ICES 1990 PAPER C.M. 1990/G:32
Ref. B

EFFECTS OF TRAWLING AND LONGLINING ON THE YIELD AND BIOMASS OF COD STOCKS - NUMERICALLY SIMULATED

by

Åsmund Bjordal 1) and Taivo Laevastu 2)

1) Institute of Fisheries Technology Research, P.O. Box 1964, N-5024 Bergen, Norway.

2) Alaska Fisheries Science Center, 7600 Sand Pc
Seattle, WA 98115, USA.

23a

ABSTRACT

Numerical studies were conducted on the effects of trawl and longline catches on a cod stock and possible yields from it.

Five year mean age composition of Pacific cod (<u>Gadus macrocephalus</u>) from the Bering Sea was used as initial age composition of the stock, which was normalized to 1 ton. Age specific Z (total mortality) was computed from this distribution and natural mortality was derived by subtracting fishing mortality from Z. Age compositions of catches were either prescribed from empirical data or created with fishing mortality coefficient (F), which was assumed constant with age after the age of full recruitment. The computations were done with different catch levels for six years assuming average constant recruitment.

Essential results of this study are: a) The stock left in the sea decreases with increasing catch and reaches an equilibrium if recruitment and catches remain constant. With similar catch levels this equilibrium is reached earlier with longline and is higher than that of trawl. b) If a given level of stock in sea is desired, higher annual catches can be taken with longlines than with trawl. c) By the same catch size longlines remove more older and more piscivorous fish which is beneficial to recruitment if the latter is largely controlled by predation.

The above mentioned essential results indicate, among others that some longline fishing might be allowed to continue when TAC for trawlers has been reached.

INTRODUCTION

Until the 1950-ies it was believed that fishing had a minor impact on the size and variability of the fish stocks. The relative impact of fishing on stocks versus natural fluctuations is to some extent still unclear. However, increased fishing effort and improvement of fishing gear and methods have during the last 30 years coincided with a considerable decrease of major fish stocks despite a rising number of regulations to manage the fish resources.

Today there seems to be general agreement among fisheries scientists that fishing has a significant impact on the dynamics of fish populations, and that this impact is dependent on the status of the stocks. Further, it is known that the main fishing gears operate with different principles of capture and with different size- and species-selective properties. Proper management of fish stocks should therefore not only be based on recommendations on total catch quotas but also on how these quotas should be taken. However, the catching regime for harvesting a given quota is to a large extent decided on the basis of the traditional composition of gear types within a fishing fleet, with little attention to the conservation effects on the fish stock of given gear types.

Some authors have recently focused on multigear exploitation of groundfish stocks. Laevastu and Favorite (1988) reviewed the effects of fishing and the "optimum take". Analyzing the effect of different trawl gears in a mixed species fishery, Murawski et al. (1989) pointed out the negative impact of discards of undersized target species on proper stock assessment and future yield. Wespestad et al. (1982) recommended restrictions on bottom trawling to reduce the by-catch problem of crabs and halibut in the Bering Sea groundfish fishery, while similar restrictions were not found necessary for longlines and off bottom trawling. O'Boyle et al. (1989) compared the bioeconomical effects of trawl and longline fishing in the Scotian shelf groundfish fishery and concluded that the yield and employment picture was superior for the longline fishing and that regulatory acts were necessary only for the trawler fleet. Comparing the size distribution of landed cod catches (not including discards), Bjordal (1989) showed that trawl and seine net catches contained 19% small cod while corresponding values for longline and gillnet were 6% and 2%, respectively. He also compared the conservation aspects of trawls and longlines and, although data are scarce on several conservation topics such as discards, survival after escapement and environmental effects, existing knowledge clearly indicates the conservational superiority of longlines versus trawl.

In order to recommend an optimal catching regime (gear type and effort) in a certain fishery, total bioeconomical models should be developed which include data on the conservational aspects of the different gear types: species- and size selectivity, discards, survival after escapement, fish quality, ghost fishing, environmental aspects and energy conservation as a basis for socio-economic and management considerations.

In the present study we have focused on the effects of trawling and longlining with different catch levels and age composition of catch on the stock remaining in the sea, using a numerical model.

