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The Danish fishery into the next century

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Abstract

A brief review of the development of the Danish North Sea fishery in this century is given. The future development of the Danish fishery depends on several factors. The most important factors: the resource, the environment/recruitment, the fisheries management agreements and the development of the economy, particularly for the fishing industry will be discussed. Examples of the effect of these factors will be given. The overall fishery in the North Sea is expected to stabilize or decrease slightly. The likely development of the industrial fishery and the fishery for human consumption are discussed separately. Primary attention is given to the scenario dealing with increased price on fish products, multispecies management, increased interest for high valued species, demand for high quality fish products and internationalized markets.

1. Introduction

Denmark is, today, the third largest exporter of fish in the world, and fish products comprise 6% of the total Danish export (1987). The Danish landings of about 300 000 tonnes of fish for human consumption and 1 200 000 tonnes for reduction into fish meal and oil form a firm basis for the industry, although foreign landings in Danish ports are significant. About 50% of the landings used for human consumption and 75% of the landings for reduction stem from the North Sea.

The fishery is, obviously important for the Danish economy and it is necessary that we are prepared to deal with changes in the fishery. Through our participation in the international cooperation on fisheries management, as well as through our national policy for the fishery sector, we will be able to adjust to changes of the conditions of the fishery.

The previous speakers have described how the ecosystem and fish fauna of the North Sea may change in the future. The introduction of the Single Market in the European Community and the increased internationalization and thereby increased competition of economies and trade, will change the conditions of the fishing industry. Moreover, continuous development of new technology and changes in the demand for fish products will influence the fishery.

Finally the future potential of the Danish fishery is strongly dependent on international fisheries management. Fisheries management has, for more than 40 years, been implemented as a result of international agreements and actions to protect the seas from environmental changes will only be effective if they are taken at an international level.

It is very difficult to predict the development of these factors and, thereby, the future development of the Danish fishery. Even to outline a few scenarios of reasonable likelihood is difficult. However, if one showed attempt to predict the development of the Danish fishery into the next century it is first necessary to discuss how at least some of these factors influence the Danish fishery today and may be expected to influence the fishery in the future.

As a starting point, I will give a brief review of the development in the Danish fishery in the North Sea. Next I will discuss how various factors can influence the development of the fishery. A discussion of some likely scenarios of the development of the industrial fishery follows, and finally I will deal with scenarios of the likely development of the human consumption fishery.

2. The development of the Danish North Sea fishery in this century

I will, as a starting point, give a brief review of the development of the Danish fishery in the North Sea. The term fishery here refers the size and the structure of the fleet and the landings.

The development in number of vessels by GRT size class for Danish vessels in North Sea and Skagerrak ports is shown in Figure 1. Vessels from other parts of the country also fish in the North Sea and, similarly, vessels from North Sea ports take part in fisheries outside the North Sea. Nevertheless, the development of the fleets in the North Sea ports gives a strong indication of the North Sea fishing activity.

The fleet size has increased more than tenfold from during this century. It increased steadily up to World War II. From 1955 to 1965 the fleet nearly doubled.

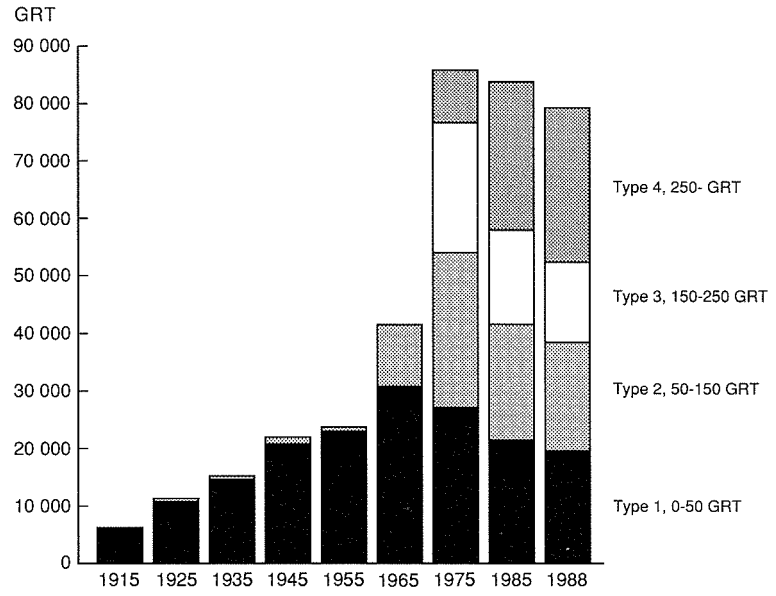


Fig. 1. Total Gross Register Tonnage of fleet in Danish North Sea ports grouped by GRT class.

The increasing trend continued and the highest absolute increase appeared between 1965 and 1975 where the fleet doubled again. The fleet has been approximately stable since 1975. However, most recent years show a declining trend. The fleet in the North Sea and Skagerrak ports amounted to 80 000 GRT in 1987.

Throughout this period, the number of vessel has increased at a much slower rate than the total vessel size measured in GRT. As seen in Figure 1 the Danish fleet has been enlarged by introducing larger and larger vessels in the fleet during this period.

The quantity of landed fish has increased by about a factor of 40 during this century. During the last 30 years, the industrial fishery was developed and reached a maximum catch of around 1.2 mill tonnes in the 2nd half of the 1970's. During the same period, the human consumption fishery increased as well to about 100 000 tonnes.

During the last 10 years, the industrial fishery has declined to a total catch of about 900 000 tonnes in 1987, whereas the landings for human consumption increased to 180 000 tonnes in 1987.

The question is now whether we will see a sharp increase in fleet size and landings around the year 2000 after this relatively stable period in the 1980's?

Will the Danish fleet in the North Sea increase, decrease or remain the same in the future ?

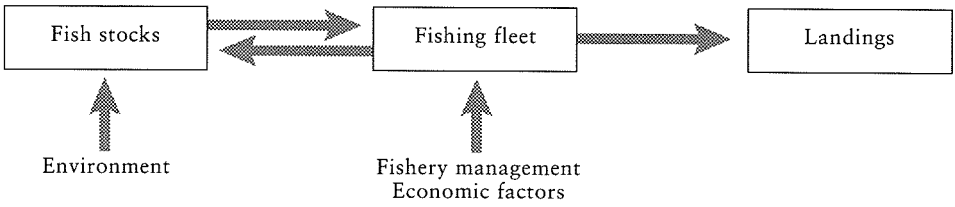
Will the structure of the fleet change and will it pursue other target fisheries?

To answer these questions we need to discuss how various factors influence the development of the fishery.

3. Factors determining the future fishery

3.1. *Description of the factors*

The basic principles and main factors affecting the fishery are shown below.



The supply of raw material for the fishery, that is the size of the fish stocks, is subject to natural variability.The stocks are subject to environmental changes through variable recruitment to the stocks and varying growth patterns of the stock. Of course, interactions between the fish stocks also influence the size of the fish stocks and, thereby, the fishery.

