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A century of fisheries research and management

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Abstract

Towards the end of the last century there was a growing concern about the future exploitation of the resources of fish in the sea.

In a number of countries Fishery Research Institutes were established, the International Council for the Exploration of the Sea was founded, and an extensive research activity was started in the North Sea.

Throughout the main part of this century the fishing effort grew steadily, changing the size and composition of the stocks of fish, and endangering the future yields. The need for management increased and so did the demand for research.

Large investments have been made in research. The biology and dynamics of the fish populations, and the complex interactions between the fishery and the ecological systems in the North Sea have been thoroughly investigated.

On this basis the governments of the North Sea countries, cooperating through international commissions, have established fisheries management systems.

The present state of the art of fisheries management, and of fisheries science is a result of a parallel evolution, and enable us to predict and to plan for the future exploitation of the marine resources.

Introduction

I sometimes wonder what fisheries research and management look like when seen from outside by someone who is not familiar with its details, its perspectives, its history, and the coherence of its elements.

The fragments of a picture which are being painted for the public in newspapers, radio and TV, by for example a fisherman who has been deprived of his rights to fish where he always used to fish, by a Minister who is going to negotiate quotas with his colleagues from other countries, or by a member of an environmental organization may differ quite a lot from each other and from the 'true' perception of fisheries research as seen by the fishery biologist.

The fisherman may look at the researchers as some ivory-tower-academic persons who sample fish for fun and construct theoretical solutions to imaginary problems with the result that the fisherman suffers economic losses.

The Minister may see the biologists as a group of persons who are occupied more than he would like with marine biological con amore research trying to solve problems which may arise in the future instead of always being occupied with the production of reports on the day-to-day fisheries problems which he has to face in his work.

The environment activist may think that the fishery biologist betrays his mission – and nature – by not always working for more severe restrictions of the exploitation of marine resources.

These points of view are, of course, extremes and do not represent the perception of all fishermen, Ministers or environment activists – but they are part of the pattern of the public picture of fisheries research.

I would like, very briefly, to describe to you how the fishery researcher, himself, sees this field of work. Here, as in many other cases, the historic perspective helps you to understand the present.

The historical perspective

These days are historic days for the Danish Institute for Fisheries and Marine Research, a research institution which was formally founded a hundred years ago. These years are historic years for many fishery research institutes, such as, for example, the Dutch and the British institutes which are both represented here today. These two institutes just passed their one hundred years anniversaries.

At this meeting, we have chosen to celebrate the anniversary by looking into the future. However, before doing so, you must know something about the present and the past.

In Denmark, the first governmental fishery biological institute was established in 1889. The entire staff consisted of one man, C.G. Joh. Petersen, who did all the work himself with the help of a few students during the summer period, (Fig. 1). He was extremely productive and creative and the founder of methods and thoughts which still form the basis of the modern version of the science which he and his contemporaries in our neighbouring countries founded.

This small laboratory developed during the following years into a scientific institute: The Danish Biological Station. The institute worked exclusively in the inner

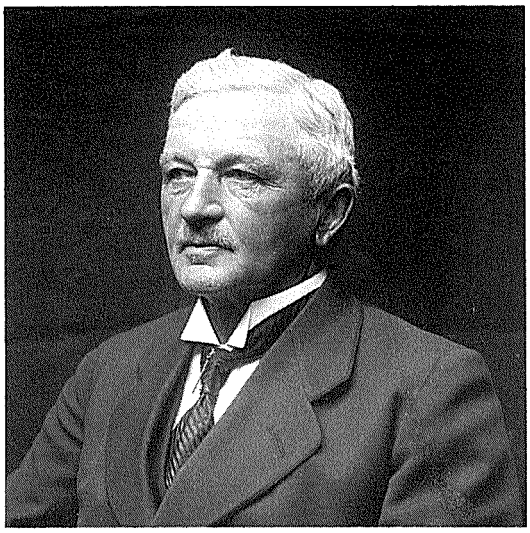

Fig. 1. C.G. Johannes Petersen, the founder of Danish fisheries research.

