The 8th Norwegian-Russian Symposium
Bergen 15-16 June 1999

SOME CONSEQUENCES OF LONG-TERM MANAGEMENT STRATEGIES

Tore Jakobsen

Institute of Marine Research
Bergen

Introduction

Management strategies can be divided into three types: Short-term, medium-term and long-term.

A short-term strategy means that management decisions are made only for one year at the time. Usually the decisions are made on the basis of biological management advice, but this is not necessarily followed. Some medium- or long-term considerations may be involved, but they are often vaguely stated and secondary in the decision making. Unfortunately, most stocks are still managed in the short-term perspective.

A medium-term strategy typically deals with a period of 3-10 years. The aim can be rebuilding a stock to a desired level or avoiding a stock decline in the given period. Stability in catches could be another goal. The catch and stock projections usually involve estimates of uncertainty and risk analyses. The risk must be related to some reference point, normally a minimum desirable level of spawning stock biomass, e.g. B_{pa}. Medium-term strategies are gradually becoming more common. An example where it is applied in management is Norwegian spring-spawning herring.

A long-term strategy requires an agreement on the principles for management of the stock. The level of exploitation and the need for stabilisation of catches are important issues that must be addressed. A long-term strategy involves harvest control rules which specify how management actions relate to the state of the stock. Usually this means that pre-agreed management measures are introduced if the stock falls below a given level, e.g. B_{pa}. The strategy should be the result of a process where managers, fishermen, the fishing industry and scientists meet and discuss various strategies. This was done in Iceland where they agreed on the long-term strategy for Icelandic cod now in effect.

Long-term strategies can have many forms, simple or complex, and the advantages of a particular strategy may depend on the biology of the stock. Among the simple forms, a fixed F (fishing mortality) strategy (Figure 1) and a fixed TAC strategy (Figure 2) can be seen as two opposite extremes. The first allows catches to follow the natural fluctuations of the stock, the second, which in practice may be impossible to fully achieve, aims at stabilising the catches. The following discussion deals with some consequences of these two strategies applied to Northeast Arctic cod.

The Model

The large environmental fluctuations in the Barents Sea and their effect on the fish stocks represent one of the main challenges in modelling Northeast Arctic cod. In the present model, changes in the environment are indirectly represented through variation in recruitment. This is done by looking at recruitment success, i.e. actual recruitment compared to what would be expected from a spawning stock-recruitment relationship.

Having used the post war period as basis, stock fluctuations in the model show similarities with those experienced in this period. Density dependent growth, maturation and cannibalism is included, but the effect of a collapse in the capelin stock is not fully implemented. Apart from this, the main problem is how to model the behaviour of the cod stock at extreme high and low levels which are outside our range of experience. The simulations start with the stock from the most recent stock assessment and is projected forward 50 years. However, this is not a stock prediction, but a simulation of how the stock can be expected to react under various management strategies. The model is very preliminary and some of the results should be taken with caution.

The two strategies are run on the basis of the harvest control rules showed in Figure 1 and 2, i.e. fishing mortality and TAC, respectively, are reduced linearly when SSB falls below 500,000 t (B_{pa}) and will be zero if SSB falls below 100,000 t (B_{lim}).

Fixed F strategy

A fixed F strategy is simulated for fishing mortalities of 0.3, 0.4, 0.5 and 0.6 and the resulting catches are shown in Figure 3. Over the range of fishing mortalities from 0,4 to 0,6 there are small differences in average catch, but at 0,3 it is approximately 100,000 t lower. The maximum is reached at about 0.48, i.e. close to the F_{med} value of 0.46 which has been used by the Mixed Russian-Norwegian Fishery Commission. The mean catch level, about 850,000 t, appears to be high compared to historical levels. This seems to be linked to the recruitment level and could indicate some mis-specification in the model.

Figure 4 shows the corresponding levels of spawning stock biomass (SSB). Not surprisingly, low F gives high SSB and vice versa.

Although a fixed fishing mortality is the strategy, the harvest control rule will frequently come in force for F=0.5 and F=0.6 and this will temporarily reduce F (Figure 5). For F=0.4 SSB falls slightly below 500,000 t in one year, while it is always above 500,000 t for F=0.3.

There is also a clear correspondence between fishing mortality and the mean weight of the fish in the catches: Low mortality means more large fish in the catches (Figure 6).

With a stock showing fluctuations like the Northeast Arctic cod, a fixed F strategy will necessarily lead to variations in catches. However, these variations will increase substantially for F>0.4 (Figure 7).

Expected catch rates (e.g. catch per trawl hour) are approximated by the ratio C/F and will vary considerably for all fixed F strategies (Figure 8), although the variations will in practice probably be less than the figure indicates. However, the catch rates are clearly higher when fishing mortality is low.