In addition, the size of the fish stocks depends on the level of fishing. If a fish stock is subject to a very high fishing for a period of years, it is possible to deplete the stock and, thereby, prevent any or allow only a limited fishery on that stock for the following period.

In other words, the fishing fleet can affect the stocks and future production if the fishery does not allow recruitment and growth of the stock to balance the quantity caught from the stock.

The fishing fleet is affected by international fisheries management, such as catch limitation in terms of quotas and rules for mesh size, closed fishing periods, and limited access to other countries' waters.

In addition to these factors which are all being related to the fish stock being an international, natural and renewable resource, the future development of the Danish fishing industry will depend of a number of economic factors: The development in population structure, demands for fish products, prices and costs, and general competitive ability of the fishing fleets and industry.

In order to predict the future fishery, defined as the size and structure of the fleet and the landings, I will now go a bit more into detail for each of the factors shown in the figure. First of all I will describe the recent development of the resources in the North Sea and examine at possible unexploited stocks in the North sea.

3.2. *The fish stocks in the North Sea*

It is obvious that the abundance of the marine resources will influence the fishery in the North Sea. However, as two factors, the environment and the fleet itself may affect the stocks it is useful to give some examples from the North Sea. Figure 2 shows the catch by species for the eleven most important fish species in the North Sea grouped in biologically.

It can be seen that the catch of the valuable roundfish species cod, haddock, whiting and saithe increased abruptly in the early 1960s. The catches increased chiefly because of significantly improved recruitment (Holden 1977) and this event is often referred to as the 'gadoid outburst'. The declining trend observed in the cod landings in the 1980'th is not caused by poor recruitment in this period but, rather, by an increasing trend in fishing intensity on the cod stock during the last 20 years. The fishery has on average caught more cod than compensated for by recruitment and growth, and thus reduced the 'average' cod stock.

The catch of herring increased significantly in mid 1960'th. Both the adult stock and the juveniles were fished in considerable quantities, and this overfishing resulted in declining spawning stock sizes and catches in the second half of the 1970'th. Poor recruitment, resulting from the low spawning stock size and possibly also adverse environmental conditions during this period hindered a rebuilding of the stock size and the herring fishery was, in practice, closed for about 10 years.

Strong recruitment to the sprat stock in the 1970s allowed a considerable fishery (Fig 2), but the fishery declined again in the early 1980'th. The reasons for this varying recruitment are not fully documented, but it is believed to be associated with hydrographical and environmental changes (Anon, 1986).

These examples show that fish resources are subject both to natural variability and to reduced yields as a result of overfishing. A prediction of the future resources must therefore take into account both aspects.

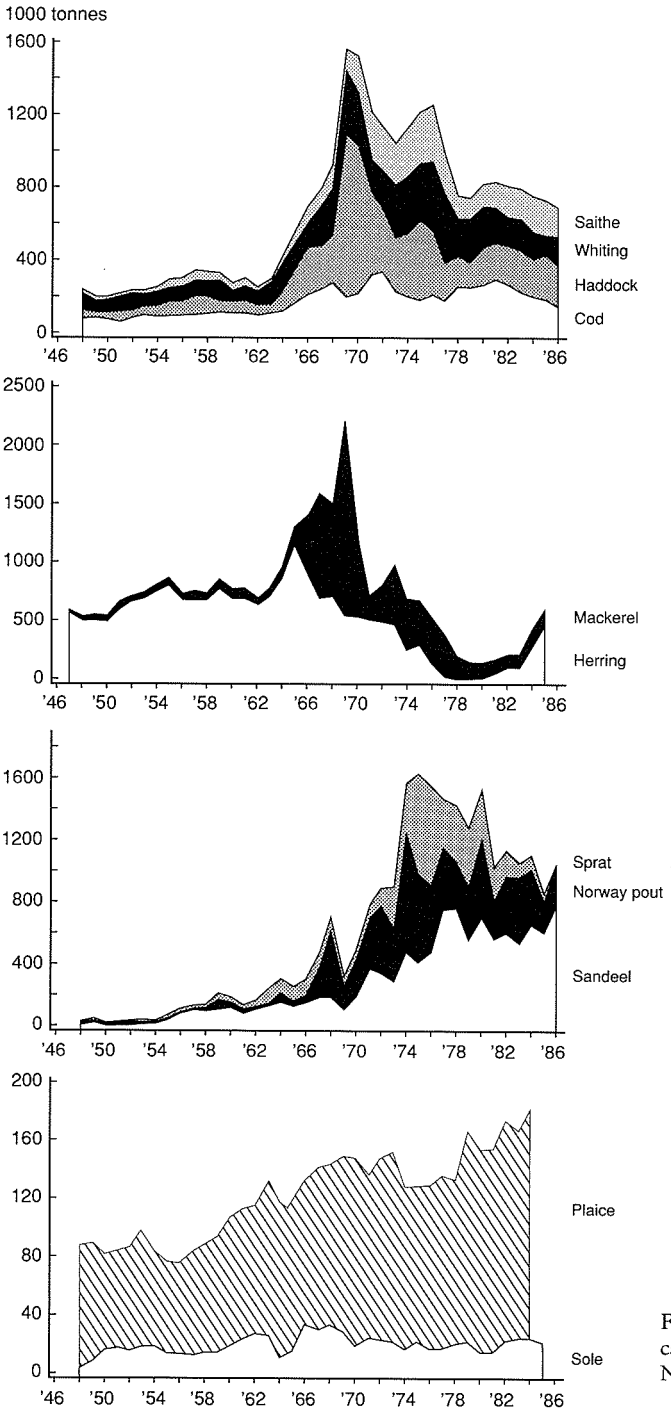


Fig. 2. Total international catch by species from the North Sea.

3.3. *Fisheries management in the North Sea*

As discussed overfishing can influence the future fishery, and since fisheries management plans control fishing activity, fisheries management will have a strong impact on the future fishery. International management and agreements on measures to maintain the water quality of the marine areas are also of course, in the long run very important for the fish production. Let me give some examples of a more direct short-term implication of fisheries management.

In 1983, agreement was met on the Common Fisheries Policy between EEC member countries. The main principle in that policy is, that for each stock, an annual Total Allowable Catch (TAC) is agreed for a management area (i.e. the North Sea). The TAC is, thereafter, subdivided into national quotas based on historic fishing rights. In recent years, it has been agreed to reduce the fishing pressure on, for example North Sea cod, and the TAC has, therefore, been set to restrict the fishery. Subsequently the national quotas have been fished before the end of the year and in this case the fishery has been directly affected by the fishery management policy.

In addition to the TAC and quota system, a number of technical measures are in force. These measures set rules for minimum landing sizes, minimum mesh sizes, closed areas and by-catch rules for fisheries using small meshes (f. ex. industrial fishery, shrimp fishery).