Danish waters – in the Kattegat, the western Baltic and all the fjords. When, in 1952, it was absorbed in the Danish Institute for Fisheries and Marine Research, a total of 54 volumes of scientific articles had been produced – by relatively few scientists – but containing some of the most important contributions to fisheries science of the epoch.

Around the beginning of this century, most European countries were engaged in fisheries biological research in the areas of main interest to their fisheries. The need for international cooperation was realized and 'the International Council for the Exploration of the Sea' (ICES) was founded in 1902 in Copenhagen as a forum for cooperation between marine biologists from a number of Western European countries who were concerned about the exploitation of the resources in the sea.

Fig. 2. The Danish research vessel *Thor* 1902. Scientists working in the hydrographic laboratory.

This very old international organization has played a major role in fisheries research ever since. Today, it is the organization which provides the scientific background and data for the management of the resources of fish in all northern European seas, which provides knowledge about the pollution situation in the sea and which coordinates marine and fisheries research in the entire North Atlantic area.

In Denmark, the foundation of ICES in 1902 led to the establishment of 'the Commission for Fishery and Marine Investigations'. This commission created four

laboratories: one for studies of plankton, one for hydrography, one for fisheries investigations in the North Sea and one for fisheries investigations in the Faroes and Icelandic waters.

One of these four laboratories became more known to the public than the rest, the one headed by Johannes Schmidt. His work on the migration of the European freshwater eel as well as the *Dana* expedition around the world 1928-30, of which he was the leader, were scientific achievements which rightly attracted attention. At the same time, however, considerable scientific work was also carried out by the three other laboratories in Danish and North Atlantic waters. Also here, a long series of scientific publications were produced until these laboratories in 1952 merged with The Danish Biological Station into the Danish Institute for Fisheries and Marine Research.

1952 was an outstanding year in Danish fisheries research due to the creation of the new institute, but so were 1889 and 1902.

The decades marked by these years may be used to separate four periods of time, which each had its own characteristics, with respect to the development of the fishery, the development of research and the development of fisheries management. – And you may add one more decade – the 1970s marking the beginning of the present era.

The first decades of fishery biology

In the old days – before the 1880-decade marine life was explored by zoologists and botanists who discovered new species and described them, described their anatomy and physiology, studied their biology and who wondered how, and thought of how the ecosystems of the sea were functioning. The term ecosystem was not used at that time, but the thinking of many scientists was along the same lines as that of the present ecologist. The study of hydrography was to a great extent taken care of by naval officers.

The fishery was mainly a coastal fishery for cod and plaice in the North Sea, while offshore fishery for herring had been carried out for several centuries. There was no sign of overfishing. However, there was an awareness of the fact that the resources of the sea are not inexhaustible, but also that much more might be harvested from the sea to help feed the malnourished populations which existed in Europe at that time, as they do in the third world today.

Governments asked prominent naturalists for advice on the fish potentials, the distribution of the fish stocks, the state of the fishery etc.and, gradually, a new branch started to grow within marine biological science – the branch was later known as 'fishery biology'. And, as mentioned, it was around the 1880s that the first government fishery biological institutions became established.

At the beginning of the century, international cooperation began and throughout the first half of this century there was a slow, but steady, development of both the fishery and fishery research.

This was still the descriptive period of fisheries biology. The major part of the science was occupied with describing the biology of fish, their distribution, their

reproduction, their migration, their growth, behaviour etc. – and their environment, the basis of fish food, the production of plankton and the life cycles of other animals living in and on the sea bed.

During this period, an enormous quantity of knowledge was gathered about the lives of the fish in the sea.

The newest findings were discussed at the annual meetings of ICES, at symposia and other scientific meetings. Joint international surveys were planned and hundreds and hundreds of articles were published in the proceedings and journals of the International Council, and in those of national laboratories.

