On the management of Cod and Haddock in the North Sea

A report produced for the Scottish White Fish Producers Association Limited

By Jon Kristjansson, March 2003

Introduction

In October 2002 ICES proposed closure of the cod fishery and a reduction in the fishery for other demersal species in the North Sea. The reasons for this are given on the ICES website in an article by Robin Cook (Cook 2002):

The recent ICES advice (October 2002) relating to cod and associated species is the result of the cumulative failure to control fishing pressure on a range of stocks over the last decade. As long ago as 1992 ICES advice was, 'Recovery of the cod stock would require, at minimum, a marked and sustained reduction of effort or even a closure of the fishery'.

The advice was repeated in 1993. In 1996 ICES noted that 'recent analyses suggest that the stock may collapse under fishing mortality rates above 0.75. Present fishing mortality is above this level.'

ICES also stated that, 'As it is unlikely that a lower fishing mortality can be achieved by the application of technical measures and or TACs/quotas alone, ACFM believes that the required decrease can only be achieved by a reduction in effort in the directed fisheries for cod and the mixed roundfish fisheries which take a large cod component'.

It is quite clear that ICES believed that substantial action was required many years ago and warned that traditional management tools were not working. More recent advice in 2000 and 2001 was 'that fishing mortality on cod should be reduced to the lowest possible level' and re-iterated the failure of TACs to bring about the necessary reduction. This advice was only one step short of a closure.

***Fishing is virtually the only factor we can control** (the emphasis is mine, J.K.), so if we want a sustainable fishery for cod in the future, it is fishing pressure that we have to reduce. And because the reduction has been left so late, it has to be very big and very soon. Recent decommissioning is a step in the right direction, but unfortunately it is simply not enough to halt the decline. For Scotland, and some English boats there is an added problem. Since 1999 there have been no good year classes of haddock in the North Sea. That means the stock will decline rapidly after 2003 and unless a good year class appears soon, haddock could also collapse. The signs are that 2004 could be a crunch year for roundfish boats. We need to plan to face that problem now, it is not just cod that are in jeopardy. Scientists have wrestled with the problem of this very difficult advice knowing that it will have huge implications. It was not given lightly and it remains only scientific advice. The management challenges in dealing with it are enormous but they need to be faced if* *we are to have sustainable fisheries in the future.*

After visiting the fish markets in Aberdeen and Peterhead I was of the opinion that the haddock I saw showed clear symptoms of hunger. I concluded that if the haddock population was starving, it would neither help the cod, nor the haddock, to reduce the fishery. A cod taking to the bottom in its first year of life would have a hard time looking for food amongst large numbers of starving haddock. I considered the hunger symptoms to be the result of overcrowding, leaving little food for the individual fish. In fact I considered this might be the result of a long and continuous battle to reduce the fishing pressure. I expressed my views in an interview in Fishing News 26. January 2003.

Upon request of the Scottish White Fish Producers Association Limited, I agreed to undertake a further investigation of the fish and review the scientific arguments supporting the advice to reduce or close the fisheries. The results are presented below.

Materials and methods

Samples of haddock were collected for growth studies during a fishing trip with a Scottish seiner to the grounds north of Fraserburgh. I also collected samples at the fish market in Peterhead. Basic data on fishing and biological parameters were taken from ICES reports. Scales were used to determine age and for the back calculation of growth. A linear relationship between scale radius and fish length was assumed.

The management since 1987

As stated above, the main effort has been put into the reduction of fishing effort. The assumption behind this is the belief that the fishery is the main factor causing death of the fish (fishing mortality). Reducing fishing mortality will increase survival and the stock will increase, allowing for more catch later. For this to be true, there has to be a surplus of food, the food resource is not fully utilized.

Fishery biologists measure fishing effort in two ways: 1. By direct measurements of fishing effort, i.e. number of boats or fishing hours adjusted for the size of the vessels etc., or 2. By indirect methods which involve estimating the so-called instantaneous fishing mortality (F), the rate at which the fishery removes fish from the stock.

