 plaice from about 10 cm. long and upwards per trawling hour, then these extreme cases would, if we accept the catch coefficient based on the experiments mentioned on p. 47 viz., 0.25, give an occasional actual density of the true stock of 10,000 plaice per trawling hour area, which would thus be about twenty times as great as the average. Against this greatest possible density we have, in certain parts of the Northern North Sea, a minimal of 0 plaice for a whole series of trawling hours.

All these estimates and calculations as to the actual size of the stock of plaice in the North Sea are evidently very uncertain, since most of the factors in the calculation are not yet fixed, and of only very varying approximate value. I am, however, of opinion, that the figures here given are at present the only ones which can make any claim to a certain scientific value.

III.

Are any signs apparent of an actual overfishing or essentially increased tax on the plaice stock of the North Sea through the increased fishing?

1. *The decrease in the number of large and increase of small plaice in the catches as a probable sign of permanent alteration effected in the composition of the stock of fish.*

The results of the international investigations on this point are as follows:

It is impossible to know the real alterations which have taken place in the stock of plaice in the North Sea since the introduction of more intensive fishing by means of the trawl, since we know nothing of the composition of the stock of plaice in earlier years, and but little of that of the present stock. Even as to the composition of the landings of plaice by market classes we only possess exact information as to the last twenty years, and material which can really be used for purposes of comparison is, as a matter of fact, only to hand for the past ten years, since the beginning of better catch statistics. In a period of so few years, however, casual phenomena and other factors

which in reality have nothing to do with any actual alteration of the stock and landings, play too great a part to permit of our drawing reliable conclusions. In spite, however, of these difficulties in connection with the investigation of this problem, we can regard the following as certain.

The quantity in weight of *older and larger* plaice from about 45 cm. upwards has, since the introduction of more intensive trawl fishing in the North Sea, *decreased* considerably, not only relatively, but also absolutely. The relative decrease is shown by the fact, that the percentage in weight of large plaice in the landings has more or less regularly decreased, while that of the small fish has correspondingly increased. And that an absolute decrease exists is evident from the fact that the percentage continues, although the total quantity in weight of plaice landed has not decreased at all, but even increased. This absolute decrease of the weight per cent must be equivalent to an absolute reduction in the numbers of the largest and oldest plaice. As a matter of fact, the experience of all the North Sea fishermen during the last 20 or 30 years shows, that such plaice are, in comparison with former times, now rarely if ever caught. Especially characteristic in this respect are the catches of the Danish plaice fishery. Whereas formerly, before the introduction of intensive fishing by means of the "Snurrevaad" from larger vessels, i. e., in the 70's and 80's, plaice weighing 20 to 45 kg. the score, or of 50 cm. and upwards in length, made up an essential portion of the catch, scarcely any such are caught now. This absolute decrease of the large plaice means, with the same total weight of whole catch, besides a relative, also an absolute increase in the numbers of the small plaice. The simple explanation of this is, that the loss suffered by the fishery yield owing to the decrease of the large plaice is being compensated by an increased capture of small plaice. That the average weight of the plaice in the landings should also have decreased is easy to understand, and is also confirmed by experience in those places where corresponding catch statistics are kept, as for instance in Denmark. There can be no doubt, that the decrease of the large plaice and increase of the small in the landings, and the corresponding reduction in the average size of the plaice are a *direct result of the more intensive fishing* and indicates, at the same time, an actual alteration in the composition of the plaice stock. The largest and oldest plaice — or as PETERSEN expresses it, *the old accumulated stock of same* — have been fished away, and are scarcely likely to be replaced, as long as the present intensive fishing continues.

2. Though it is an undoubted fact, that the composition of the original stock of plaice is being permanently altered by the intensive fishing, it will yet be asked, on the other hand, whether there are any certain signs that *the size of the plaice stock has simultaneously decreased in number and weight*. In nearly every one of the countries which fish the North Sea it has proved, that with the increased intensity of the fishing, as evidenced by the increased number of fishing vessels, as well as their increase in size, and the added catching power of the nets, the weight of plaice taken per unit of catch — trawling hour, fishing day, cutter day — has on the whole continually decreased. This is however, in itself no strict proof that the density of the shoals of plaice has decreased owing to the more intensive character of the fishing; the phenomenon could also be explained by the fact that in fishing a stock of plaice of a certain constant size, the quantity of fish falling to each unit is inversely proportional

to the number of units; or, in other words, the single catches which compose a constant total catch will be smaller and more numerous the greater the number of the fishing vessels and their fishing days (units of capture). For instance, the average catch per cutter day of the cutters from Esbjerg fishing in the North Sea has decreased from 564 kg. in 1897 to 254 kg. in 1908; fishing was however only carried on in 1897 for 2313 cutter days, as against 8418 in 1908. During the first of the mentioned years these cutters took 1,305,660 kg. of plaice from the stock of the North Sea, in the last-named year 2,130,172 kg. Given a constant stock and constant and equal encroachment upon the stock, then the yield per cutter day would have decreased from 564 kg. in 1897 to 155 kg. in 1908. The stock has thus, with the increased intensity of the fishing, been more severely (about 1.6 times) encroached upon. Such an absolutely more intensive fishing of the stock can possibly, if continued for some considerable time, lead to an absolute decrease in same. This would be shown by the fact that the increase of the yield which took place with the increased absolute intensity of the fishing, became less in course of time, and finally only slightly noticeable, if at all, in spite of the utmost exertions on the part of the fishery. This is as much as to say, that the yield of the fishery is now no longer, as was formerly the case, merely the interest on the capital represented by the stock of plaice, but already contains a portion of the capital itself.

Various signs seem to suggest that our fisheries in the North Sea, as far as they are carried out by means of the trawl, and in particular the plaice fishery, have already reached the point just referred to, and *that an actual reduction of the stock of plaice has thus already commenced.*

It is very probable then, that the shoals of plaice in the North Sea are not so dense as heretofore; the larger and older plaice are much more rare, and thus also the average in age, weight, and size have been reduced. And it is equally probable that all this is a result of the intensive trawl fishery, dating from the commencement of same.