Fisheries scientists were becoming more and more internationally oriented as is, by nature, their field of work.

International fisheries management

At that time, there were no front page stories about political fighting over quotas to disturb the work of the scientists – and yet, there was a general concern about the trends of the fishery.

More fishing boats were being built, more efficient gear were introduced, the fishing effort increased. Catches were high but the stocks and the catches of some of the most important species had started to decrease.

This concern about the fish stocks was not expressed in quantitative terms. It was much like the kind of concern which we experienced many years later when we observed trends of increasing contents of carbon dioxid of the atmosphere, or the oxygen deficits in the sea, or the diminishing size of the rain forests of the world, trends which you could predict may result in catastrophes of different degrees of severity – but you cannot say exactly what is going to happen, when!

It was quite obvious to the scientist and to the politicians of that time that this development – this increase of the fishing effort – could not continue without serious long-term damage to the stocks and the fishery. Restrictions were needed.

In the 1930s, the first bills were passed in European parliaments which prohibited the landing of plaice and haddock under a certain minimum size. It was realized that the basis for a larger biomass of fish had to be built on conservation of the youngest and fastest growing fish.

In 1937, a conference was called in London where the countries fishing in the North Sea met and signed a Convention which was to form the basis for improvement of the North Sea fish stocks though protection of the smallest fish.

The convention was not ratified before the war broke out. However, it was replaced in 1946 by 'the North Sea Convention' under which most European fishery nations agreed on minimum landing sizes and minimum mesh sizes for some of the more important North Sea species.

A Commission was established to follow the development of the fish stocks and the fisheries and to act as a forum for its member countries for negotiations of international fisheries management regulations. Now, not only fisheries research, but also fisheries management had become internationally organized.

Fish stock assessments

The mid-fifties to the mid-seventies was an extremely eventful period in the development of the North Sea fisheries and fisheries research and management.

The fishing effort in the North Sea increased dramatically in that period – and the catches also increased (Fig. 3 and 4).

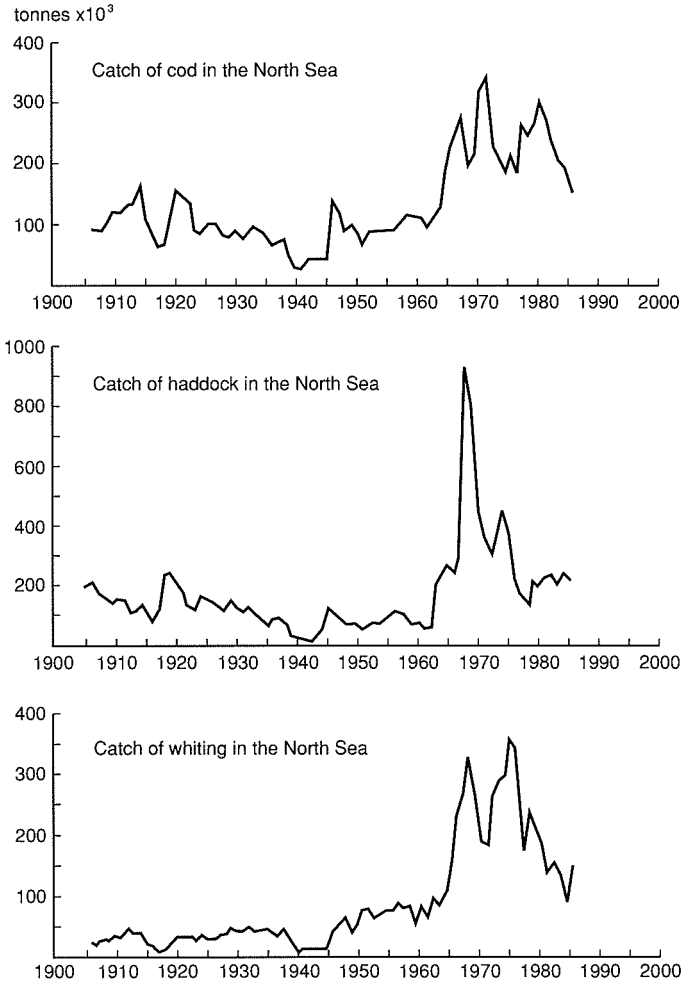

Fig. 3. Catches of cod, haddock and whiting in the North Sea from 1905-1987.