Since it often is difficult to get reliable information on the actual fishing effort from logbooks and the belief that technological advances are resulting in ever increasing fishing power of vessels, fisheries biologists tend to use the second method as the basis for their calculations. When they maintain that the fishing pressure has increased they really mean that the (calculated) fishing mortality has increased. This is very important and therefore needs further explanation:

Mortality is made up of two components, one resulting directly from the physical removal of fish from the stock through fishing (fishing mortality, F) and deaths occuring of natural causes (natural mortality, M). Natural causes include deaths caused by predation, diseases, parasites, malnutrition, unfavourable environmental conditions, loss of condition following spawning etc. The total (instantaneous) mortality (Z) is a combination of the two types of mortalities. The relationship between the different types of mortalities is:

$Z = F + M$

Generally, only Z, the total instantaneous mortality, can be measured at any given time. This is done by estimating how fast different year classes disappear from the stock, using data gathered by comparing the catch of the different year classes in research surveys or in landings from the commercial fleet between years. Fishing mortality (F) is not measured directly. It is **calculated** according to the equation above by subtracting natural mortality from the total mortality. Unfortunatly it is very difficult to measure natural mortality. Therefore it is **assumed** to be a "likely value" based on old information from different places. In most stock assessment work it is assumed to be a constant, but this is not likely to be the case. **M must be variable and constantly changing according to the present situation of the stock and/ or the environmental conditions, including competition or predation.** Since natural mortality is based on an "educated guess", so must estimates of fishing mortality similarly be regarded as guesses.

Change of fishing effort in recent years

a) Change in fishing hours

Figures 1 and 2 show the trend in effort of some demersal fleets in the past. It can bee seen that the fishing effort measured in vessels-hours has decreased dramatically in recent years. During the period the fishing pressure from the trawl fleet has been reduced by a factor of 4.5, and the seine fleet has almost disappeared (From ICES CM 2001/ACFM:07). In addition to reduction in fleet activity, mesh size in towed gear has been increased from 100-120 mm during the last two years. Since the selectivity of the gear is closely related to mesh size, this alone implies a great reduction in fishing pressure on small fish. This is in line with ICES recommendations to protect small fish:

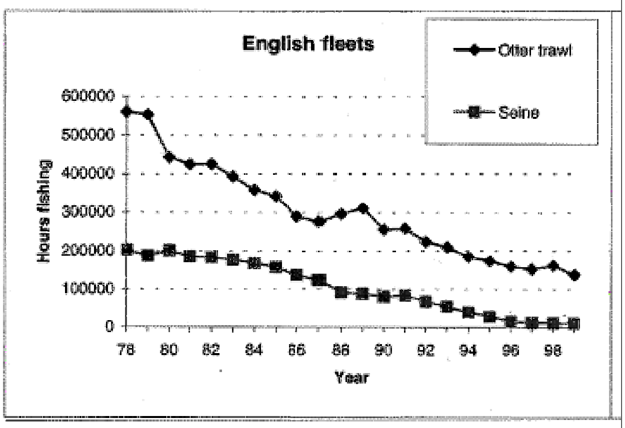

Fig. 1. The fishing pressure of the English trawl and seine fleets 1978-1999. (From ICES CM 2001/ ACFM:07).

"The newly agreed increases in minimum mesh size for North Sea fisheries, if implemented fully, would have a positive effect on the exploitation pattern of North Sea cod when fisheries taking cod eventually reopen. However, the implementation and enforcement of these measures has not been evaluated yet "(ICES Cooperative Research Report no. 255).

b) Fishing pressure measured as fishing mortality (F)

The following statement is taken from the latest ICES report: *Fishing mortality has remained at about the historic high and above* F_{pa} *since the early 1980s and F in 2001 is estimated to be above* F_{lim} (ICES Cooperative Research Report no. 255).

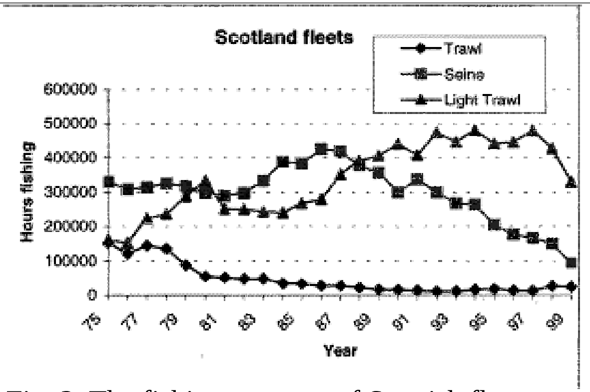

Fig. 2. The fishing pressure of Scottish fleets 1978-1999. She seine fleet has been reduced by a factor of 3 during the period and the light trawl fleet in 2000 is back to the 1987 level (From ICES CM 2001/ACFM:07).