3. Though it is unfortunately impossible to learn anything about the composition of the landings of plaice from the North Sea at a time when the fishing of this sea was not yet so intensive as now, we can yet do so with regard to certain *sea districts outside the North Sea*, which have only of late years been fished at all, and which, in comparison with the North Sea, can still be regarded as virgin fishing grounds. We may therefore also consider the plaice stock on such grounds as being more in its original condition than is the case with the North Sea. A comparison of the composition of such stocks, which have only of late been fished, with one which has for a long time been subjected to intensive fishery, may perhaps throw some light upon certain alterations in the stock which may be regarded as due to increased fishing.

First in this respect come the *fishing grounds of Iceland*. A comparison of these grounds with the North Sea is the more valuable for our purposes, since the Iceland plaice, while a distinct race, yet resemble in racial characteristics the plaice of the North Sea, especially the so-called northern plaice; moreover, and this is especially valuable, the investigations as to the age of the Iceland plaice have shown that they do not differ essentially in this respect from those of the North Sea; Icelandic and North

Sea plaice of equal size being of approximately the same average age. In any case, the Iceland plaice are not younger than North Sea plaice of the same size.

The material at our disposal for purposes of comparison consists of German market measurements of Iceland plaice from the year 1909, carried out with about 27,000 plaice during all months of the year.

The composition of these German plaice landings from Iceland calculated for the whole of the year 1909 is as follows:

Table 9. *Composition of the German plaice landings from Iceland for the year 1909 and the English from the North Sea for 1906/1907.*

Year	Total of landings		Average weight in kilos	Percentage in number under cm:						cm. Interval of		Range cm.
	Weight in kg.	Estimated number		25	26	29	31	36	51	Mode D	median C	
Iceland 1909	304,774	466,490	0.653	1	2	8	16	50	94	33	35	19-74
North Sea 1906/07	30,750,713	121,869,899	0.252	34	44	67	78	91	98.5	24	26	15-76

Thus the plaice in the landings from Iceland are considerably larger than in those from the North Sea. This does not, however, prove anything with regard to a difference in composition between the two stocks of plaice, but merely expresses the fact that the small plaice under 25 cm. long, which play a considerable part in the North Sea landings, are scarcely ever landed from the Iceland fishing grounds, although they are certainly to be found there, and are no doubt also caught. It does not pay the Iceland steamers to bring these small fish in, evidently because plaice of large and medium size are to be had in relatively considerable numbers. The predominant size-class in the Iceland plaice landings, which makes up 50 % of the total number, lies between 32 and 41 cm. being thus medium plaice in the terms of our fish markets. "Large" plaice in our acceptance of the term, i. e. over 35 cm., amount in the landings from Iceland to about 57 %.

For the purposes of comparison between the composition of the stock of plaice in Iceland waters and that of the North Sea stock, we are only concerned with that part of the series of measurements lying above the value of greatest density of the Iceland series, i. e., 33 cm. Compared thus, we see that plaice from 35 to 54 cm. which are, on an average, from 5 to 11 years old, are of equally frequent occurrence in both waters. Plaice from 55 to 59 cm. long, averaging from 11 to 15 years old, are somewhat more numerous in the Icelandic waters, while the oldest plaice, from 15 to 25 years old and upwards, measuring 60 cm. or more, are in the landings from Iceland about three times as numerous as in those from the North Sea. Here it must be borne

in mind, that according to the general experience, about 20 years ago, when steam trawling was commenced, these very large and old plaice were caught in much greater quantity, both relative and absolute, than is now the case. The extremely intensive fishing of the Iceland grounds, which are of very restricted extent, has evidently already eliminated a great part of the superfluity of large, old plaice, the so called accumulated stock, and reduced the composition of the stock to something similar to that of the North Sea. There can however be no doubt, that the Icelandic plaice even now reach a greater age than those of the North Sea, which is evidently a sign of more primitive conditions prevailing.

If we examine the composition of the landings from Iceland with regard to sex, and compare with the conditions in the North Sea, a greater and very remarkable difference is noticed, viz., an extraordinarily large majority of males as compared to females. Of 11,675 Icelandic plaice examined with regard to sex, not less than 70 % were male, and only 30 % female; a proportion which, at least in the southern North Sea, is only found on the spawning grounds at spawning time, otherwise males and females are as a rule caught there in equal numbers. In the northern North Sea, as far as investigations have been carried out, e. g., in the Moray Firth, we find that somewhat similar conditions to those of Iceland waters prevail, the males here outnumbering, from 18 cm. upwards, the females in a proportion of 54 : 46. If we compare, as is most correct, only the higher parts of the series of measurements from 33 cm. and upwards, which is the value of greatest density in the Iceland series, then the proportion in number of male and female plaice of 33 cm. and upwards in the North Sea about 40 : 60, in Iceland waters 66 : 34. Among plaice of 40 cm. and upwards we have for the North Sea 18 : 82, for Iceland 47 : 53, while plaice of 50 cm. and upwards, i. e., abt. 9 years old or more, appear in the proportions of 10 : 90 for the North Sea, and 30 : 70 for Iceland. *Thus we see, that in Iceland waters a great many more males reach an advanced age than is the case in the North Sea.* Of all male plaice over 32 cm. in the North Sea, only about $1\frac{1}{2}$ % reach a length of 50 cm. or more; in Iceland waters about 4 %. Of females of the corresponding size class in the North Sea about 8 % reach a length of 50 cm. and more, in Iceland waters about 25 %.

The male plaice thus reach a considerably larger size on the Iceland fishing grounds than in the North Sea, and naturally also a correspondingly greater age.

A further, and very characteristic difference in the proportions of the sexes in the North Sea as compared with Iceland is the fact that *the point of intersection of the curves of sex for Iceland occur at a considerably higher length than for the North Sea.* In the southern North Sea this point of intersection, i. e., the length at which male and female appear in equal numbers, is about 24 cm., in the Scottish fiords about 37 cm. and for Iceland about 44 cm.

It is probable that these remarkable differences between the plaice stock of the Iceland fishing grounds and that of the North Sea with regard to the proportions of the sexes, indicate that the Iceland stock is in a more primitive and natural state, that of the North Sea being more strongly affected by fishery. When a primitive, little fished stock is so intensively fished that a decrease in the density, i. e., an absolute reduction in the size of the stock takes place, and when this is chiefly due to the fact that the older fish are taken in relatively greater quantities than the small, which is

certainly the case on commencement of more intensive fishing, then necessarily, as can be shown, the number of males will show a greater decrease than that of the females (since the larger males are, to begin with, fewer and older than females of equal size) and not only this, the point of intersection of the male and female curves of frequency will fall to a lower length.