Way back in the forties or thirties or even before that time, the biologists had thought of how to describe in a quantitative way the interaction between the fish stocks and the fishery. Some progress had been made but the real break-through did not come until the mid fifties when two British scientists, Beverton and Holt published their book on population dynamics of the North Sea fishes.

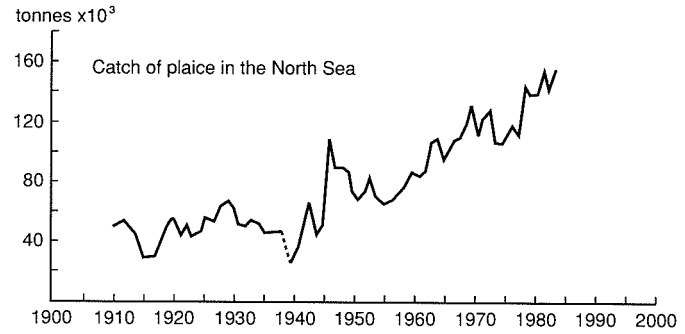

Fig. 4. Catch of plaice in the North Sea from 1910-1987.

This book, which represented a giant step forward in fishery biology, was based on the work of those scientists who described the fish, their biology and the fishery in the first part of the century, and it became the basis of almost all fishery research and management in the last part of the century.

It gave the scientists methods which enabled them to predict the development of catches and stock sizes under different assumptions about the future development of the fishery. It enabled them to say something, in numbers, about what would happen to catches and biomasses if the fishing fleet was to be reduced or increased by a certain proportion. That was exactly what was needed by politicians as a basis for making decisions on management. Now you could calculate and draw curves which described the relations between fishery, stocks and yields as for example a yield per recruit curve (Fig. 5).

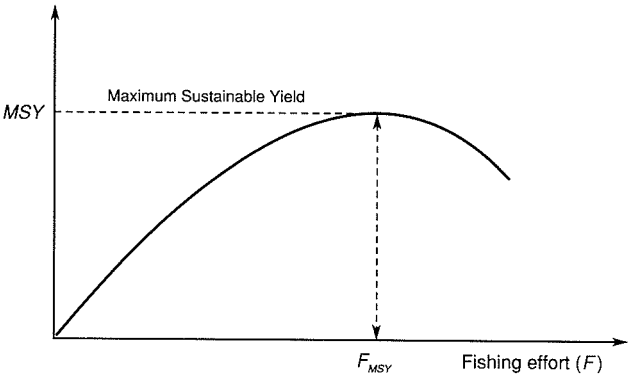

Fig. 5. Yield curve showing Maximum Sustainable Yield.

These new theories and methods came at the right moment because the fishery needed management more than ever.

The fishing fleets grew and the catches went up much more drastically than before the war. A new fishery for herring for fish meal and oil production was started and became known as the industrial fishery of the North Sea. The catches of herring increased and resulted in a heavy overfishing of the herring stock (Fig. 6).