Despite the fact that fishing hours of all fleets have been drastically reduced, ICES maintains that the fishing mortality has increased. Figure 3 shows increasing mortality through the whole period and very high value in year 2000. This contradicts the information on the reduction of the fleet/fishing days, but ICES chooses to rely more on this calculated information than hard facts from the real world, i.e. the reduction of the fleet and fishing days.

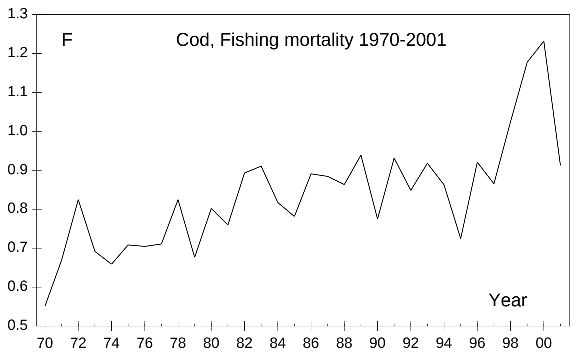

Fig. 3. Fishing mortality (F) of cod 1970-2001 according to ICES (ICES Cooperative Research Report no. 255)

The difference in the trend of fishing effort, as shown by fishing hours, versus calculation of the fishing mortality (F) is explained by increased fishing power of the fleet. But how likely is this? Has the fishing power of individual vessels increased several times during the last 15 years.

In my opinion **increased natural mortality** is the main cause for this apparent increase in fishing mortality. It has occurred during a period where growth rate has been declining and the condition of the fish falling. The proximate cause has to be that less food is available to the individual fish.

Year	Advice	Predicted catch corresp. to advice	Agreed TAC	Official landings	ACFM landings
1987	SSB recovery; TAC	100-125	175	167	182
1988	70% of F(86); TAC	148	160	142	157
1989	Halt SSB decline; protect juveniles; TAC	124	124	110	116
1990	80% of F (88); TAC	113	105	99	105
1991	70% of effort (89)		100	87	89
1992	70% of effort (89)		100	98	97
1993	70% of effort (89)		101	94	105
1994	Significant effort reduction		102	87	95
1995	Significant effort reduction		120	112	120
1996	80% of F(94) = 0.7	141	130	104	107
1997	80% of F(95) = 0.65	135	115	100	102
1998	F(98) should not exceed F(96)	153	140	114	122
1999	F = 0.60 to rebuild SSB	125	132	80	78
2000	F less than 0.55	<79	81	62	59
2001	lowest possible catch	0	48.6	42.3	41
2002	lowest possible catch	0	49.3		
2003	Closure	0			

Table 1. ICES advice, TAC and landings (tons x 1000) 1987-2001

(ICES Cooperative Research Report no. 255).

ICES advice on management in the past

As quoted above, the main advice has been to reduce the fishing effort. It is interesting to examine how the ICES recommendations have been adhered to.

Table 1 lists the recommendations each year, the TAC set by the politicians and the landings and fig. 4 shows a graph of the TAC and landings in the period 1987-2001. It can be seen that the politicians have followed the advice from ICES and the landings have in most instances been lower than the TACs.