Fixed TAC strategies.

Three fixed TAC strategies are simulated: For 600,000 t, 700,000 t and 800,000 t. In all cases the harvest control rules will come in force at the start of the period and during the period of poorest recruitment success in the model (Figure 9). It is, however, surprising to see that in the first part of the period 800,000 t can be maintained longer then 700,000 t and 600,000 t. This outcome is dependent on assumptions about recruitment and cannibalism at spawning stocks levels higher than experienced in the historical data and is clearly questionable, but demonstrates that the outcome of a fixed TAC strategy could be difficult to predict.

The SSB will in periods fall well below 500,000 t, but will for long periods be considerably higher for all options, and more than 2 million t for TAC=600,000 t (Figure 10).

Fishing mortality will be at a low level in a large part of the period, but is not as closely linked to the TAC level as might be expected (Figure 11). When the stock declines, fishing mortality will rapidly increase until harvest control rules are enforced. F levels needed to take the TAC may exceed 1.0 in the year before harvest control rules are introduced. Without harvest control rules the stock could at this stage be virtually wiped out in a couple years if the fleet capacity is large enough.

Also the catch rates show a somewhat surprising relation to the TAC levels (Figure 12), but are generally highest with a low TAC.

Discussion and Summary

The model is preliminary and will probably be somewhat adjusted after a closer scrutiny. Furthermore, it does not assume a situation with large fluctuations of the capelin stock which could change the results considerably. However, the main aim of this paper is to compare a fixed F and a fixed TAC strategy and in this respect the model seems satisfactory.

The results indicate that a fixed TAC strategy probably cannot be sustained over a long period even for a relatively low TAC. A fixed F strategy will give higher average catches which are not very dependent on the F level (but will decrease markedly if F is further increased). These simulations therefore clearly indicate that a fixed F strategy is preferable unless there are strong economic arguments for the higher catch stability, at least temporarily, obtained by a fixed TAC strategy.

Less fluctuations in catches, higher mean weight of the fish in the catches and higher catch rates are factors that would favour a relatively low F if economic considerations are taken into account in the fixed F strategies. This will have to be weighted against negative effects on other species by having a large cod stock.

If a long term management strategy is adopted it needs not follow the relatively simple approach outlined here. A number of other strategies are possible. It will, however, have to be based on the information available at the time and new scientific knowledge can change the basis for the strategy. Furthermore, the economic situation can change as well as the objectives of the managers and the industry. Therefore a long-term strategy is not meant to last forever and should at any rate be regularly re-evaluated. If the strategy shall be effective, however, it must not be discarded only because TAC levels start declining. With a stock like the Northeast Arctic cod this is unavoidable in the long run and should be part of the common understanding of how this stock behaves.