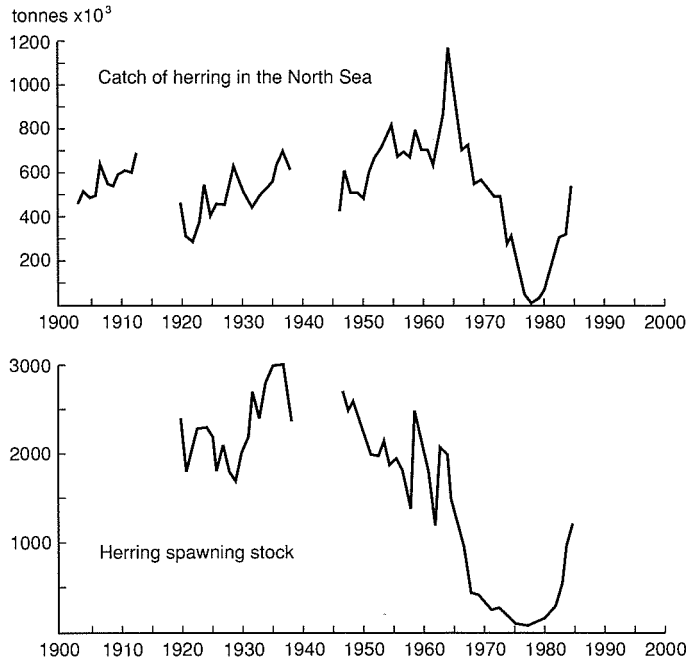

Fig. 6. Catch and spawning stock of herring in the North Sea from 1905-1986.

The advisory function of ICES

The need for management and the need for management advice grew.

The International Council organized itself to meet these needs. A number of biological working groups were formed to meet regularly to assess the state of the stocks and fisheries by using the new techniques, to compile all new information, to plan and execute joint projects, joint surveys, to harmonize techniques, data collection etc.

Quite a unique and fantastic mobilisation of international fisheries science took place in these years. First a few, then soon more than 30 biological working groups were set up covering the entire North Atlantic area and continuously compiling all relevant knowledge to be passed via the scientific high court of the Council – its 'Advisory Committee on Fisheries Management' – to all its member countries and to those International Commissions responsible for international fisheries management.

The first international management Commission, the old 'North Sea Commission' was, in 1964, replaced by 'The North East Atlantic Fisheries Commission' (NEAFC), which now covered the whole of the North East Atlantic Area, while the western part of the Atlantic was covered by a corresponding Commission for the Western Area called ICNAF. The North East Atlantic Fisheries Commission received its advice on the state of fisheries and stocks directly from ICES through an annual report based on the work of the many Working Groups each covering a fish species or a stock in a certain area like the North Sea Herring or the North Atlantic Cod.

The decline of the herring fishery

As you have seen in the figures, very great changes took place in stocks and fisheries from 1965 to 1975. Especially the very large herring catches and a very clear decline in the herring stock in the North Sea gave reason for concern. The biologists recommended a reduction of the fishing effort. However the 14 member countries of NEAFC could not agree. In addition the convention did not allow for reduction of the fishing effort by means of quota systems. This facility was not introduced until 1975 - and then, in 1977, a total ban on herring fishery was introduced in the North Sea.

The biologists, the managers, and the politicians gave much attention to the North Sea herring fishery in these years and also to the North Sea mackerel fishery which suffered almost the same fate.

The media focussed on these problems too, because it was a frightening example of a huge resource of fish being severely overexploited. Out of a total of 9 mill. tonnes of fish in the North Sea, herring and mackerel had constituted 6 mill. tonnes. Now, they were down to 2 mill. tonnes. How would scientists and managers handle this? What was going to happen? Indeed an interesting situation!

On the top of these problems, management was further complicated by a gradual taking over of the North Sea fisheries management from NEAFC by the EEC Commission. In addition, the introduction of economic zones as a result of the Law of the Sea Conferences meant that the distant water fisheries of EEC countries had to be abandoned and effort was transferred to the North Sea and the waters west of the British Isles.

At the mid-seventies, the total North Sea catch reached 3 mill. tonnes – the catch had doubled in 15 years – and that happened in spite of the very drastic decline in the stock of herring and mackerel.