An example of this type of management measure is the 10% by-catch rule used in the industrial fishery. When fishing for Norway pout using small meshed trawls, a vessel is not allowed to catch more than 10% of 'protected' species. The reason for this measure is that the by-catch usually consists of small specimens of, say, haddock and whiting, and these specimens would, if not caught in the industrial fishery, otherwise grow to large fish. The large fish could then subsequently be caught in the human consumption fishery.

The bycatch of cod, haddock, whiting and saithe in the Danish Norway pout fishery are given below for three periods.

Period	Bycatch percentage
1975 - 1977	16%
1978 - 1983	9%
1984 - 1986	7%

The data show a significant drop in bycatch percentage around 1978 and a further decrease in 1983. In 1977-78 The Norway pout Box was introduced, in which fishing with small meshed nets was banned. This measure led to a diversion of effort and reduced Norway Pout catches and by-catches. The agreement on the Common Fishery Policy in 1983 implied an overall agreement on by-catch rules and increased enforcement.

This example shows that the industrial fishery is affected by the technical measures which are introduced to balance the income between the industrial fishery and the human consumption fleet.

3.4. *Economic factors*

The resources in the North Sea are not exploited unless they have been shown to generate a profit for the fleet. The profit is determined by the revenue from the sale of fish and the capital and running costs of the vessel.

A general review of fishery economy is beyond the scope of this contribution, but I will give a couple of examples to demonstrate how swiftly the fleet react to changes in the economy.

Figure 3 shows the price per kilogram of fish landed for reduction as well as the fishing effort in the Norway pout fishery in the North Sea. The fishing effort is calculated as an index of the total number of fishing days in the Norway pout fishery.

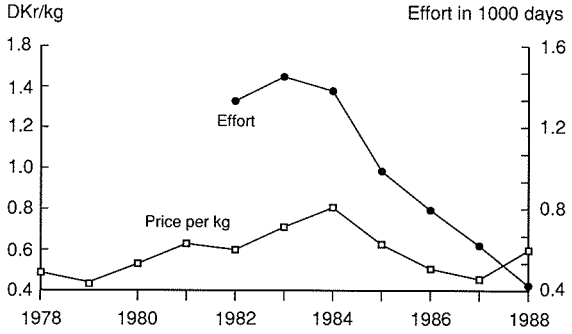


Fig. 3. Price per kg of fish for reduction. Total effort in the Norway pout fishery.

The figure strongly suggest that fishing intensity depends on the revenue from the fishery. A possible explanation for why the fishing effort has declined from 1987 to 1988 despite the increasing price for fish for reduction is that the stock size of Norway pout in 1988 was rather low (Anon 1989a). At low stock sizes the catch per day will be low, and this could apparently not be compensated for by increased prices per kg in 1988.

The other example covers the cost side of the fishery. As trawlers tow their gear they are much more energy consuming than vessels using passive gears, such as gill nets and hooks.

The number of vessels using nets/hooks and trawlers built in five year periods after 1965 are shown below.

	Nets–hooks	Trawlers
1965 - 69	79	218
1970 - 74	153	123
1975 - 79	269	107
1980 - 84	115	67

The example shows that after the so called 'energy crisis' in 1973 the number of energy saving gill netters increased whereas the number of trawlers decreased.

The above discussion shows that in order to predict the development of the Danish fishery into the next century one needs to consider the development in stock sizes, possible changes in fisheries management and changes in economy and technology. Most

of the assumptions on the future development of these factors have different implications for the industrial fishery than for the human consumption fishery. It will therefore be preferable to discuss the future scenarios for each sector separately.

It should, however, be borne in mind that there is no clear cut distinction between industrial vessels and human consumption vessels.

4. The future development of the Danish industrial fishery in the North Sea

4.1. *The present status of the industrial fleet fishing in the North Sea*

Table 1 shows the landings by species in tonnes from the North Sea for 1987 for a number of vessel categories. The table is based on the sales slip databases maintained by the Ministry of Fisheries, and includes all landings taken from the North Sea. The number of vessels given for each vessel category in Table 1 do not necessarily coincide with the number of vessels registrated in North Sea ports and cannot be directly compared with the data presented in Figure 1.

Table 2 gives the value of these landings. It can be seen that all vessel categories with the exemption of three have virtually all (more than 80%) of their income from human consumption landings. The industrial vessel categories are all found among large trawlers above 150 GRT. About 85% of all landing for reduction are taken by this group of large trawlers.

The total number of industrial trawlers (using 80% of income criteria) is about 160. The total number of vessels fishing in the North Sea in 1987 was about 1200.

Although the data describe the fishery in 1987, where few small vessels took part in the industrial fishery because of the low price for fish for reduction, they clearly indicate that the industrial fishery is dominated by large vessels.

The structure of the fleet has, as suggested in Figure 1, changed considerably since 1950 when the industrial fishery was developed. To get an idea of the future development, I will give a brief review of this development with particular emphasis on the resources fished for reduction.

4.2. *The fish resources used for reduction*

The catch composition of the total international industrial fishery in the North Sea is shown in Figure 4. The fishery developed in the early 1950's as a fishery for herring, and herring remained the most important species until the middle of the 1960's. From 1960, the catches were increased significantly from around 500 000 tonnes to 2 000 000 tonnes in 1968. The increase was caused by large landings of herring and a sharp increase of species grouped in 'other species' in Figure 4. This group consisted of mackerel, haddock and whiting. Although landings of this group of species declined in the 1970's, the high catch level was maintained because of increased catches of sandeel, Norway pout and sprat. The species composition was now changed, so that the three industrial species accounted for 80% of the total landings for reduction. From 1975 and onwards, landings have declined to the present level of around 1 200 000 tonnes as a result of a declining sprat stock and, in recent years, declining catches of Norway pout.

Table 1. Danish landings from the North Sea in 1987 (in tonnes). Landings by species and vessel category. Number of vessels by category.

Vessel category	No. of vessels	Species										
		Cod	Haddock	Whiting	Saithe	Plaice	Sole	Herring	Mack-erel	Other human consump.	Indus-trial	All
Beamtrawl	22	9		0		225				1002	1053	2289
Trawl GRT <20	129	676	111	13	15	1581	3		1	847	4513	7760
Trawl 20=<GRT<60	163	4482	1643	102	496	2124	27	3	1	2252	10225	21355
Trawl 60=<GRT<150	223	3217	2455	199	2210	575	4	1351	67	6945	111025	128048
Trawl 150=<GRT<250	99	796	578	325	986	103	3	3451	58	2318	321594	330212
Trawl 250=<GRT<500	55	462	596	371	906	35	0	7211	10	619	316113	326323
Trawl 500=<GRT	7	38	31	63	53	2	0	2244		49	71866	74346
Netters GRT<20	164	3950	230	5	42	1748	99	0	1	892	0	6967
Netters 20=<GRT	77	6716	33	8	98	328	20	0	0	567	40	7810
Purse Seine	11	4			1			30777	22849	0	663	54294
Danish Seine	231	8504	910	13	16	8632	2		0	1546		19623
Missing information	–	7991	1110	148	504	6214	172	2932	803	21121	80949	121944
All	1181	36845	7697	1247	5327	21567	330	47969	23790	38158	918041	1100971

Table 2. Value of Danish landings from the North Sea in 1987 (in Danish kr.).