Figure 1. Fixed F management

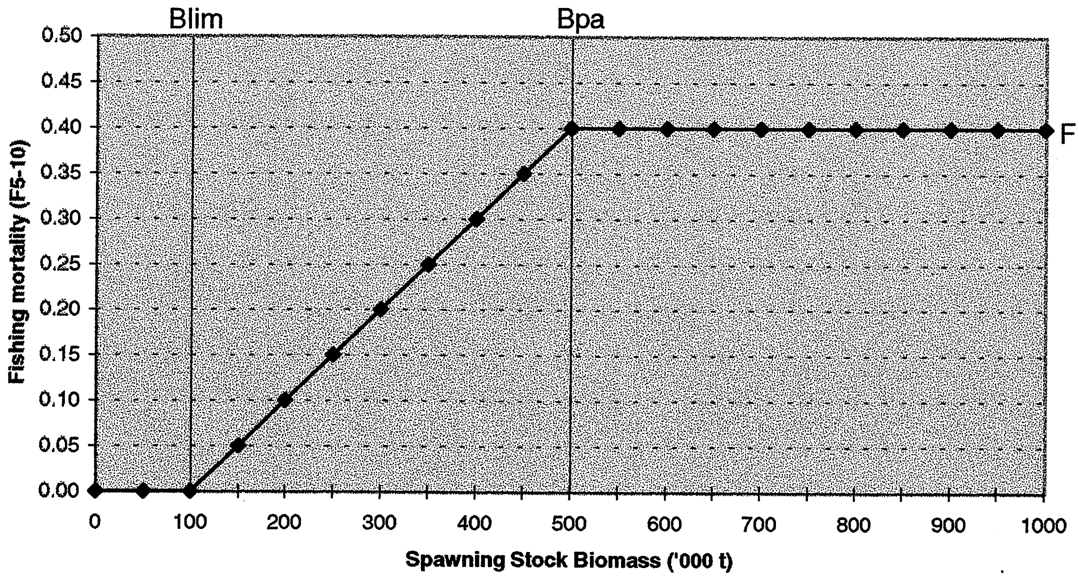
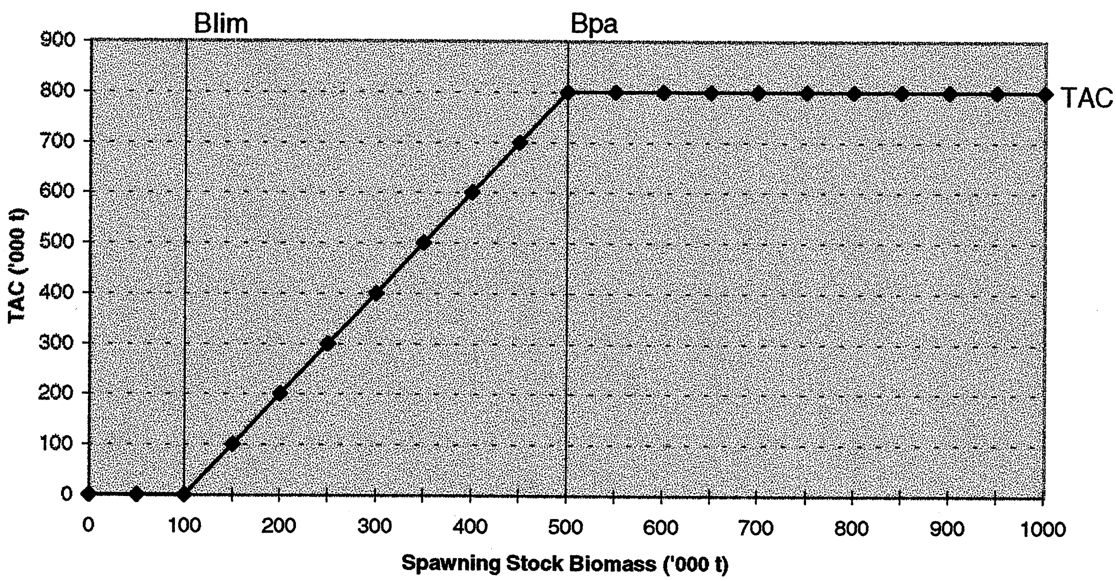