The basis of this was a steep rise in the abundance of a number of North Sea species. Species like sprat, sandeel and Norway pout had become so abundant that the total catch of these three species, which now replaced herring as a basis for fish-

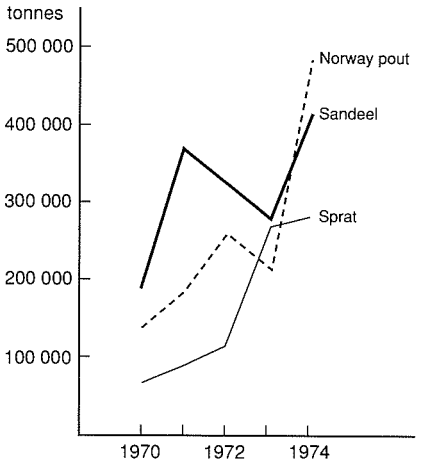

Fig. 7. Increasing catches of Norway pout, sandeel and sprat from 1970-1974.

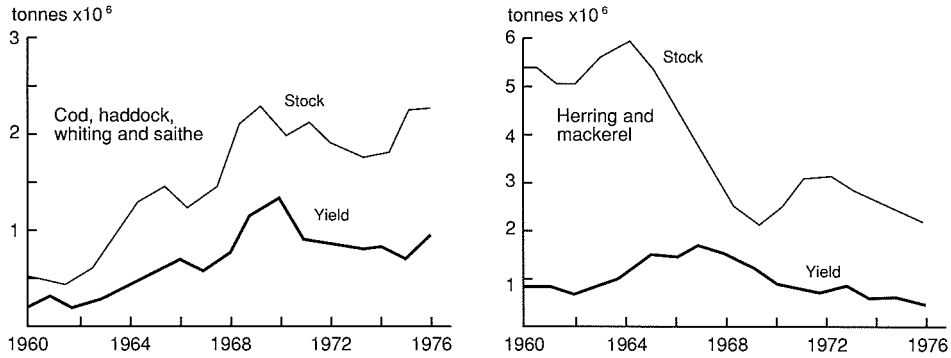

Fig. 8. The fluctuations in stocks and yields of North Sea cod, haddock, whiting and saithe, and of herring and mackerel.

meal production, rose from a hundred thousand tonnes to over a million. But also stocks of haddock, cod, whiting and saithe increased (Fig. 7 and 8).

So, even after the heavy decline of the herring and mackerel stocks there were still 9 mio tonnes of fish in the North Sea and still a basis for large catches. – but different species now dominated. At this stage fisheries science took a new step forward.

The North Sea model

It is obvious that there are mechanisms in nature which regulate the sizes of populations. Fish prey on each other, they compete for food, etc., and obviously these mechanisms were acting. But how? How can you possibly predict what is going to happen in the sea when, for example, the fishery removes the major part of the mackerel stock or some of the large cod? – What may that mean to the size of the stocks of other species which serve as food for mackerel and cod? How can you manage a fishery when conservation of one species may mean that you reduce the stock of another species?

Two scientists from the Danish Institute for Fisheries and Marine Research, Andersen and Ursin, established the basic theory for a model describing the species interaction in the North Sea. This work became another very important step forward in fishery biological science and fishery management.

Scientists in other countries were working on other aspects of the same problem. Among these were the two next speakers, Niels Daan from the Netherlands and John Pope from the UK.

Fifteen years have gone now since the North Sea model was first published – and since this concept was first introduced to the managers. Since then, a great deal of research effort has been used to create a solid data base for obtaining the parameters needed and the modifications required in order to make the model applicable to present management problems. Today, many scientists are working on these problems. International working groups have been established to handle them, and research vessel surveys including many vessels over several years are being engaged in this work.

The dimension of this effort indicates the size of the problems the biologists are faced with when they have to not only understand the complicated interaction between the ecosystems of the sea and man's exploitation of them – but, on top of this, have to establish methods that enable management of these systems. Management has worked on a one species model basis for many years. It is now starting to work on a multispecies basis also.