Materials and Methods

A numerical simulation was used in this study. The initial age composition of the stock in the sea was taken as the five year mean (1983 to 1987) age composition of the cod (*Gadus macrocephalus*) stock in the Bering Sea (Fig. 1). The recruitment to the exploitable stock was assumed to be constant and equal to the five year mean recruitment. The initial stock size was normalized to 1000 kg and the corresponding initial distribution of numbers in different age classes was computed.

The five year mean age composition of the stock was also used to compute total mortality (Z) (Fig. 2), from which age dependent natural (or senescent) mortality was obtained by subtracting estimated fishing mortality which was assumed to be 15 percent of exploitable population and constant with age after full recruitment to the exploitable stock.

Two different age compositions of trawl and longline catches were used in the study. In one set of simulation runs, a number based fishing mortality was used, which was assumed to be constant with age after the age of full recruitment. In the second set of runs mean age compositions of Japanese trawl and longline catches from the Bering Sea in 1983 were used (Fig. 3). Computations were done for six years with each prescribed catch level (80kg, 160kg, and 240kg, and F=0.10, 0.15, and 0.20). The quantitative interaction between fishing mortality and senescent

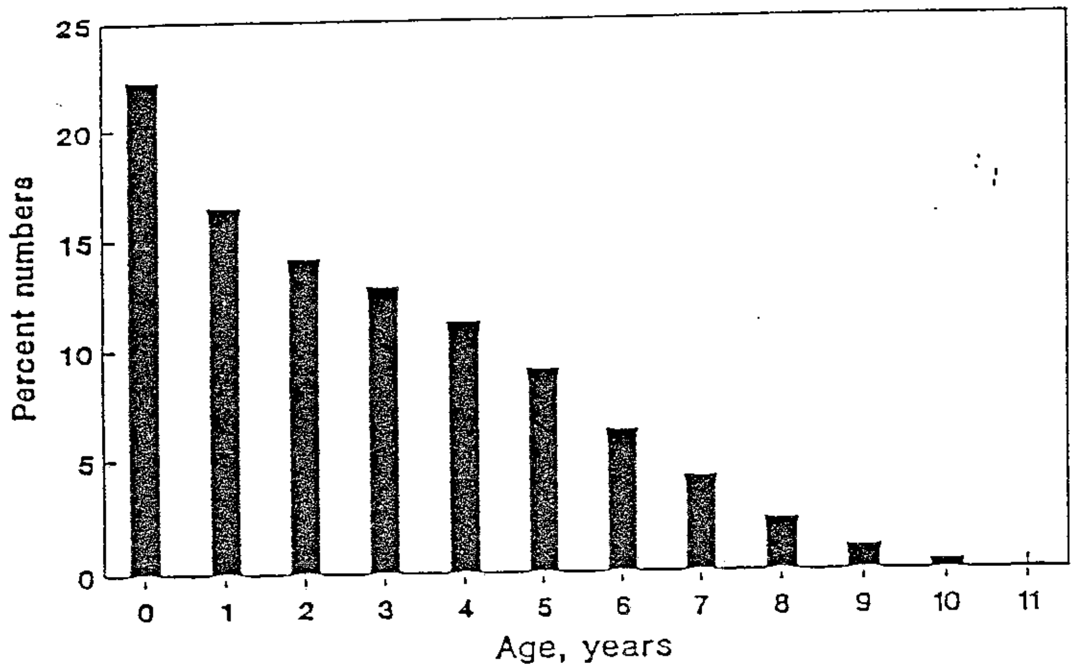

Figure 1. Initial age composition of Bering Sea cod stock (five year mean, 1983-87).