Figure 2. Fixed TAC management



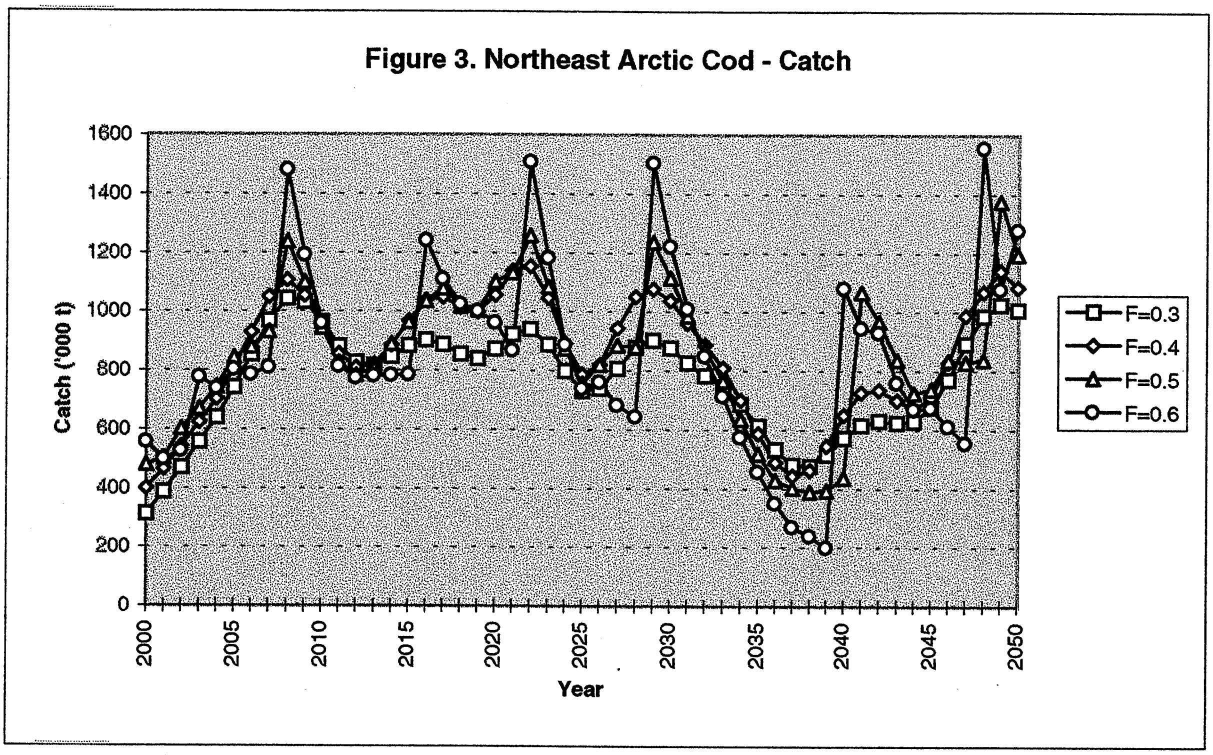


Figure 3. Northeast Arctic Cod - Catch
Catch ('000 t)
0
200
400
600
800
1000
1200
1400
1600
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Year
F=0.3
F=0.4
F=0.5
F=0.6

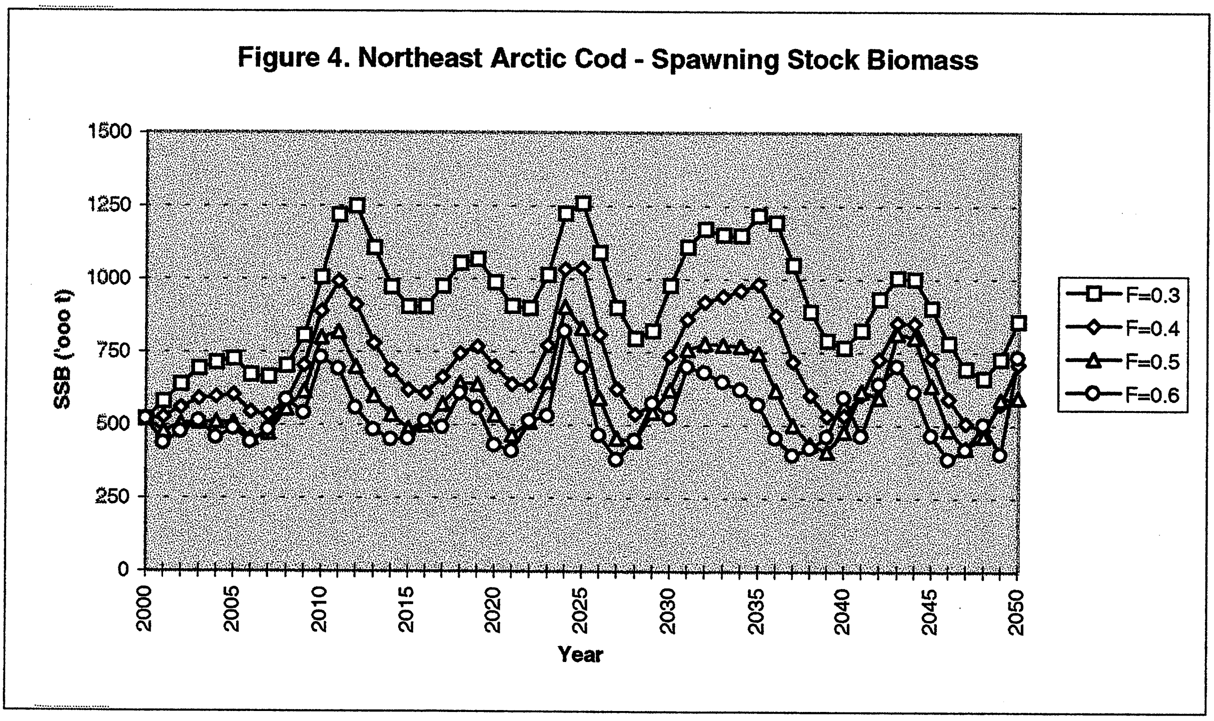


Figure 4. Northeast Arctic Cod - Spawning Stock Biomass
SSB ('ooo t)
0
250
500
750
1000
1250
1500
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Year
F=0.3
F=0.4
F=0.5
F=0.6