Vessel category	Species											% human consump.
	Cod	Haddock	Whiting	Saithe	Plaice	Sole	Herring	Mack-erel	Other human consump.	Indus-trial	All	
Beamtrawl	76	2	1		2316	36			14166	405	17003	100
Trawl GRT<20	5716	744	64	80	15724	5716		2	8153	2320	33187	93
Trawl 20=<GRT<60	39540	12556	536	2615	20682	39540	4	4	36010	4543	118376	96
Trawl 60=<GRT<150	30672	17382	923	11218	5597	30672	2528	277	109521	50099	228417	79
Trawl 150=<GRT<250	7351	3471	1353	4546	1020	7351	2899	225	35986	141287	198246	30
Trawl 250=<GRT<500	4236	3339	1500	4493	327	4236	4626	25	8295	140669	167531	18
Trawl 500=<GRT	357	167	277	205	19	327	1239		559	29009	31832	12
Netters GRT<20	45167	2146	30	245	16911	45167	1	5	29424	0	100814	100
Netters 20=<GRT	80853	266	64	557	2984	80853	0	0	19933	21	106066	100
Purse Seine	34			6		34	61455	45410	2	402	107309	100
Danish Seine	75488	6579	70	70	86933	75488		0	17669		186979	100
Missing information	80149	8359	924	2744	61570	80149	4004	1568	75697	36343	283144	
All	369639	55011	5742	26780	214083	369639	76756	47516	355583	405098	1578904	

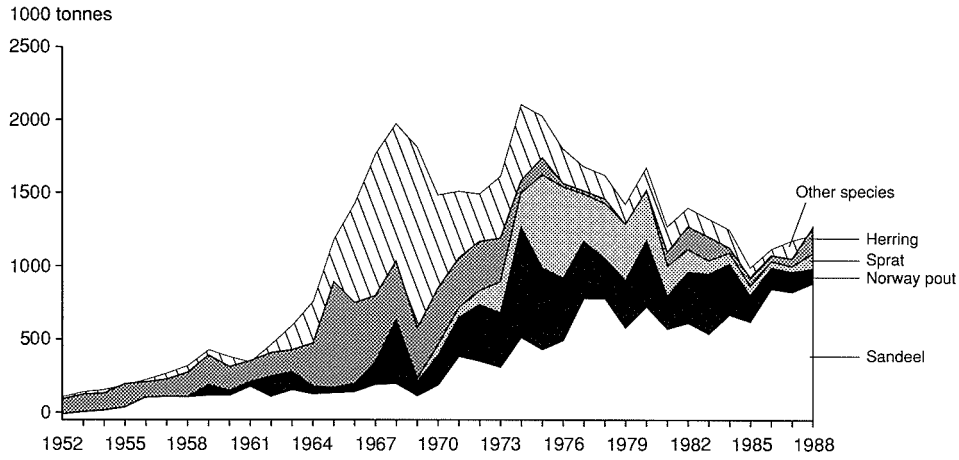


Fig. 4. Species composition of the industrial fishery in the North Sea.

We can now conclude that, for the industrial fishery, the fleet structure has, in this period, changed towards larger and larger vessels and, with respect to landings, the three industrial species (sandeel, Norway pout and sprat) now account for more than 80 percent of the industrial landings.

4.3. *The future resources of the industrial fishery*

The resources fished for reduction are very much a result of management policy. In the 1950's and 1960's, when the fishery was still increasing, several species were fished but in recent years only species for which the by-catch rules can be met are fished in significant quantities. Therefore, the likely resources for the industrial fishery must be discussed in the light of the likely development in fisheries management in the North Sea.

Before fisheries management is discussed, will consider the likely development in the available resources, irrespective of what management actions might be taken.

Presently exploited resources. As shown in Figure 2, landings increased rapidly in the 1950's and 1960's. For all of the eleven most important commercial fish stocks, the fishing intensity has increased since 1960 without increasing the overall yield from the stocks (ACFM report 1988). The spawning stocks of cod and haddock are now at their lowest since the 1960's.

The increased catches of plaice during the last 15 years are caused by a series of strong year classes and increased fishing intensity. In addition the greater fishing pressure also on young plaice implies that, irrespective of the increased recruitment, there has been no increase in spawning stock size.

For all of the important round- and flatfish species, the fishing on the younger age groups has increased in this period and a few consecutive small year classes will bring stock sizes close to their historic minimum levels.

The pelagic stocks of herring and mackerel in the North Sea have been low in 1980's. The herring stock has been increasing and a total catch of around 600 000

tonnes was taken in 1987. This is rather close to the likely long-term yield from the stock.

The North Sea Mackerel stock is at a low level and the high catches of mackerel in the North Sea seen in recent years is of Western Mackerel Stock origin. It is very difficult to predict the future mackerel catches. However, it is not likely that catches can be increased above the present levels irrespective of the origin of the stock.

The resources exploited in the industrial fishery have, with respect to sandeel and Norway pout, been stable for about 10-15 years, although the most recent development in the Norway Pout stock shows a declining trend. The sprat stock has been declining since around 1980. In summary, there is no reason to believe that the traditional 'industrial' resources will increase in coming years.

Unexploited resources in the North sea. Figure 5 shows the estimated stock size (Daan *et al.* (in press)), and Sparholt (in press) for the most important fish stocks in the North Sea as estimated for 1983-85.

The total biomass is estimated to be about 9 mill tonnes of which the eleven most important commercial stocks discussed above comprise about 6 mill tonnes.

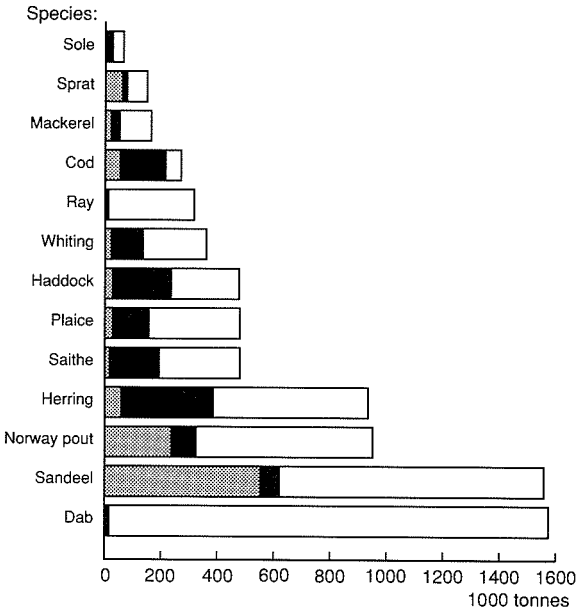


Fig. 5. Total biomass in the North Sea. Total international catch and Danish catch of the most important species.