The fishing grounds of the *White Sea*, or rather, the *Barents Sea*, have only been fished by trawlers since 1905, and yielded in the beginning, as also now, relatively (i. e., per unit of fishing power) great quantities of very large plaice. The measurements which up to now have been carried out with these plaice are unfortunately only few in number, only a little over 11,000; they show the following composition of the catches.

Table 10. Composition of measured plaice from the Barents Sea.

Number measured	Percentage under cm:						Interval		Range cm.
	25	26	29	31	36	51	D.	C.	
11,129	0.04	0.08	0.7	2	11	89	41	42	23 — 73

We see, that far more large plaice are landed from the Barents Sea than even from the Iceland waters; whereas the Iceland plaice show 50% over 35 cm. we have here no less than 89% of this size. It must, however, be born in mind, that in the Barents Sea, as in the case of Iceland, small plaice are also to be found, and must be found, in quantities, since the Barents Sea is a separate plaice region for itself, and moreover with distinct local racial character. The most prominent racial characteristic of the Barents Sea plaice is, that it is an extremely slow-growing race; i. e., the fish are considerably older than North Sea or Iceland plaice of equal size. According to the determinations of age by the bones, which have been carried out in Germany, the Barents Sea plaice, for instance of 40 cm. long, are already on an average 15 to 20 years old, while North Sea and Iceland fish of the same size are on an average only 6 years old. Plaice from the Barents Sea over 50 cm. long are almost invariably more than 20 years old and some of the fish examined had reached an age of from 45 to 50. In the North Sea and Iceland waters, plaice of 50 cm. are fish of 8 years old and upwards; the oldest of the North Sea plaice examined were from 30 to 33 years old.

The plaice from the Barents sea resemble, in this racial characteristic of slower growth, to a remarkable degree the fish of the Baltic, and especially the eastern Baltic: there also we find plaice of 40 cm. at an age of 20 years or more. A strong point of difference between the Baltic and the Barents Sea lies however in the fact that in the Baltic the utmost limit of growth is probably attained at a length of 40 cm., with an age of 20 years, no plaice being found beyond this, whereas in the Barents Sea the plaice reach fully 30 cm. more in length and 30 years more in age.

The high percentage of very large and very old fish in the Barents Sea, and the fact that these plaice reach there a far greater age than in any other waters, particularly the North Sea and the Baltic, clearly prove that the Barents Sea is a fishing ground which is still in a virgin state, and has only been fished for some few years. We can probably safely assert that this new fishing ground will, by intensive fishery, very soon become exhausted, and *probably in relatively less time than the Iceland waters*, since the plaice in the Barents Sea grow much more slowly, and take almost twice as many years to reach a size of 50 cm. or more in length.

Also the relative frequency of the two sexes shows the primitive character of the plaice stock in the Barents Sea, in a manner similar to that in the case of Iceland. Among the largest plaice of 40 cm. and upwards in the Barents Sea, about 40% are males, as against 60% females, i. e., a considerably higher percentage of males than in the North Sea. The point of intersection of the curves of frequency for male and female is found in the measurement series from the Barents Sea at 44 cm., i. e., at the same length as for Iceland.

The final results of the investigations as to the changes which have taken place in the stock of plaice in the North Sea, as a result of the intensive trawl fishery are as follows:

1. It is very probable that the density of the plaice shoals of the North Sea has, with the introduction of intensive trawl fishing, remarkably decreased, the absolute size of the plaice stock being also thereby reduced.

2. The reduction in the stock of plaice has not affected all size-classes in equal degree, but chiefly the larger and older plaice. This is shown in the catches and landings by a relative decrease in weight and number of the large plaice and increase of the small, as well as in the reduced average size of the plaice. The larger and older males especially have decreased greatly in numbers, and the point of intersection of the curves of frequency of the sexes has fallen to a lower length.

If these conclusions be accepted as justifiable — which I think they must be — then we have the answer to the question, whether the productive power of the North Sea is great enough to continually replace the quantity (about 30 to 40 %) annually taken from the stock by means of fishery. And the answer must, it seems, be a more or less emphatic negative. For if the fishery, as it has hitherto been carried on, has effected such changes in the stock as shown above, it has actually removed more than can be replaced each year. And we can with equal certainty expect, that if the fishery continues, year after year, to take the same quantities of plaice in the future as hitherto, the stock of plaice must become still further reduced, the change being characterised by a further decrease in the number of large plaice and relative increase in that of the small, with a corresponding fall in the average weight.

IV.

The Introduction of protective measures for the plaice.

1. to 4. *The necessity of international protective measures. Protection by means of closing times, closed areas, or by prohibition of certain apparatus. Size-limits. Vitality of undersized plaice taken in the trawl.*

The General Report arrives at the following conclusions upon these points:

1. Any protective measure against overfishing of the plaice stock and in particular against the imprudent and useless destruction of young plaice, can only be carried into effect when based upon international co-operation and internationally enforced for the whole of the North Sea.

2. The international decreeing of *close seasons* and *closed areas* for the plaice is not feasible out of regard to the capture of other sea fish which either do not need protection, or require to be protected at other times or in other places than the plaice.

3. The international prohibition of certain implements of capture which have a destructive effect on the plaice stock, e. g., the trawl, though in itself an effective measure, can of course not be enforced until a new and less destructive implement has been constructed. Were it only as regards the plaice and other flat fish, then such an implement could be found in the *Danish Snurrevaad*, but for the present, and as far as we are able to see, there can be no question save of an apparatus which can be used for all bottom fishes alike, and this will, in all probability, always be a trawl in some or another, more or less altered form.