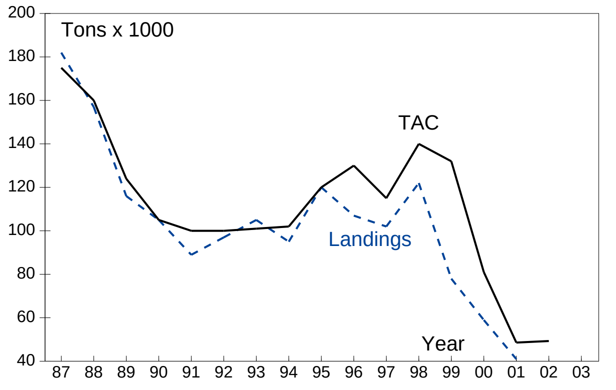

Fig. 4. ICES advice, TAC, solid line, and landings, broken line, 1987-2001 (ICES Cooperative Research Report no. 255)

The question arises why stocks decline when scientific advice has been followed so closely? ICES owes an explanation and I trawled through the report in order to find an explanation. The explanation given was this:

"Fishing mortality has consistently been underestimated and stock size overestimated in previous assessments, and the current assessment suffers from the same problem. The quality of the assessment improved in 2000 and 2001 due to the

exclusion of commercial CPUE data. This year the assessment again showed retrospective bias, possibly because of a decrease in the quality of the landings data in 2001." (ICES Cooperative Research Report no. 255).

By saying this ICES admits that they have based their advice on wrong measurements since 1987! There is no biology in the explanation. The report mentions that growth rate has declined, without trying to find a plausible reason:

"In recent years the growth rate of North Sea cod has declined. The reasons for this are not known, but if growth remains slow, the rate of recovery of SSB will be delayed. Slower growth may also expose juveniles longer to discarding" (ICES Cooperative Research Report no. 255).

Slower growth is usually a sign of food shortage , and should tell the managers that the assumption of excess food allowing "build up" of the stock does not hold. It has been suggested to use the growth rate as a measure of relative stock size (Hofstede 1973) and for management of lake fisheries in The Netherlands.

Why did the management fail?

In my opinion the assumption of surplus food, allowing for an increase of the demersal stocks in the North Sea, was wrong. When fishing pressure deceased, number of fish increased and less food was left for the individual fish. Selective fishing, caused by increased mesh size, that targets the bigger fish, has compounded the problem by altering the community balance (inter- and intra-specific competition, -predation). There are more small individual in the population and they face a stiffer competition from other species as well.

ICES admits that the growth in all fish stocks has been slowing down in recent years, without being able to explain it. This strongly supports the explanation of overcrowding:

"In all species, fluctuations in the weights-at-age have been observed over time (Cod, haddock, whiting, saithe, sole, plaice,). All of these show declines in the weights of higher ages within the recent ten years. In addition it is known from survey information that the strong 1996 and 1999 year classes of plaice and haddock, respectively, are delayed in growth. While the phenomenon is far from being well understood and may have different causes for different species, there are some common implications for assessment and management. Lower size at younger ages widens the time span, thus the amount of discarding of a year class, and the recruitment to the landings occurs at a later age. Both effects will distort the correlation of estimated stock numbers with survey estimates" (ICES CM 2001/ACFM:07).

Haddock off Scotland in 2003

At first glance the fish seen on the fish markets in Aberdeen and Peterhead were typical of a starving population, thin and maturing at small size. In order to verify the age and growth of haddock, samples were taken at the fish market in Peterhed and in a fishing trip at the grounds north of Fraserburgh. The results of age and growth analysis are shown in Appendix 1. It should be noted that the results represents this area only, even though fishermen informed me that the composition of the haddock catch was similar other places in the North Sea. Age and growth Fish of age 4 dominated the samples., being 78% of the Fraserburgh fish, 22% was 3 years old and most of the fish were sexually mature. Three year fish are growing more slowly than 4 year fish did at the same age. Back-calculations of length in exploited stocks frequently exhibit a tendency for computed lengths at given age to be smaller, the older the fish from which they are computed. This is called Rosa Lee's phenomenon, and can be explained by selective (fishing) mortality favouring greater survival of the smaller fish at a given age. The opposite is the case here: The growth of 3 year old haddock caught off Fraserburgh is slower than the growth of 4 year haddock. This indicates low fishing pressure, and could be caused by general reduction of the fleet, increased mesh size, from 100 to 120 mm in two years, or combination of both. Also, it is possible that the large 99- year class suppresses growth of younger fish, supporting the view that the large population of haddock is obstructing further recruitment of other species, i.e. cod. The fish at the fish market in Peterhead was larger than the Fraserburgh fish. Four year old fish dominated the samples, older fish grew faster than young fish, size at age and overall growth was better than in the Fraserburgh fish. This could be caused by gear selectivity, high-grading or local growth differences (Appendix 1).