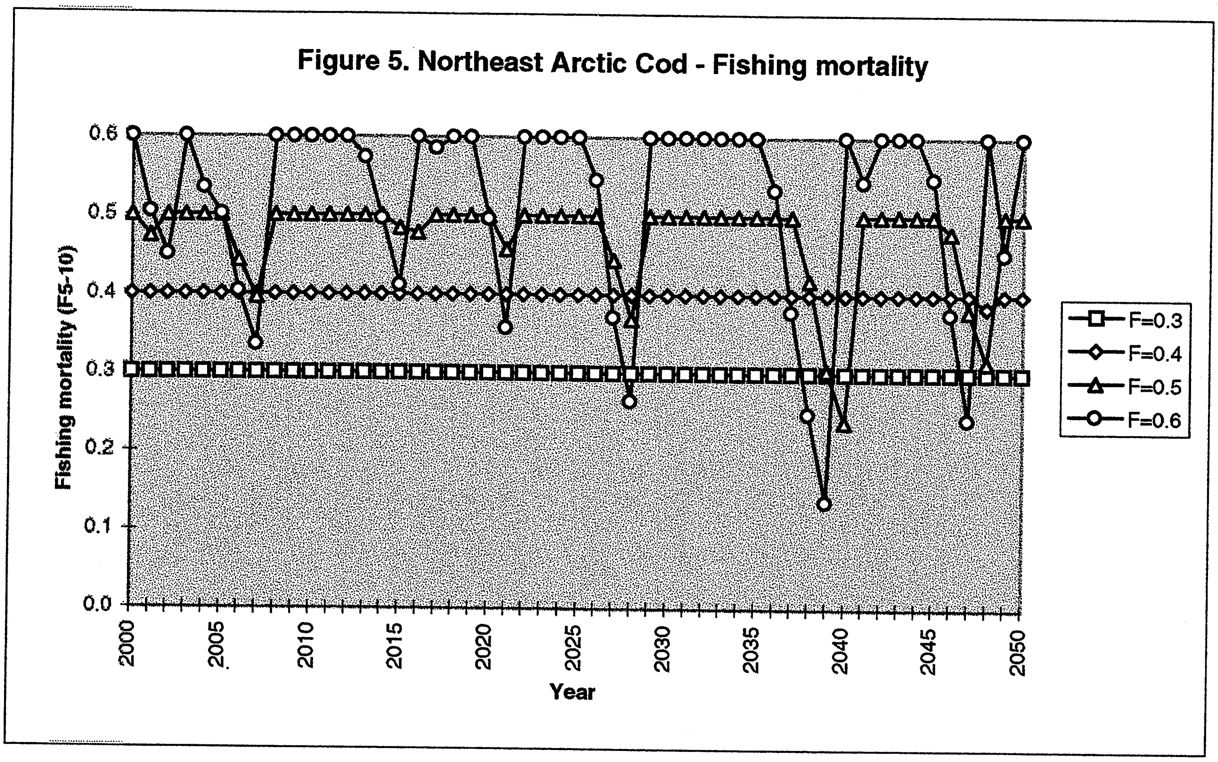


Figure 5. Northeast Arctic Cod - Fishing mortality
Fishing mortality (F5-10)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Year
F=0.3
F=0.4
F=0.5
F=0.6