There remains then, as the only possible protective measure which can be discussed, a *size-limit* for landing and sale, i. e., prohibition against landing or selling plaice under a certain length. The countries in question are unanimously agreed as to the necessity of fixing such a size-limit by international co-operation, and that moreover, at the earliest possible date

Such prohibition as to landing and sale of plaice under a certain length would, however, — upon this point also all are agreed — not be the same as a prohibition against capture, and can never become so, as long as the trawl and similar implements remain in use in their present form. On the shore grounds these undersized plaice will continue to be caught, and that in greater or less, but always considerable numbers, by the nets. If then, such size-limit is to be an effective protection for the undersized plaice, it is necessary that the undersized fish caught can *be returned alive and unharmed to the water*.

The important question of how and to what extent this is possible has been carefully investigated in several countries. The results show, that with the method of trawling at present in use, viz., hauls of from four to seven hours duration, most of the plaice are dead when brought to the surface, or if alive, are at any rate not capable of living long. This is not so much due to the duration of the haul as to the fact that the pressure exerted when the net, full of fish, is drawn to the surface, kills or severely injures the greater number of the plaice, especially the smaller fish, and at

any rate considerably reduces their chances of living for any length of time. The large sailing trawlers, which bring their plaice to market dead on ice, can in this respect be classed as almost equal to the steam trawlers; those sailing trawlers however, which keep their fish alive in receptacles provided for the purpose, and sell them alive in the markets, i. e., all the German, and part of the Dutch sailing vessels, naturally make shorter hauls, and most of the plaice are brought up alive. A large portion of the small, undersized fish caught are also alive when brought to the surface, but their vitality is often impaired, so that we must also in this case reckon with the death of half or two-thirds of the number returned to the water. The *Danish Snurrevaad*, with its quite short hauls of about half an hour's duration, is the only implement up to now which provides practically *complete protection* of the undersized plaice caught therein.

From this it follows, that the introduction of a legal size-limit for the plaice can, with the present methods of fishing, only afford real protection for the undersized plaice if fixed so high that it can no longer pay the fishermen to work those grounds where the undersized fish are found in greatest numbers. In other words, the trawlers must voluntarily agree to a restriction of their fishery, and renounce the working of the young-fish grounds. And they will do so, as soon as the proceeds of their catches there no longer suffice to pay the working expenses, or do not afford sufficient profit.

V.

Size-limits, and the restrictions imposed by them on the fishery.

An extremely important point is the question of how high a size-limit should be in order to render trawling unprofitable at those places where the most young, undersized plaice are caught, and this not as regards plaice fishing alone, but the whole yield.

In order to solve this problem as regards the English fishery, MASTERMAN has carried out careful investigations in the following manner. He calculates, for each individual area, fished by English vessels, and chiefly those with which we are here concerned, as being richest in young plaice, viz; A₃, B₄, B₃, C₃, for each month 1) weight and value of all fish taken with the trawl, including the plaice, and 2) what percentage of the weight and value of these trawling catches is represented by such plaice as lie below the lengths of 20, 23, 26 and 29 cm. He thus arrives at the loss in value which the trawlers would suffer if compelled by a legal size-limit to return all plaice under these lengths to the sea unused. It appears, as might be expected, that this loss not only increases in proportion to the height of the size limit, but varies, given an equal size-limit, for the various areas, and in these again according to the different months of the year. The loss is naturally greatest in those areas, such as A₃ and B₄, where the greatest numbers of young undersized plaice are caught by the English vessels, and also the smallest fish of other species than the plaice which are otherwise

marketable; also in one and the same area in those months in which the densest shoals of plaice are met with, as in the spring months from April to June, and in the autumn months of September and October. As soon as the loss in marketable value of the catch in a certain area at a certain time reaches a given point, for instance 20 to 30 % or more, then fishing in such area and at such time will become unprofitable, and the fishermen will find it better to turn their attention to other and more paying grounds.

The result of MASTERMAN'S investigations is that of the four lengths, 20, 23, 26 and 29 cm., with which his calculations have been made, a size-limit of 26 cm. would cause such loss to the trawlers that it would be unprofitable for them to work the true young-fish areas, viz: A₂, A₃, B₄, and a part of B₃, especially during the spring and autumn months. And those trawlers in particular, which, sailing chiefly from London, carry on plaice fishing on the young-fish grounds as their chief industry, and cause great destruction among the young plaice, would no longer be able to make any profitable catch. The same end would naturally be even better attained by a higher size-limit than 26 cm., for instance 29 cm., but a size-limit of 29 cm. would cause too heavy a loss in plaice on other grounds than the young-fish areas, and must therefore be considered as too high. A size-limit of 20 cm. on the other hand, would be far too small, as it would scarcely be calculated to deter the fishermen from working the young-fish grounds. A limit of 23 cm. is also too low, and would at the outside only render fishing in Areas A₂ and A₃ unprofitable in spring and autumn.

Similar investigations to those in England have hitherto only been carried out on a very small scale in other countries. As far as it has been done in Germany, the results seem to show that a size-limit of 23 cm. would only exceptionally render fishing in A₃ and B₄ unprofitable, and only when the steamers wanted to fish especially the localised shoals of young fish in the spring and autumn months. A size-limit of 26 cm. would probably render steam trawling in Area A₃ unprofitable for most months of the year (with the exception of the winter, which is always a poor time for plaice in trawling), and also in a great part of B₄, where the great shoals of young fish occur.

As regards Area A₂, which is chiefly fished by Holland, no corresponding investigations have unfortunately been carried out. As however the Dutch fishermen do not observe any size-limit, and take and consume much smaller plaice than the German or the English, we can with a fair degree of certainty presume that a size-limit as low as 23 cm. would render this Area A₂ unprofitable for trawling, especially for the steamers.

With the small sailing vessels, chiefly German and Dutch, which fish for plaice off the southern coasts of the North Sea in the areas A₃, B₄, A₂ and B₃, and bring their catches of plaice *alive* to the market, conditions are somewhat different to those which apply to the steamers and the large sailing vessels (smacks, etc.) which fish far out at sea. For these small vessels, especially for the German, the plaice is the most important and most valuable fish in their catch. They take on an average smaller plaice than the steamers which fish farther out at sea, and the number of undersized plaice in these catches is considerably larger. It is thus certain that a lower size-limit than that required for the steamers would suffice to render the fishing of their present grounds quite unprofitable for these sailing vessels; in any case, a size-limit of 26 cm. would here have the same effect as a limit of 29 cm. for the steamers. But while the steamers

would only be obliged to change their fishing grounds, these sailing vessels, which are fitted for the capture of live plaice, would soon be forced, by the introduction of a comparatively low size-limit, to *give up fishery entirely* as unprofitable, or alter their methods of fishing, for instance, by introducing the Danish "Snurrevaad" and building larger vessels with motor engines. Conducted on these lines, plaice fishing can be made to pay, even with a size limit of 26 cm., at least in the areas A₃ and B₄, as is clearly shown by the results of the Danish plaice fishing in the North Sea.