The need for this kind of approach has not diminished since the mid-seventies. On the contrary, today, species interactions cause serious management problems not only in the North Sea but in other seas as well. North of Norway, for example, the cod, capelin and seal stocks are interacting with large fluctuations as a consequence.

The latest development

Let us just for a moment return to the fishery in the mid-seventies and see what happened in the North Sea during the following years.

The herring stock recovered slowly, and the fishery is now, carefully managed, on its way up. The mackerel stock did not return in the North Sea but the western stock increased tremendously and spread into the North Sea.

The cod fishery continued at a high level and the stock declined drastically.

The stock of plaice endured increasing catches, quite contrary to the situation before the war, but the catches in the southern part of the Kattegat fell drastically as a consequence of oxygen deficit. Oxygen deficits have also occurred in the North Sea, but still not to a degree where you can measure their effect on the fish stocks.

The management of the fishery in the North East Atlantic is still dealt with by NEAFC, but only for areas outside the EEC's economic zone. The North Sea and other EEC waters are managed within the EEC systems.

ICES still provides basic biological advice, now twice a year, – covering more than a hundred fish stocks. The report of the Advisory Committee of Fisheries Management has grown from some 50 pages to more than 500 indicating the huge amount of detailed knowledge compiled as a basis for management decisions.

The EEC countries have agreed to a common fisheries policy. Shares of stocks have been divided into quotas between member countries. Programmes for long term adjustment of the fishing capacity have begun.

All in all, the machinery which is now in existence, is rather well functioning, on the basis of scientific advice. A system has been created where, at least theoretically, the resources of fish in the sea can be exploited in a rational way and at the same time conserved for of continuous exploitation.

In practice, however, there are still lots of problems – political problems, enforcement problems, and nature playing tricks on everybody, when series of large or small year classes change the predicted pattern. More serious is the overall pressure on the environment which results in oxygen deficits, temperature increases etc. These aspects will no doubt be in focus in the years to come when they may inflict new causes of mortality, behavioural changes and other effects on the fish. New scientific steps forward will be needed to handle these problems. And where will they come from?

They will of course come from some of the many scientists working in this field.

Not only those who are directly involved in the calculation of the fish stocks and yields for the coming years, but also the many scientists who are hardly noticed by the managers or by the media, but who are doing the research which is the very basis of all fisheries management. What you usually meet, what you see, is the top of the iceberg. What you hear about are the quotas for next year and the calculations which led to these quotas. What you should not forget, is the indispensable work on hydrography of the sea, the plankton – fish larvae – relationships, the studies of behaviour, feeding physiology, the studies of causes of mortality, fish diseases, the experimental work, the development of mathematical models, the design of new instruments, the study of sound in the sea as a measure for counting of fish etc., etc.

Only when you do this work, only when you do research, can you obtain the information needed for fisheries management.

I hope I have been able to give you a very broad idea of the development in the North Sea of the fishery as well as of the research on and the management of its resources. The next three lectures will start from here and make their daring jumps into the future.

I would like to finish off my lecture by showing you a picture of the headquarters of the Danish Institute for Fisheries and Marine Research, Charlottenlund Castle – not only because it is a beautiful building, but also because it has become kind of a symbol of Danish and international fisheries research.

Fig. 9. Charlottenlund Castle.

The old institute 'The Danish Biological Station' and the laboratories under the Commission all lived here from 1936 until they merged into DIFMAR in 1952. The ICES had its headquarters here from 1936 to 1980. Many statutory meetings were held here, hundreds of Working Group meetings, symposia etc.

I think I am right in saying that very few past or present fishery biologists have not visited Charlottenlund Castle and many have returned several times.

The Castle is more than two hundred and fifty years old and houses a one hundred year old research institute. It is the very old and solid foundation of a very vigorous, productive and useful scientific institute.

May they both last for at least another hundred years.