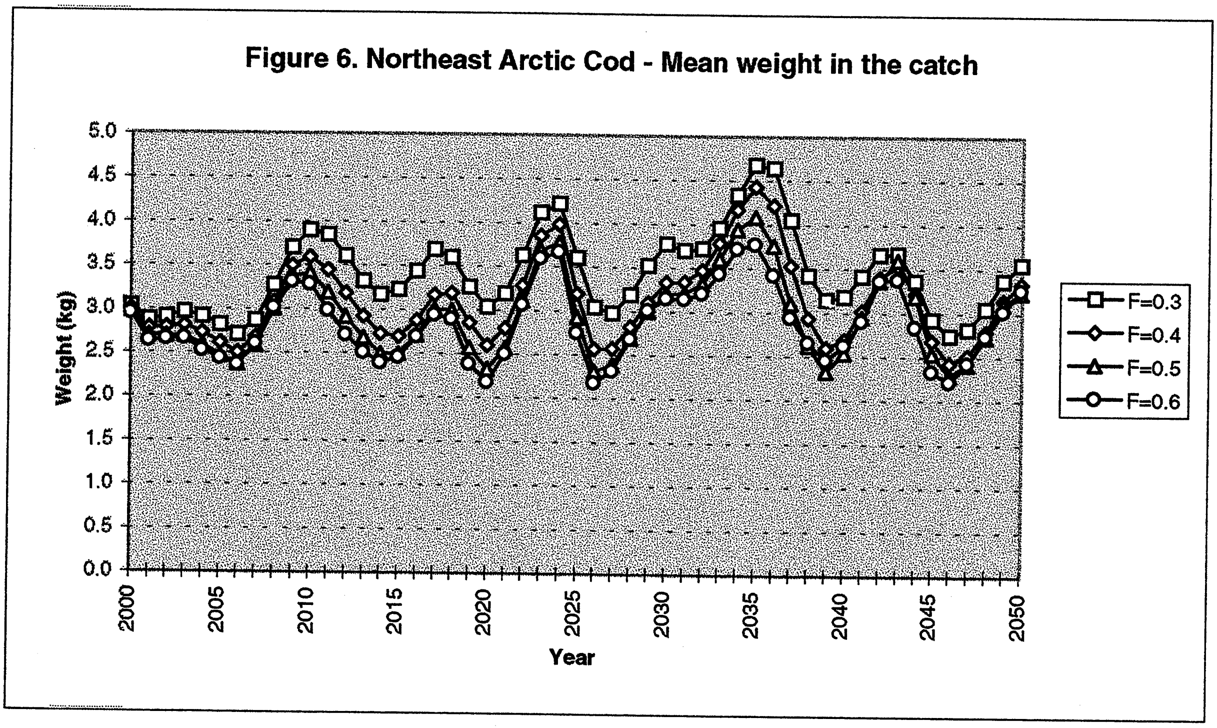


Figure 6. Northeast Arctic Cod - Mean weight in the catch
Weight (kg)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Year
F=0.3
F=0.4
F=0.5
F=0.6

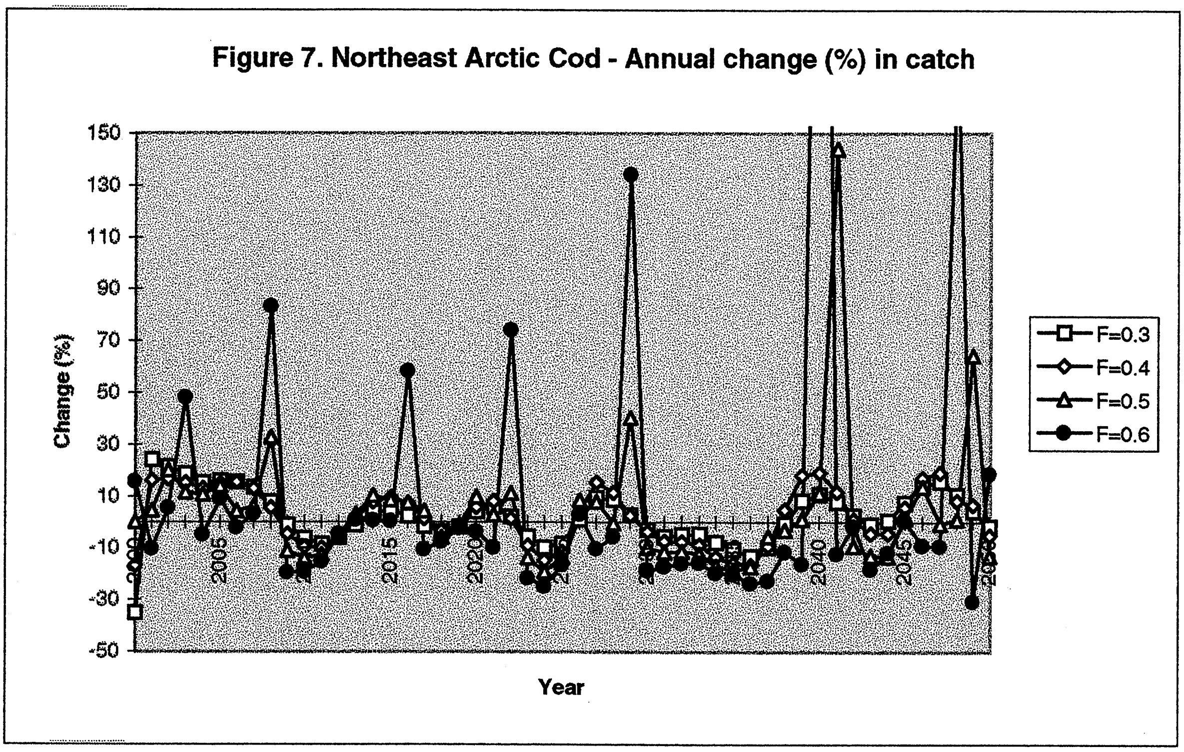


Figure 7. Northeast Arctic Cod - Annual change (%) in catch
Change (%)
Year
F=0.3
F=0.4
F=0.5
F=0.6