If it were possible, by means of the introduction of an international size-limit (e. g., of 26 cm.) to render unprofitable, and thus entirely prevent the trawling of the coastal areas of the southern North Sea, or at any rate the young-plaice grounds therein contained, for a great part of the year, this would certainly mean an effective protection of the younger stages, not only of the plaice, but also of other important food fishes, such as the common sole and the turbot. The protection would mean practically the same thing as the introduction of close seasons and closed areas, with this essential difference however, that it is left entirely to the fishermen themselves how far they will respect the close seasons and closed areas, this being for them only dependent on, whether the fishery pays or not.

The height of the size-limit must then be determined, on the one hand, by the probability which it affords for the protection of the young plaice as stated above, and on the other hand, by the loss caused to the fishery of the different countries by the introduction of such size-limit.

The loss which would be suffered by the different countries owing to size-limits of various height, can only be calculated from those series of measurements which we have obtained as to the composition of the landings based on market measurements. We can designate as *loss* the quantity of those plaice which lie below the length of the size-limit given, expressed as percentage of the total landings. And we must here distinguish between *loss in number*, *loss in weight*, and *loss in value*. The two last may to a certain degree, though not entirely, be regarded as proportional to each other. The weight percentage of loss will probably always be somewhat higher in reality the loss in value, and thus represent its maximum. On the other hand, the actual loss both in number and weight, will generally turn out somewhat higher, as shown in the calculations from the landings, as, if the size-limit is strictly observed, there will always be a number of plaice which are not landed, although they may be of the required size or even larger. Thus the difference between the weight per cent and the true percentage value should be more or less equalised, so that the weight per cent can be regarded as a good indication of the loss.

In the comparison given below, the lengths of 20, 21, 22, 23, 24, 25, 26 and 29 cm. are taken as possible size limits, and the loss in number (*n*) and weight (*w*) shown for each country with each size-limit. The loss values are in many cases more or less uncertain, owing to the lack of sufficiently extensive market measurements to allow of their exact determination. This is the case for instance with Holland and Scotland, while Belgium for the same reason cannot be taken into consideration at all. The uncertainty is not however, so great in the case of any of the countries here shown, as to render the figures valueless; they can and will no doubt be altered by renewed and more accurate investigation, which must, in particular, be extended so as to obtain

mean values for a considerable period of years; the alteration will however scarcely be so great as to make any essential difference in the result. Thus the loss figures for the German sailing vessels, which are here calculated from the measurements for the year 1909, will probably appear lower when other years are included, for instance 1905, as the catches for 1909 contain, in contrast to those of 1905, an extraordinarily large number of small plaice.

Table 11. Probable loss inflicted on the plaice fishery of the different countries in number and weight per cent of the total catch, by the introduction of a size-limit.

Country		Loss of plaice in number (<i>n</i>) and weight (<i>w</i>) per cent with a size-limit of cm:								Existing size-limit
		20	21	22	23	24	25	26	29	
England. Steam and Sail	<i>n</i>	1	3	7.5	14	22	32	41	63	18—20 cm.
	<i>w</i>	0.2	1	2.5	5	9	14	20	37	
Germany Steam	<i>n</i>	0.7	2	5	11	19	30	42	73	18 cm.
	<i>w</i>	0.2	0.7	2	5	10	16	25	52	
	Sail	<i>n</i>	0.8	5	14	30	49	65	77	
		<i>w</i>	0.4	3	9	21	37	52	66	
	Steam and Sail	<i>n</i>	0.7	3	9	20	34	47	60	
		<i>w</i>	0.3	1.6	5	11	20	31	42	
Holland. Steam and Sail	<i>n</i>	8	17	30	43	55	66	75	92	None
	<i>w</i>	4	9	17	27	38	49	59	82	
	Sail	<i>n</i>	22	37	53	67	—	91	—	
		<i>w</i>	18	32	47	60	—	86	—	
Denmark. Sail	<i>n</i>	—	—	—	—	0.5	4	16	70	25.6 cm.
	<i>w</i>	—	—	—	—	0.3	2	9	59	
Scotland. Steam and Sail	<i>n</i>	—	—	—	1	—	3	6	17	None
	<i>w</i>	—	—	—	0.2	—	0.6	1.4	5	

The first point which strikes one as of particular importance in this table is the fact that a size-limit of uniform length, say 25 cm., would cause very different losses in the respective countries. The greatest contrast in this respect is that shown between Holland and Scotland; in the case of the latter, a size-limit of 25 cm. would only cause a loss of less than 1 % of the total value of the yield, while in Holland it would mean no less than 59 %. And this enormous difference exists in spite of the fact that neither of the two countries in question observes any size-limit. The explanation naturally lies

in the fact that the Scottish plaice fishery is based on the capture of large plaice in the high sea regions of the northern North Sea (G, F, E, D and B₁) the Dutch, on the other hand, almost exclusively on the capture of small and very small plaice in the shore areas (A₂ and B₃) of the south eastern North Sea, the stock here being fished with particular intensity by Holland, as both steamers and sailing vessels take all small plaice caught, down to far below 18 cm. These very small plaice can always find a market in Holland, especially when brought to land alive, as is the practice of most of the sailing vessels.

A similar difference in the loss caused by a size-limit, though not so great as that here shown between Scotland and Holland, appears between the steamer and sailing ship landings of the same country in cases where the sailing vessels are smaller, fish chiefly for plaice, and principally or entirely in the coastal areas. As the sailing vessels in such cases are concerned with a stock composed, on an average, of smaller plaice, the average size of the fish in their catches is naturally smaller than in the case of steamers fishing larger and more distant grounds. Correspondingly, we see that with a size-limit of 25 cm., the loss to German steamers in weight and value would amount to only 26 %; in the case of the sailing vessels however, to 52 %, i. e., twice as much. Similar conditions evidently prevail also in Belgium and Holland.