As shown in Figure 5, the biomass of dab is around 1.6 mill tonnes and, together with about 200 000 tonnes of long rough dab, the dab comprise a large part of the 'unexploited resource'. Figure 5 further illustrates that a biomass of about 300 000 tonnes of skate and rays contribute significantly to the 'unexploited resource'. The remaining estimated biomass of about 600 000 tonnes of unexploited species consists of a large number of relatively rare species in the North Sea.

In addition to these species, a number of species can, in some years be found in the North Sea in significant quantity. One example is the horse mackerel stock.

Recruitment and the environment. Although the environment affects the fish resources, it is not possible, in simple terms, to describe the 'present' North Sea environment, nor is it the subject for this contribution. On the other hand, the current estimates of stock sizes in the North Sea do not represent the long term average. Instead the stocks in the period from 1983-85 are the result of recruiting yearclasses from late 1970's to the mid 1980's. It is therefore relevant to briefly compare the recruitment in this period with the previous decades.

In general, the roundfish stocks have experienced good recruitment compared to years before 1960. The year classes of important species such as cod and haddock have more than doubled from the 1930's to the 1960's (Holden 1978). Also the recruitment to the plaice stock in the North Sea was good in this period.

The North Sea herring and mackerel were both at a rather low level at the beginning of the 1980's. A combination of high fishing intensity and poor recruitment depleted these stocks. Good recruitment in the 1980's reversed the trend and stock size of herring is increasing in this period. There is no improvement in recruitment of North Sea mackerel and the stock size in 1983-85 is low. Concerning the 'industrial' species of sandeel and Norway pout, there seems to be good recruitment in this period, whereas recruitment to the sprat stock is declining in the 1980's.

Overall climatic changes caused by the green-house effect can, of course, in the long run change the recruitment pattern in the North Sea. It is beyond the scope of this contribution to predict the effect of such changes. I think that the most reasonable assumption is that, although species composition will change as a result of increasing water temperature, it is unlikely that higher recruitment can be expected to the future stocks of the North Sea, which is presently very productive.

With respect to cod, haddock and Norway pout, we have seen rather weak year classes in the last couple of years. Although this cannot be taken as an indication that these species are returning to the same recruitment level as before 1960, it shows that there is no guaranty that recruitment will remain at the rather high level observed in recent years.

In summary, it seems unlikely that the total landings from the North Sea will increase in the future. The exploited fish stocks are all heavily exploited, and increasing fishing intensity will not lead to increased catches. Of the species which today is only lightly exploited, there seem to be some possibilities for increased landings but these species are of low value today.

The recruitment levels have, in general been high during recent years and, from my point of view, we cannot expect that the recruitment level will increase in future.

It is, in fact, more likely that the total international fishery will be reduced in the future, or stabilize around the present level. Already today it is the general impression that there is an over capacity in the fleet. Several fisheries are restricted in their fishing and fewer vessels can catch quota.

It is therefore likely that the Danish fleet (including the industrial fleet) shown in Figure 1 will decrease or, at best, remain at its present level. As explained in the introduction, this is not only a question of the available biological resources, but also highly dependent on the economy and earnings of the fleet, as well as fishery management agreements. Since the industrial fleet is capable of fishing virtually all

species, fisheries management decisions is particularly important for the future development of this fishery.

I will now discuss this aspect with regard to the Danish North Sea industrial fleet. Which stocks will be utilized for reduction in future, and how will the fleet develop?

4.4. *Fisheries management and economic development*

Unchanged fisheries management. Assuming that fisheries legislation does not change in future, the core of the industrial fishery will be sandeel, Norway pout and sprat. The sandeel stock seems to be able to sustain the high catches and the stock size is considerable (see Fig. 3).

The most recent yearclasses of Norway pout have been weak (as for other roundfish species). However, it seems likely that the average catch level of this species can be maintained. The sprat stock has shown signs of recovery in recent years but, ultimately the yields will probably be lower than in the exceptional period in the second half of 1970's.

In summary the development in the species composition in the last two decades suggest that the total landings will be in the order of 1000 000 - 1 400 000 tonnes.

Slightly modified fisheries management. Increased catch levels will need other fishery management actions in the North Sea. From the estimates of abundance of the stocks in the North Sea, it would seem to be possible to take a much larger proportion of the dab stock. Dab is not likely to be of high value in the human consumption fishery and, provided it can be caught without severe by-catches of other demersal fish, it could, if excluded from the list of protected species, enlarge the resource for the industrial fishery. A lift of the EEC ban of landing herring for reduction purposes would also increase the landings.

Changes in prices and fisheries management. However, the determining factor for the industrial fishery will be the price of fish products, both for human consumption and for reduction into fish meal.

The FAO prospects concerning the production and consumption of fish indicates a shortage of 21 mill tonnes of fish on the world market in the year 2000. Fish products will, therefore, be expensive food and the prime management objective will be to maximise the yield of fish for human consumption.

This will imply that all species for which there is an outlet on the human consumption market will be used for that purpose. The 'industrial' resources will only consist of species for which there is absolutely no use for direct human consumption. This development point to a reduction of the industrial fishery as we know it today.

Nevertheless the management objective of getting high yields of high valued species may also give new visions for the industrial fishery. It has recently been shown (Anon 1989) that a selective fishing on the predator species in the North Sea can increase the North Sea yield with about 25%.

Thus, although the value of the yield needs to be considered, intensive fishing on the 'invaluable' predators can, ultimately, increase the total yield. It has been sug-

gested (Gislason 1989) that, because of long-term recruitment fluctuations, such strategies should be formulated for 3-5 year periods.Such periods would also tally well with the changes in market demands.

If this type of management is realised, there will be a need for a highly effective fleet which can catch the low valued fish and the low value predators. In other words, this fleet will 'cultivate' the sea.

This development is supported by the likely development of the gears used by vessels in the future. These gears will be much more species selective. In addition new technology will enable a much more selective catch with respect to species and size groups.

In recent years, there has been increased research and development in fish oil and fish meal products in order to offset the decreasing world market prices for fish meal. Fish oil and fish meal products can in the future be refined to food supplements and other raw materials in the food and medicine industry. The development of new products is expected to increase the demand for landed fish of high quality. In this respect, there will be no difference from the fish landed for human consumption. There will also be a demand for flexibility in a vessel's ability to catch different species in the future. That is, the future 'industrial' vessel shall be able to catch the traditional 'industrial' species, to catch the selected predators for a given five year period and to land fish both for reduction and for human consumption, and all types of landings should be of high quality.

The biotechnology industry is likely to develop methods to produce cheap protein, and, thereby, replace fish protein in cattle fodder.

The current industrial vessels, characterised only by the ability to catch a large quantity of fish per day, will, as I see it, not exist in the next century. However vessels landing a flexible set of selected species for reduction of a high quality will exist and be based in Denmark.