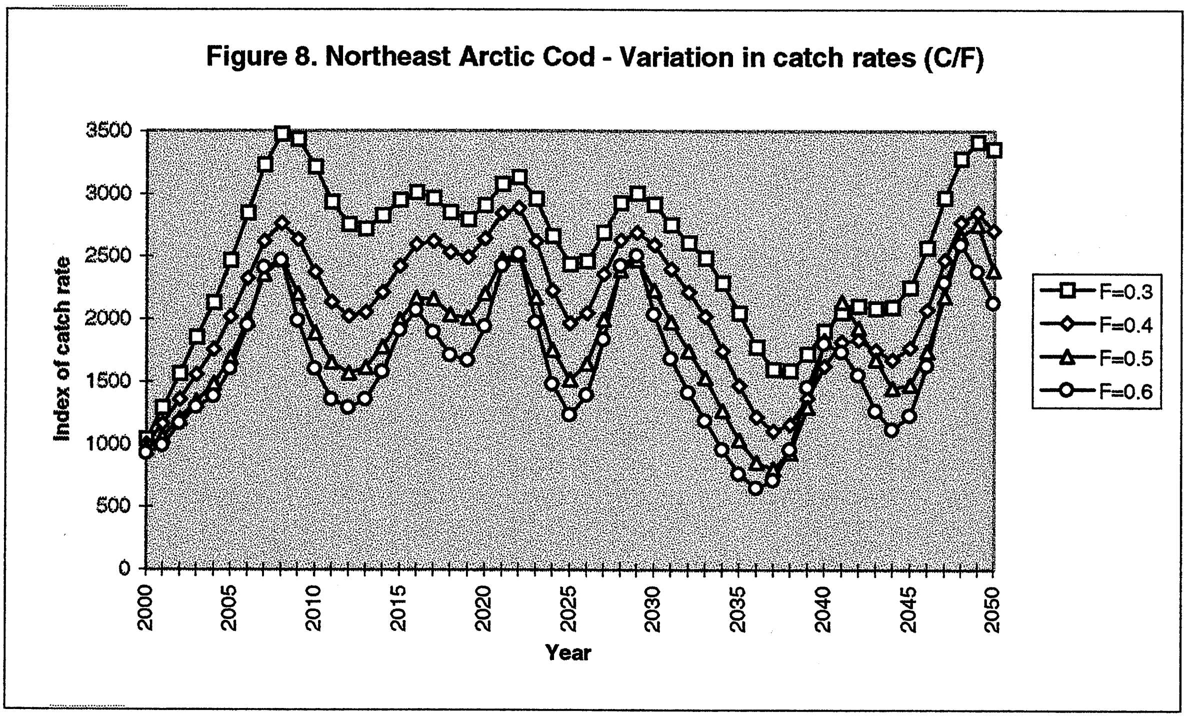


Figure 8. Northeast Arctic Cod - Variation in catch rates (C/F)
Index of catch rate
Year
F=0.3
F=0.4
F=0.5
F=0.6