It has been mentioned above, that on the basis of the investigations carried out in England, a size-limit of about 26 cm. was considered necessary, in order to provide really effective protection for the undersized plaice in the coastal areas concerned, with the present methods of trawl-fishing. It is evident that in the event of such size-limit of 25 or 26 cm. — the same which is already legally decreed in Denmark — being introduced, by international co-operation, as the general limit for the whole of the North Sea, the immediate loss thereby occasioned in several countries would be extraordinarily heavy, in certain cases no doubt so serious as to render it a matter of doubt whether such fishery could continue to exist at all. This last applies particularly to the German, Dutch and Belgian sailing ship fishery in the areas A₃, A₂, B₄ and B₃, where plaice form the principal part of the catch.

In the face of this threatening danger to a number of fisheries attending the introduction of a size-limit of 25 to 26 cm. it will be easily understood that the countries here concerned, while recognising the necessity of size-limits, and of higher size-limits than hitherto, cannot advocate the adoption of a universal size-limit uniform for all countries, at any rate unless it be extremely low, and in any case lower than that at present customary in Denmark. In Holland, such an international size-limit in the interest of the Dutch plaice fishery is desired, in the first instance, to be not higher than 20 cm., in Germany not higher than 23 cm. Or for instance, in Belgium and Germany, a higher size-limit might be fixed for steamers, say 25 to 26 cm., and a considerably lower one for sailing vessels, say 22 or 23 cm. These proposals are supported by the indisputable facts, firstly, that plaice fishing is for the steamers, in contrast to the sailing vessels, seldom of the first importance, but plays, as a rule, a subordinate part; secondly, that the sailing vessels fish as a rule less destructively than the steamers, the fish they return to the sea having a greater vitality; and thirdly, that they utilize the small plaice, which are for the most part brought alive to the market, to

much greater advantage. A modification of this proposal is, to fix a higher size-limit for plaice brought *dead* to market, a lower one for those brought in *alive*. This would especially be advocated in Denmark and Germany.

VI.

The probable influence which an effective protection of undersized plaice and a more rational and more productive fishing would exercise on the maintenance of the plaice stock.

It is comparatively easy to approximately determine the loss of plaice which the fishery would suffer in the first instance by the introduction of a size-limit; it is however, very difficult to estimate *the compensation of this loss, and possible ultimate profit*, which would arise from effective protection of the young fish and consequent lasting improvement of the plaice stock. Such compensation, sooner or later, for the initial loss, and a possible ultimate gain must naturally, if at all possible, be guaranteed, if size-limits are to be legally enforced.

The general opinion on this point is, that such a guarantee can be given. Protection of the young undersized plaice means an increase in the reserve stock which supplies the higher age-classes, and thus, *caeteris paribus*, an increase in the number of larger and older plaice, or in other words an increased density of such fish in the stock. To what extent such increase might take place is shown by the following estimate:

The total stock of plaice in the North Sea has been estimated above at about 1,500 million fish, of 12 cm and upwards in length and from the beginning of the third year and upwards. Of these about 76 %, or 1,140 million are under 25 cm. long, and 24 %, or 360 million 25 cm. long and upwards, up to the greatest length, or for every 100 small plaice under 25 cm. long, 32 larger fish. Of this stock of plaice about 33 % are caught, according to our estimate of the fishing coefficient, every year by the trawl, and, presuming that this coefficient applies to plaice both under and over 25 cm. we get 376 million of the former and 119 million of the latter. If we could succeed, by means of a size-limit of 25 cm., in really protecting all plaice under this length, then there would be 376 million plaice every year, of from 12 to 24 cm. which, instead of being caught as heretofore, and disappearing from the stock, would remain alive and continue their growth. Some time after the introduction of the size-limit we should thus have, for every 100 plaice thus spared, 32 which had grown larger, and the stock of larger plaice would undergo a corresponding absolute increase in numbers, i. e., in this case of about 119 million, or rising from 360 million to 480 million. With a fishing coefficient of $\frac{1}{3}$ 160 million marketable plaice of 25 cm. long and upwards would be caught annually, instead of as formerly, 119 million, or one third more than than heretofore.

If we apply this estimate to the English plaice fishery, we get the following results. The quantity of plaice annually landed in England from the North Sea can be taken

(see p. 25) as 112.5 million fish, with a total weight of 29 million kg. Of these the quantity under 25 cm. amounts to 32 % of the number and 14 % of the weight, or 36 million fish, with a total weight of 4 million kg. the average weight being 111 gr. per plaice. This represents the *loss* which the introduction of a size-limit of 25 cm. would entail. There remain 68 % of the number and 86 % of the weight, i. e., 76.5 million plaice with a total weight of 25 million kg. and an average weight of 327 gr. per fish. As a consequence of the increase in the stock of plaice of 25 cm. and upwards, effected by the size-limit, according to our previous estimate, this quantity would be magnified by one-third of its amount. The catch of plaice of 25 cm. and upwards would then be increased by 25.5 million fish, weighing 8.3 million kg. which represents the *profit* accruing to the fishery some time after the introduction of the protective measures. We see, that the profit in weight is more than double the loss, it would however, in value probably be three times that amount, since a kilogramme of plaice with an average weight of 327 gr. has at any rate a considerably higher market value than a kilogramme of plaice with an average weight of only 111 gr.

The same calculation worked out for the total landings in Germany (steamer and sailing ship) shows an annual *loss* of about 6.6 million fish, with a total weight of 0.77 million kg. and an average weight per plaice of 117 gr. The *profit* would be 2.5 million fish, with a total weight of 0.57 million kg. and an average weight per plaice of 230 gr. The loss is here greater in number and weight, but probably not in value, as according to JOHANSEN'S calculation for instance, plaice of an average weight of 230 gr. have in Denmark nearly three times the market value of those which average 117 gr.