4.5. *The future size structure of the industrial fleet*

Figure 2 illustrates that the increase in the Danish fleet in the 1960's and 1970's was caused by the construction of larger and larger vessels. This tendency has continued since 1975 irrespective of the decline in total GRT of the fleet. The question is now whether this trend will continue. The size of trawlers constructed in 1988 is in the order of 500 to 800 GRT. One of the reasons for building bigger and bigger vessels is that the capacity and daily catch is much bigger. For such vessels an analysis (Anon 1989a) shows that the catch per day is proportional to the square root of the GRT of the trawler.

A preliminary analysis of the data sets presented in Tables 1 and 2 shows that the large trawlers (above 500 GRT) have very high catch rates in the sandeel fishery. On average, this vessel class catches 3 times more per day than vessels between 150 and 250 GRT. The about 100 vessels in this group could, in other words, be replaced by about 30 large vessels. This development can be supported by the shortage of labour in the future.

It is, however, questionable as to whether the present fishery legislation (by-catch rules) will allow for similar high catch rates in other North Sea fisheries. The expe-

rience during the last two to three years where 'supertrawlers' have been in use is that they take part in the sandeel fishery in the North Sea, but that in other parts of the year they fish for blue whiting and horse mackerel outside the North Sea.

Bearing in mind the likely demand for flexible vessels in the future it seems reasonable to assume that the future North Sea trawler will be of the same size as the large trawlers of today (250-500 GRT), but that the very large trawlers (above 500 GRT) will need to fish outside the North Sea a large part of the year.

5. The development of the Danish human consumption fleet

5.1. *Present status of the Danish human consumption fishing fleet in the North Sea*

The total Danish landing from the North Sea in 1987 was around 180 000 tonnes for human consumption and 900 000 for reduction into fish-meal and oil. Table 1 shows the total Danish landings from the North Sea divided into vessel category. The vessels are grouped according to type of vessel and size class.

Table 2 shows that of the total value of the landings was around 1.6 billion d.kr of which the human consumption was 1.2 billions. Also in terms of number of vessels the human consumption fleet is the largest in the North Sea. The total number of vessels fishing in the North Sea in 1987 was around 1200 vessels of which about 1050 vessels are fishing for human consumption the whole year or have more than 80% of the annual income from the human consumption fishery.

In the following I will briefly characterize the different groups of vessels fishing in the North Sea. The catch in value by species are for each vessel group shown in Figure 6a - 6d.

Beam trawlers

A group of about 20 small beam-trawlers fish for blue mussels and brown shrimps (*Crangon* sp.) in the Wadden sea.

The larger beam trawlers also fish for human consumption having plaice as of the most important species.

Trawlers - 20 GRT

About 130 small trawlers fish chiefly for human consumption in the North Sea. Plaice is the most important target species comprising about 50% of the total income from the North Sea fisheries. Some of these vessels took part in the sprat/herring fishery before the closure of the 'sprat box'.

Trawlers 20 - 60 GRT

This group of vessels consist of about 160 vessels which fish for human consumption. The group of mixed species for human consumption give the largest contribution to the income. Also cod and plaice and haddock are important target species. The vessels also fish outside the North sea (chiefly shrimps in the Skagerrak and Cod in the Baltic).

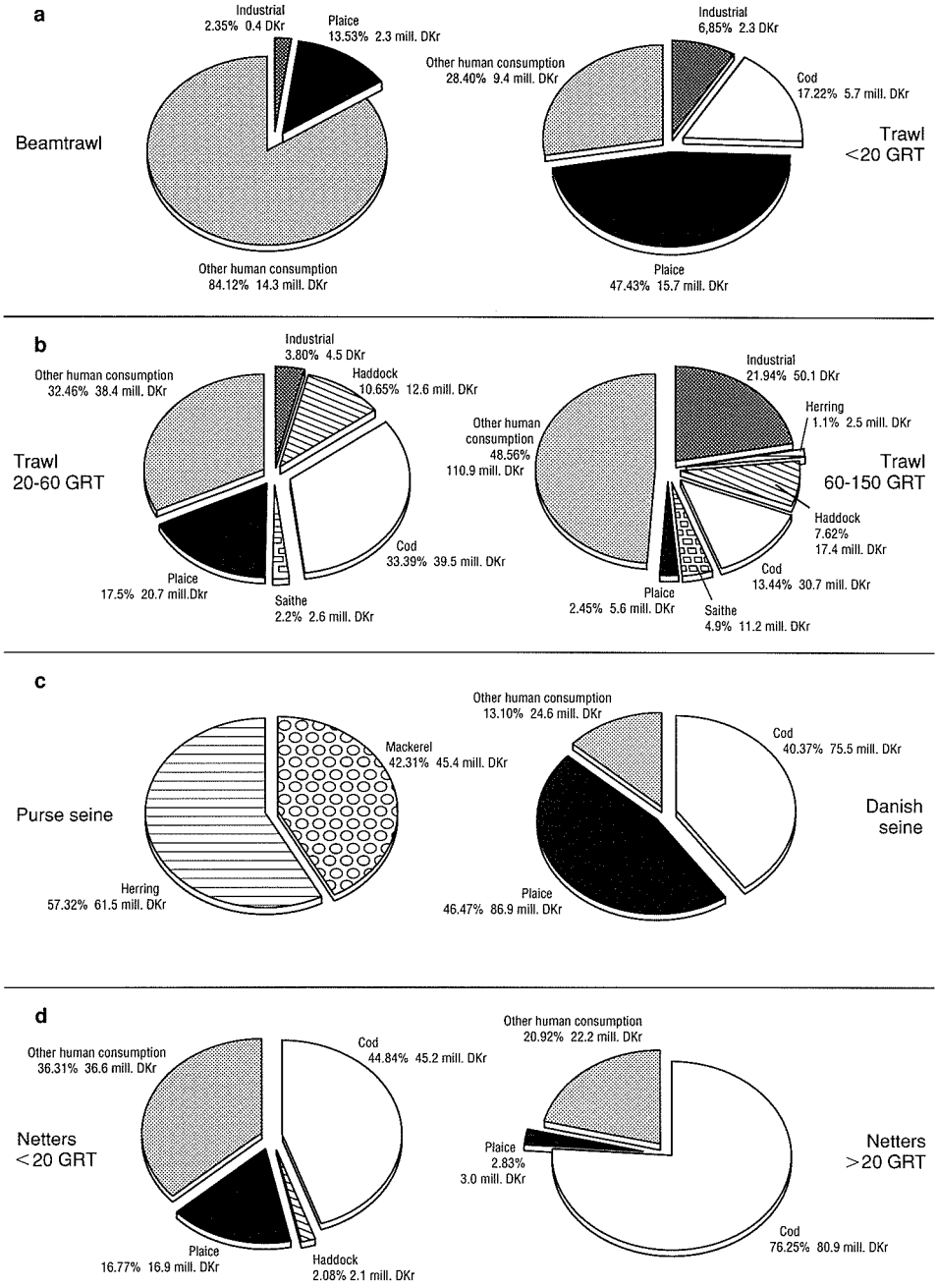


Fig. 6. a-d: Landings from North Sea by vessel group. Value in millions DKr.