Conclusion and discussion

It is beyond doubth that growth conditions for the individual fish, haddock in particular, in the North Sea have worsened in the last years. Environmental conditions, such as temperature, availability of food and competition determine the the growth rate. Growth rate is related to stock size if food production is constant, this is particularly well known from inland waters, and it has been suggested to use the growth rate for management purposes (Hofstede 1973). Onset of maturity in fish is related to growth and it is generally accepted that growth of individual fish decreases at or after the onset of maturity for then often to cease altogether.

This calls for an explanation. Size at sexual maturity is a highly variable feature within a species. It may vary considerably from one stock to another, and it may also be variable with time, reflecting temporal changes in living conditions. There is not one generally accepted view on how growth relates to maturity. In some cases it appears that the fish that grow fastest in early life mature earliest, and may mature at a smaller size than those who grow more slowly. This is usually most obvious in a pond where all the fish in the pond are of the same year class. In a given environment there are two basic things that limit the growth of a fish, i.e. availability and access to food and the size of the fish. In a uniform habitat (e.g. a pond), there is little opportunity for niche shifts. At a certain size, the environment cannot support more growth and this brings on the onset of maturity. In general then one can say that reduced growth brings on maturity causing further reduction in growth rate. Rate of growth thus generally decreases with increased size, a process that can usually be adequately described by the von Bertalanffy growth equation. The connection between growth and maturity has been extensively studied by several authors, and the relationship between size at sexual maturity and other population parameters is well known (Holt 1962, Beverton 1992). It is widely assumed that maturity brings on reduced growth, but several authors have challenged that view. They consider maturity to be the inevitable consequence of reduced potential for growth that follows increased body size if there is no ontogenetic niche shift (Alm 1959, Iles 1974, Pauly 1981). The slower growers sometimes mature at a larger size than those growing faster because in many species, the breeding season is well defined so the decision on whether to mature or not is only taken once a year. In a more heterogenous environment there are more available niches for fish than in the pond or limited environment. How the fish can use these niches depends on their adaptations (species) and within a species, on their size (Parker and Larkin 1959). There is and inverse relationship between body size and mortality in marine fish (Peterson and Wroblewski 1984).

Fishing of virgin populations often leads to increased recruitment, which in turn leads to reduced growth and reduced size at sexual maturity or stunting, especially when the largest individuals of the population are selectively removed (Langeland and Jonsson 1988). The North Sea can hardly be described as a pond but the area suitable for haddock is limited and growth rate can become density dependant. If retarded growth in haddock in the North Sea cannot be explained by change in environmental conditions, selective fishing or underfishing could be the cause. Present continued fishing pattern may eventually change the size composition of the stock to a further degree, i.e. maximum size may be further reduced and the average size of haddock become lower.

Following explanation can be put forward: When larger individuals are removed from a fish stock by selective fishing, competition (and cannibalism) decreases which in turn leads to increased recruitment. This leads to changes in stock composition towards smaller individual size and retarded growth. This situation is often misinterpreted as result of overfishing. A remedy to correct such a "skewed" fish stock would be to use unselective gear or combination of fishing methods that lead to unselective removals from the stock (Kolding 1994). Therefore, a management directed towards increased fishing pressure on small fish should be considered, as reduced fishing pressure on larger fish may not be practical or even possible. This is contrary to the existing management strategies, which suggest reduction or closure of fisheries, and regards large year classes as a positive sign for the development of the stock.

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Appendix 1

Analysis of haddock samples collected in Scotland in February - March 2003

Ageing and back-calculation

Scales from haddock were collected at sea off Fraserburgh and at the fish marked in Peterhead. The scales were used for age reading and back calculation of growth. A linear
relationship between scale length and fish length was assumed.

Fraserburgh

Scales were taken from 47 fish 25-39 cm long. 8 or 22% were immature, 29 (78%) were mature. Fish down to 25 cm were mature (fig. 1).
Three age groups were found, 2-4 years. Length distribution of three and four year old fish is shown in fig.2.
Mean lengths and back calculated lengths are shown in Table 1, and in fig. 2 shows the growth has been plotted.