For the German sailing vessels alone, a size-limit of 25 cm. would mean a *loss* of 4.5 million plaice with a total weight of 0.5 million kg. and an average weight of 111 gr. as against a *profit* of 0.8 million fish with a total weight of 0.16 million kg. and an average weight of 196 gr., thus amounting to only one-third of the loss in weight. This heavy loss would however in all probability be for the most part compensated by the higher price. Almost the same applies to the Dutch and Belgian plaice fishery from steamers and sailing vessels, while in the case of the plaice fishing from sailing vessels of these countries, the loss occasioned by a size-limit of 25 cm. would scarcely be compensated by the possible profit, at any rate at first.

It appears, that in thus calculating the profit which should accrue to the fishery by protection of the young of the plaice, the relative height of this profit in number and weight per cent is entirely independent of the height of the size-limit, and only depends on the intensity of the fishing to which that part of the stock now protected has hitherto been subjected; being equivalent to the fishing coefficient of same. If this is for instance one-third, then the profit to be expected is also one-third of the number and weight of those plaice hitherto caught, from the size-limit upwards. If the profit thus obtained is greater than the loss, then we have an *actual extra profit*. The loss in weight is thus equal to the weight percentage of plaice below the size-limit, the profit being equal to the weight percentage of plaice from the size-limit upwards, multiplied by the fishing coefficient. In this manner we can, with the view here given (p. 6) of the loss, easily calculate what size-limit must be chosen in order to provide a further extra profit. For the Dutch fishery for instance, — steamers and sailing

ships together, a size-limit of 22 cm. would, with the presumed fishing coefficient one-third, suffice to give a large extra profit. For the German steamers a 26 cm. limit would mean compensation for the loss, and 25 cm. a considerable profit; for the German sailing vessels a limit of 23 cm. would, with fishing coefficient one-third, be enough to give a considerable extra profit.

The calculation here given as to the possible profits to accrue to the fishery owing to the introduction of effective protection of the young plaice are based upon the supposition, that *all plaice below the size-limit, which are now caught by the trawl will, for the future, really be spared, and grow larger*. This supposition can however, never be entirely correct; even with the highest possible degree of protection which can be obtained by the absence of the trawlers from the young-fish grounds, there will still always be a certain number of undersized plaice caught and destroyed. But with a lower degree of real protection, the profits of the fishery will also be proportionally less; if for instance only half of all the undersized plaice formerly caught are now spared, then the increase or profit in fish of legally marketable size will also only be half so great. The profits calculated above are thus to be regarded as *maximal* values, with a fishing coefficient of 0.33.

On the other hand, the profit accruing to the fishery by protection of undersized plaice can be further increased, viz, by increasing the fishing coefficient: i. e., a more intensive fishing than hitherto of plaice above the size-limit. This part of the stock being larger than previously, it can bear more intensive fishing. With an original fishing coefficient of 0.33, this stock will increase, after the introduction of protective measures, by one-third. i. e., will amount to $\frac{4}{3}$ its former size. And if the fishery formerly reduced it by one-third, i. e., brought it down to $\frac{2}{3}$ of its amount, it can now be reduced by fishery from $\frac{4}{3}$ to $\frac{2}{3}$, i. e., by one-half, without falling below its former size. This possible increase of degree in the fishing can to a certain extent compensate for the decrease in profit caused by imperfect protection. It could, however, if carried beyond the extent permissible, also cancel the whole profit, by gradually reducing the stock of legally marketable fish below the size at which it stood before the introduction of protective measures.

Although these estimates of possible profit to the fishery, based as they are to a great extent upon hypotheses, may appear uncertain, as against a certain loss, they yet suffice to prove that *an actual, certain profit may be reckoned with in the future*, and that this profit will be the greater, the more effectively the undersized plaice are protected. And protection will be easier, the more a size-limit succeeds in restricting the ruinous trawling on the young-fish grounds, and the more the trawling, as far as it is solely or chiefly concerned with plaice fishing, can be replaced by other and more merciful methods of fishing.

Besides the *certain* profit which the fishery would obtain from the enforcement of effective protective measures, there is also a *probable* profit. An increase in the numbers of that part of the stock lying above the size-limit would mean an increase in the number of females reaching maturity, and thus, unless the whole of this increase were again removed by increased fishing, the number of eggs spawned would also be greater. Other conditions remaining unchanged, this would lead to an increase in the stock of

young plaice below the limit of size, and this again to an increase of those above the size-limit.

This discussion of the increase of the plaice stock as a result of the protection of the young plaice is, in its essentials, only theoretical. It is the more valuable for our purposes that we have already on hand some experience of practical results of protective measures. In Denmark there has existed since 1888 a prohibition against the sale of plaice under 25.6 cm. and this was reinforced in 1907 by a prohibition against landing of same. It has been proved, that the Danish plaice fishery has, in spite of the restriction imposed by so high a limit, shown a continually increasing development for the last 20 years. The introduction of this legal size-limit has thus certainly proved no hindrance in the way of profitable fishery. With regard to the North Sea in particular it has been proved that in the Esbjerg fishery district, Areas A₃, B₄ and B₅, profitable fishing can be carried on by the Danish cutters in spite of the size-limit. As regards the Kattegat, there has, for the years 1895 to 1907, with the said size-limit, been no further decrease in the average weight of the fish caught, in spite of extremely intensive fishing, which is probably greater than in any other part of the North Sea, nor does there appear to have been any decrease in weight in the total yield of the plaice fishery. It is in all probability reasonable to suppose that the plaice stock, and the quantity of fish yearly removed, have here reached a certain stationary condition, which is most probably due to the rational protection afforded to the young fish during this period. This supposition seems the more justifiable, since by the Danish method of fishing, viz., with the "Snurrevaad", practically all the undersized plaice caught can be returned alive and unharmed to the sea.

The restriction of the fishery on certain fishing grounds by means of a size-limit would naturally also involve, in addition to the loss in plaice, a further diminution of the quantity of other food fishes taken. This has for the most part not been taken into consideration in the foregoing calculations. It is however probable that this further loss would also, by the increased protection of these other food fishes, soon be compensated and turned to profit.

VII.