Trawlers 60 - 150 GRT
This group is the largest of the human consumption trawlers with around 220 vessels. Mixed human consumption fishery is the most important fishery in 1987. The fishery for deep water prawns (*Pandalus*) was a very important fishery for several of the vessels in this group.

Industrial fishery of sandeel is an important part of the fishery for some of the vessels in this group in the period from April to June, and it contributes with about 20% of the income of this group.

Trawlers over 150 GRT
The larger trawlers between 150 and 250 GRT have 30% of their income (from the North Sea) from human consumption fishery. This group of trawlers also take part in the fishery for cod in the Baltic and other areas.

The larger trawlers (above 250 GRT) have between 10 and 20% of their income from the human consumption fishery of which the herring fishery is important.

Gill netters under 20 GRT
The small gill netters consist of around 160 vessel which fish for cod, plaice and sole and other human consumption species, especially turbot.

Gill netters over 20 GRT
The larger gill netters has cod as a dominating target species, the only other species which contribute significantly is turbot. In this group around 80 vessel are found.

Purse seiners
The eleven Danish purse seiners fish for herring and mackerel in the North Sea.

Danish seiners
The Danish seiners fish for plaice and cod and these two species are both in terms of value and quantity of similar importance for the fleet. Around 230 Danish seiners fished in the North Sea in 1987.

The broad picture of the Danish North Sea human consumption fishing fleet is that it consists of a large number of vessels chiefly below 150 GRT. A great variety of species are caught. This can be exemplified by the fact that, in 1987, the group 'other human consumption' species makes up 22% of the total value of all landings from the North Sea. Only cod is marginally more important. Also landings of plaice (14%), herring (5%) and haddock(4%) are important for the Danish fisheries in the North Sea. The relative importance of the different species, of course changes from year to year and this 'picture' from 1987 only suggest the magnitude and importance of each fishery.

The question is now whether this structure of the fleet will change in the future. The discussion of the likely future development of the resources in the North Sea both pertains to the industrial fishery and the human consumption fishery. The overall conclusion was here that it is unlikely that catches can be increased in the

future, and an increasing Danish fishery must be 'taken' from other countries, which would in turn reduce their fishing fleet in the North Sea.

Again we see that future development will depend on the management actions taken and the development of the economy of the countries in our region.

Now I will discuss a bit further the future management of the fishery. This problem cannot be considered for the Danish fleet alone. I will, therefore, first look at some trends in the European fishery in this century.

5.2. *The tendency towards specialisation in the North Sea fisheries*

The historic development of the share of the stocks in the North Sea can indicate potential development in the future.

Fig 7 shows the catches of plaice in the North sea in this century and it appears that the plaice fishery has been taken over by the Netherlands. For other species similar graphs can be made. Figure 8 shows that UK (Scotland) now takes a considerable part of the total haddock catches in the North Sea, and figure 9 shows that saithe is caught chiefly by Norway and France.

A concentration or a specialisation of the fishing fleets in the North Sea has been a general trend in the last decades. Only a few countries have been able to gain larger shares of the total landings or to increase the total landings. This is, of course, an effect not only of the competitiveness of the fleet, but also of the national policy in each country.

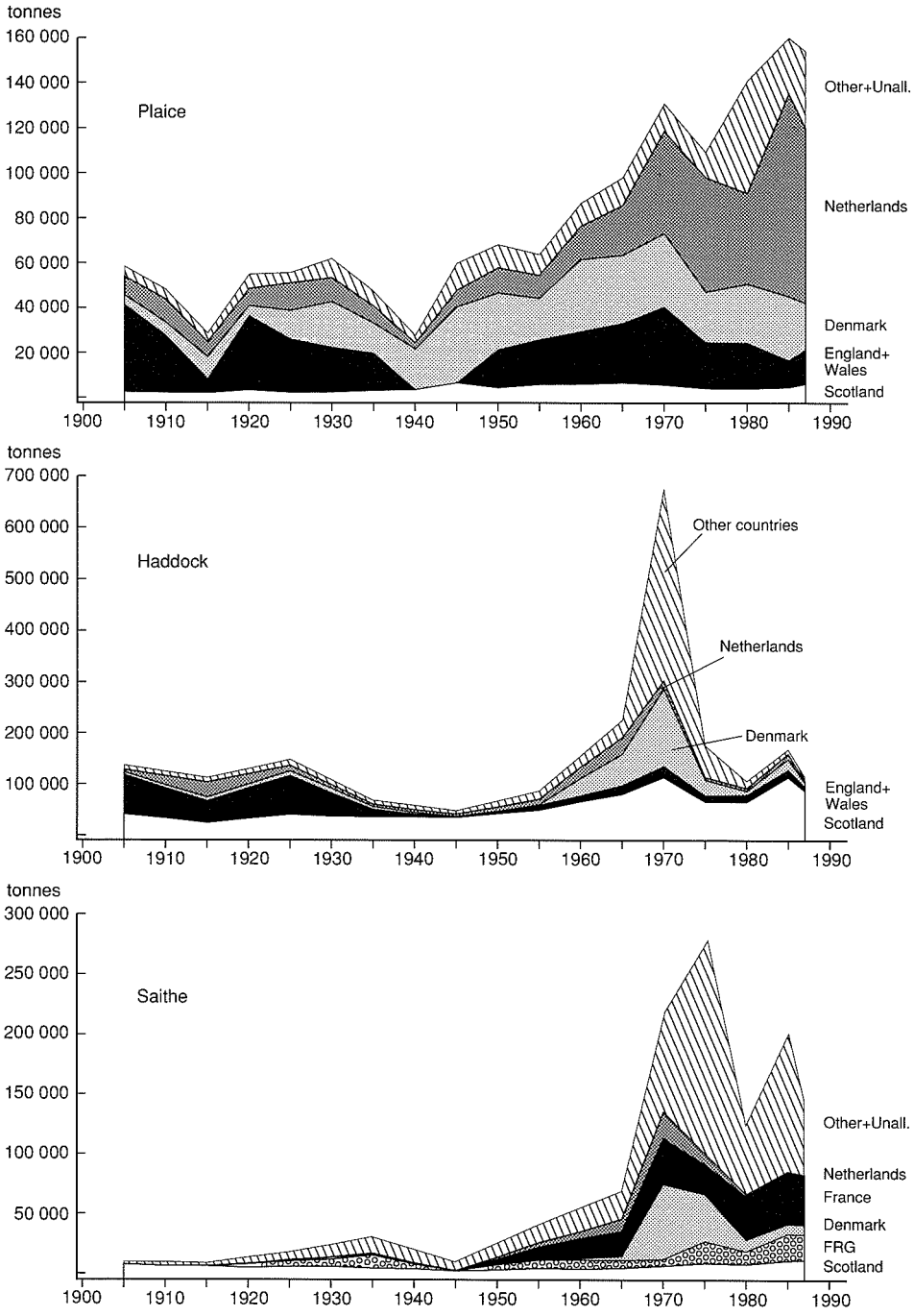
The proportion of landings by country for the main countries in particular fisheries is shown below in Table 3.