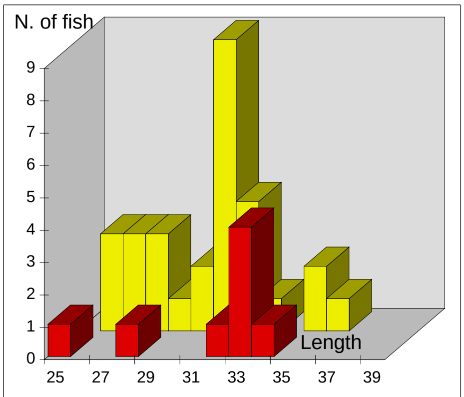

Fig. 1. Length distribution of immature (front) and mature haddock off Fraserburgh in March 2003.

Age	Weight (K=0.8)	Ycl	No	L	l_1	l_2	l_3	l_4
2	0.141	01	1	26.0	17.2	25.3		
3	0.175	00	13	27.8	14.4	22.7	27.8	
4	0.265	99	33	32.0	15.5	23.8	28.6	32.0

Table 1. Back calculated lengths of haddock caught off Fraserburgh in March 2003. L is total length and l_1, l_2 l_3 etc. are back-calculated lengths at first, second, third etc. winter. Weight, in kg is calculated, as if the condition factor, Fultons K, was 0.8. Note that 3 years old fish grow slower on the average than 4 years old fish.

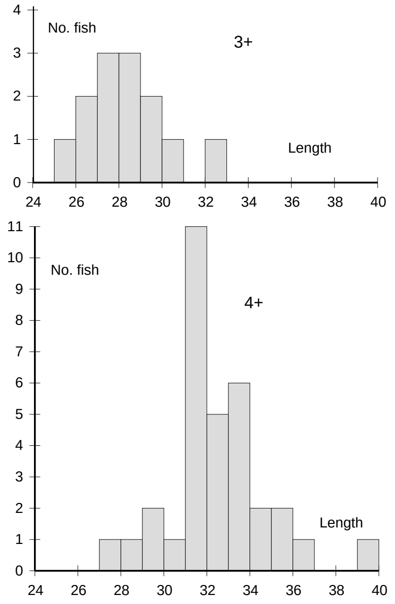

Fig. 2. Length distribution of 3 and 4 years old haddock from the Fraserburgh area.

Fig. 3. Growth of haddock caught off Fraserburgh in March 2003.

Peterhead

Samples were taken from gutted fish but I was told that most of them had been mature. Age and growth is shown in table 2 and the growth is plotted in fig. 4.
The fish was bigger than off Fraserburgh, it can be explained by different gear selection, high grading og different growth between localities. There was no information on where the fish was caught and the samples were from different pair-trawlers.

Age	Weight (K=0.8)	Ycl	No	L	l_1	l_2	l_3	l_4	l_5	l_6	l_7
4	0.359	99	17	35.1	16.3	25.6	31.5	35.1			
5	0.596	98	3	42.0	16.3	26.9	32.5	37.7	42.0		
7	0.636	96	1	43.0	16.5	26.2	33.5	39.0	40.3	42.1	43.0

Table 2. Back calculated lengths of haddock from the fish market in Peterhead in February 2003. L is total length and l_1, l_2 l_3 etc. are back-calculated lengths at first, second, third etc. winter. Weight, in kg is calculated, as if the condition factor, Fultons K, was 0.8.

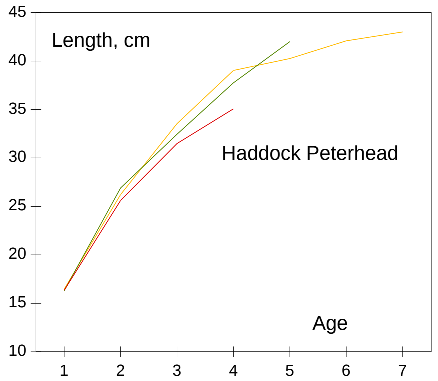

Fig. 4. Growth of haddock from the fish market in Peterhead in February 2003.