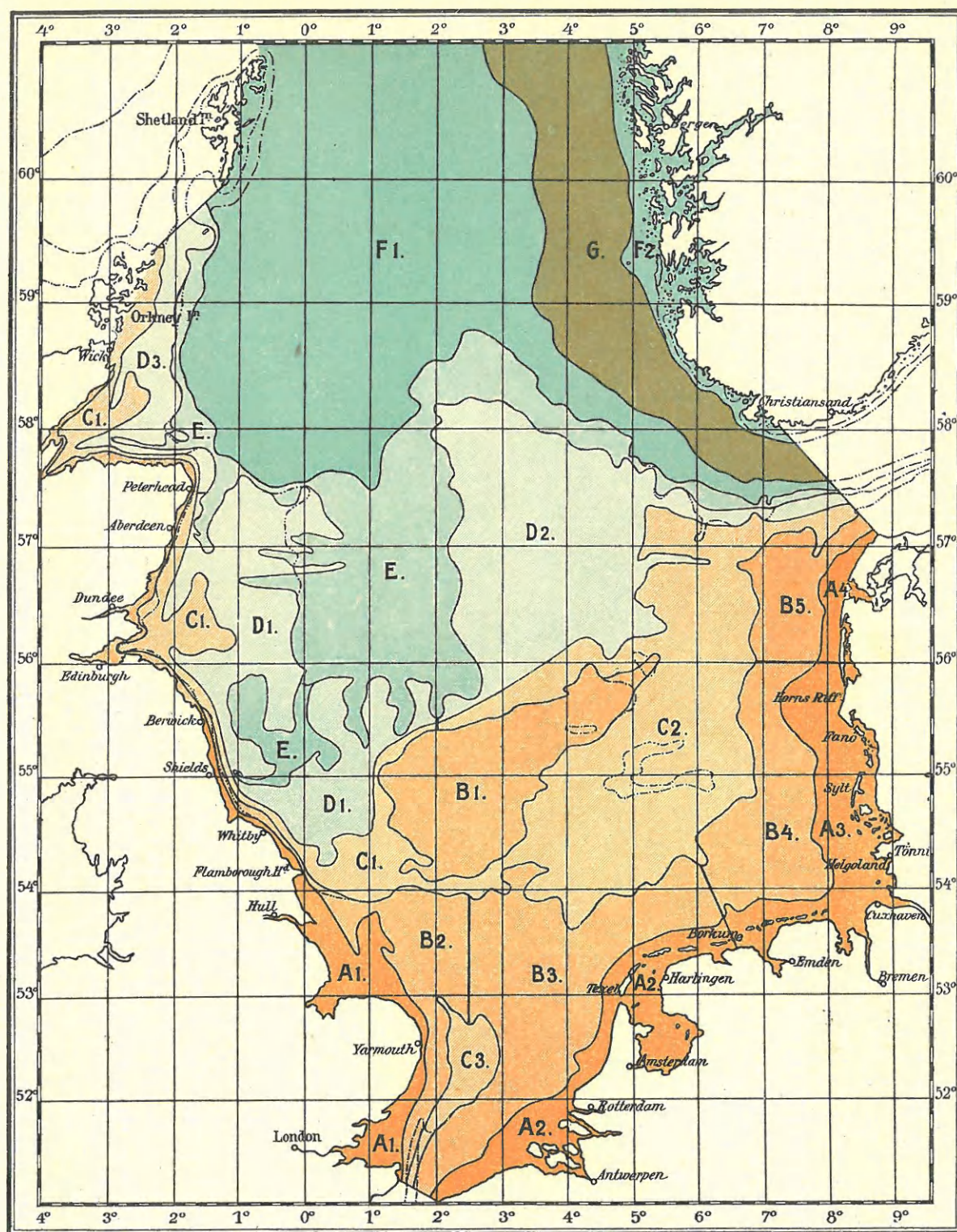
The desirable height of the size-limit for the plaice in the whole North Sea, to be determined by international agreement.

It is no part of the task of the General Reporter to formulate positive proposals as to an international size-limit to be introduced for the plaice in the whole of the North Sea. This rather concerns the Central Council, or particularly, perhaps, a Commission to be formed by the same for the consideration of the Plaice Question. The results of the international investigations on this subject, as stated in the General Re-

port, will however, form the basis upon which the discussions and decisions of such a Commission must rest.

These results of our investigations seem to indicate, that a really effective protection against the enormous, and for the most part useless destruction of the young of the plaice by the large steam and sailing trawlers can only be attained by means of an international size-limit of 25 to 26 cm. *Such size-limit is therefore extremely desirable, and an endeavour must in any case be made to introduce same.* On the other hand, it is impossible to overlook the fact that the introduction of so high a size-limit to be enforced in all the North Sea countries, would in the first instance be productive of so heavy a loss to the plaice fishery of certain countries, e. g., Germany and Holland, that these fisheries would be dangerously injured, and their very existence, upon present lines, seriously threatened. In the interest of these fisheries it would be desirable, in the general opinion, to fix for them at first — during a certain period of transition — a lower size-limit. As the fisheries with which we are here concerned bring a great part of their plaice to market *alive*, and in order to avoid, as far as possible, the difficulties which must arise, with locally varying size-limits, in connection with the enforcement of same, and the really effective protection of the young plaice, it would be advisable to allow such lower size-limit only for such plaice as are brought to market *alive*. Such a size-limit for live plaice would perhaps be sufficiently high when fixed at 22 or 23 cm.

Finally we must take into consideration the fact that our knowledge as to the possible effects of a size-limit, and especially as to the height of the actual ultimate profit accruing from such protective measure to the plaice fishery of the North Sea, is as yet very imperfect, and based rather upon theoretic conjecture than upon practical experience. The introduction of an international size-limit is thus in the first instance an *experiment*. And with regard to this experiment we trust, that it may prove feasible and that it may succeed, and hope that it may furnish the aid so sorely needed to repair the serious damage at present suffered by our plaice fishery, and prevent the threatened overfishing of the stock of plaice. But we do not know how far our hopes will be fulfilled, or how far we may be disappointed. The experiment is, moreover, a costly one. It would therefore be advisable at first to commence rather with a too low than too high a size-limit. It will then be necessary to carefully study for some years the effects of such lower size-limit, and only when it proves necessary, replace it with a higher.



Subdivision of the North Sea into Areas (Plaiice fishing grounds).

Depth of the areas:

A 0—20 m.; B 20—40 m.; C 40—60 m.; D 60—80 m.; E 80—100 m.; F 100—200 m.; G over 200 m.