Table 3. The proportion of landings by country in percentages for the main countries in particular fisheries.

Species	Country						
	DK	UK(Scot.)	UK(Eng.)	N	NL	F	B
Cod	20	30	13	–	16	–	–
Haddock	10	75	5	–	1	–	–
Whiting	23	37	–	–	17	23	–
Plaice	20	4	10	–	58	–	–
Sole	3	–	–	–	72	–	15
Herring	23	15	–	42	16	–	–
Mackerel	27	+	–	57	10	–	–
Total hum. consumption	16	24	–	27	16	–	–

No other countries are above 5%.

The overall picture of the above concentration of the fishery in the North Sea is that we have three important EC countries Denmark, Netherlands and UK(Scotland), The Netherlands take a large share of the flatfish caught by their large and effective beam trawlers, and the UK(Scotland) takes large shares of the roundfish. Denmark has no fishery in which she dominates, but takes relative large shares of both flatfish and roundfish. All three countries and Norway fish the pelagic species herring and mackerel in more or less the same degree.



Figs 7-9. North Sea catches by country; plaice (Fig. 7), haddock (Fig. 8) and saithe (Fig. 9).

These tendencies are apparent even though the EC fishery policy since 1983 has fossilised the quota share by country.

In the long run, it will be interesting to see whether the concentration on specific fisheries will continue and Denmark be completely phased out of the North Sea human consumption fisheries or, whether the Danish spreading of interest will prove to be an advantage.

From my point of view, it seems probable that fleets which can fish several resources will be competitive because of the high exploitation of the North Sea.

Several stocks (and catches) now consist of a large part of small and young fish and a relatively small proportion of old fish. A couple of consecutive poor year classes can reduce the possible catch severely and, thereby, reduce the whole income of the highly specialised fleets. As an example it is expected that the haddock landings in 1989 will be only half the level in 1985-1986. The prospects for 1990 are also not very positive, with respect to haddock.

I believe, therefore, that it is most likely that the flexible fleets will survive and that the Danish fleet will maintain its relative size. Again, however, this statement depends on the fisheries policy.

5.3. *Fisheries management and economic development in future*

The agreed Common Fisheries Policy in the European Community is set for the period 1983-1992, and will be reconsidered in 1992. Access to 12 mile zones as well as rules for limited entry into some areas will be reviewed. In addition, the Single Market will be finalized at the end of 1992. Some pathways are mapped up to 2002 where the transitional agreements concerning Spain and Portugal expire.

The CFP of the European Community has an exemption from the right of establishment under the Treaty and freedom of access to the resources are limited to national fishermen within the national quota. The Total Allowable Catch is divided into national quotas according to historic rights.

If this system is still maintained after the year 2002, it should be easy to foresee a rather stable national fishery in the future. Bearing in mind the drastic changes in catch shares (Figs 7-9) during the last 20 years, one cannot really expect the present EC fleet structure to be 'frozen' for the future. In addition the accession of Spain and Portugal in the Community has implications on the CFP as well as a possible accession of Norway in future.

At the national levels, the fixed quotas lead to problems in distributing the fishery over the seasons in an economical way and the usual competitive mechanisms are out of force when the national quota is transformed into weekly boat quotas in some restricted fisheries.

There are several indications that the quota system will be changed to another fisheries management system and this is, at present, under discussion both at the political and administrative level and among fisheries scientist (IIFET conference, 1988).

I think that the most likely outcome of these discussions is that we will get a management system which limits the fishing effort through limited entry to the fishery. In the first phase, an individual licensing system will probably be given to the exist-

ing national fleets, but in longer term one can imagine that the licenses can be transferable on an EC license-market.

The vessels owners will then buy a license to fish for a group of species in a given management area, and it will be more relevant to consider the fleet operating from Denmark rather than the 'Danish fleet'. This is in fact a continuation of the development in the last 50 years where vessel operating in the North Sea can have its home port in other parts of Denmark.

One other aspect which will accelerate the tendency of other countries to fish from Denmark (and visa versa) is the general outlook for the food processing sector. OECD predict (OECD 1987) that the food processing sector in the future will have a highly internationalized market for their raw products, and that the growth potentials will be in highly industrialised products and prepared meals.

The future development of the Danish fishery is, therefore, not only dependent on the abilities of Danish fleet to adapt to future challenges but also on the structure of the fish processing sector.

The development in import of raw fish in the last 10 years seem to indicate that the Danish processing industry and outlets through the auction system is able to attract other fishing fleets.

I think that Denmark with its fishing industry has a good chance of being one of the major fishing centers in future.

5.4. *The future structure of the Danish human consumption fleet*

The structure of the Danish human consumption fleet has changed in the recent years. Firstly the Danish seiners have gradually been reduced over a long period. As an example, the number of seines were reduced to ⅓ in the period 1955 to 1975, and more than 90% of the vessels in the seiner fleet are more than 20 years old.

In contrast the gill netter fleet has increased. In this fleet, over 50% of the vessels are built after 1970. As discussed in section 3.3 this may be strongly associated with the increase in oil price in 1973 since gill netting is a much more fuel saving than trawling.

Another possible explanation for the increase in the gill net fleet is the high quality of the fish landed by gill netters. A comparison of Tables 1 and 2 shows that the price per kg of the cod taken by gill nets is about 50% higher than cod caught by trawlers. This is caused partly by better quality of the fish and partly by the fact that gill netters, on average, catch larger fish than trawlers through better selectivity of the gear.

The latter aspect is preferable from a resource conservation point of view, at least at the present levels of exploitation of the North Sea, and will coincide with the future concern for high landings of high value.

The expected increase in fish prices and fish becoming a luxury food taken in restaurants, and for prepared high quality meals will demand high quality products. Vessels must therefore be able to gut and cool the fish in a quick and hygienic manner. Furthermore the declining population (especially of young people) in Northern Europe, will lead to a mechanized procedure on board the vessels.

All these facts point to a continuation of the increasing trend in vessel size. Labour saving machines, cooling and storage devises can only be installed on larger vessels.

The demand for flexible vessels may, however, outweigh this development. An analysis of the target species for each fleet group show that, both for trawlers and for gill netters, the larger vessels concentrate their income on fewer species.

I think that it is most likely that both small and large vessels will exist. The large ones will be equipped with all sorts of information technology, both under water before catching, and to the factories for information on the actual demands on markets all over the world. The vessel will then preprocess the catch before final processing on the factory.

The smaller vessels will deliver a wide variety of species for direct human consumption. The fish will be landed fresh and of very high quality.

Finally, I believe, concerning the likely development of the numbers of the types of the vessels, the Danish seiners will probably continue to decline and completely vanish during the next ten to twenty years.A limited number of larger beam trawlers will take over the flatfish catches, but sufficient capacity in this fishery already exist in other EEC countries. Larger trawlers will then replace the small ones and they will be the core in the 'industrialised' human consumption fleet and the gill netters will probably take over more and more of the landings for direct human consumption.

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