Figure 9. Northeast Arctic Cod - Catch

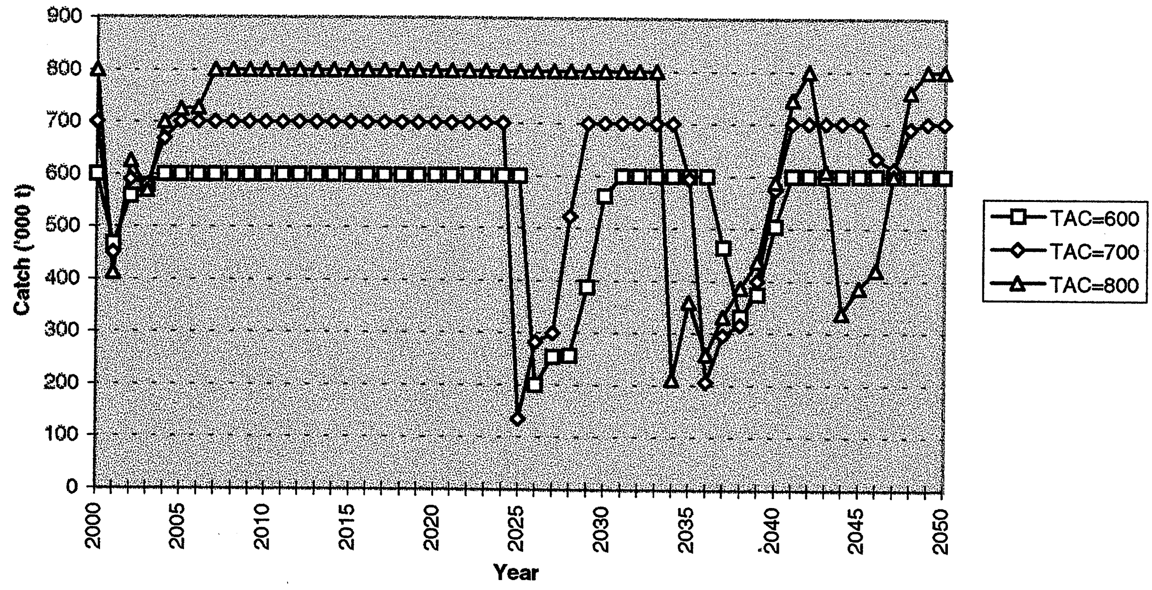


Figure 10. Northeast Arctic Cod - Spawning Stock Biomass

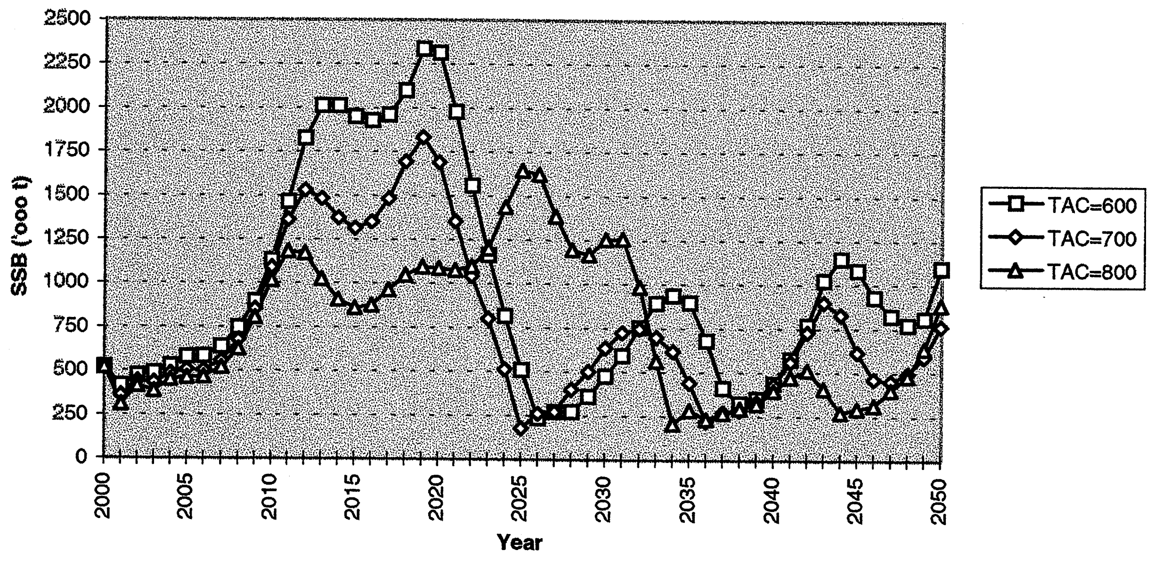


Figure 11. Northeast Arctic Cod - Fishing mortality

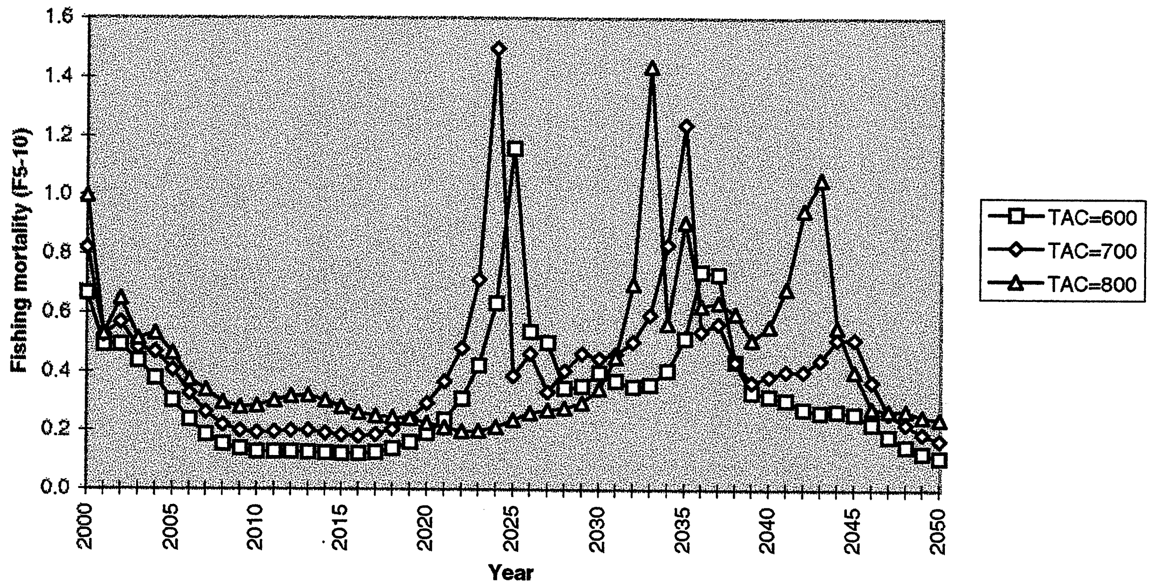


Figure 12. Northeast Arctic Cod - Variation in catch rates (C/F)