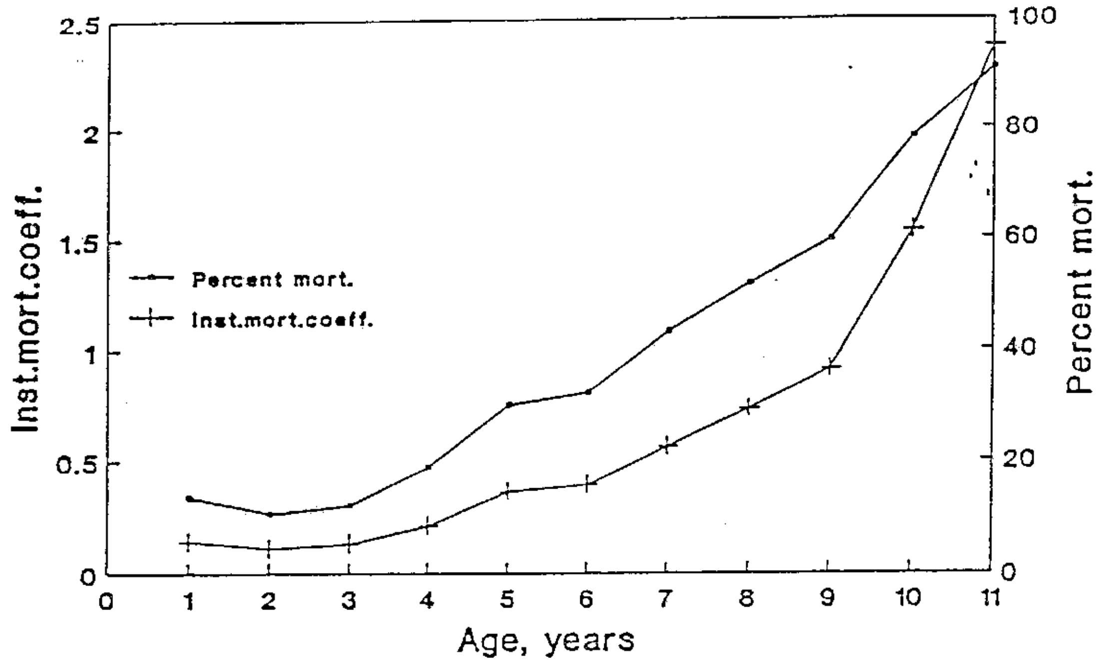

Figure 2. Total mortality of Bering Sea cod, expressed as instantaneous fishing mortality coefficient and as percentage mortality of a given age group (re. numbers).

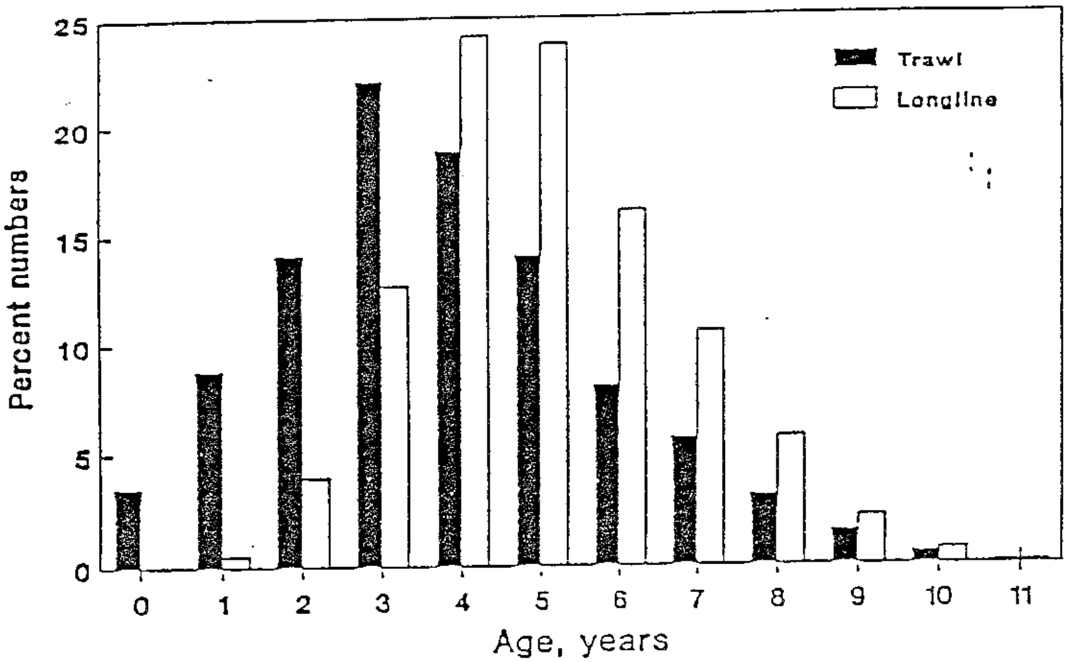

Figure 3. Age composition of Japanese trawl and longline catches (cod, Bering Sea, 1983).

mortality was taken from a numerical study by Laevastu and Bax (1986). The numerical simulation model (documented in the Appendix) can be used for the study of the effects of trawling and longline fishing in any combination of effort (catch) by these gears. In this report we present only some essential differences of these gears on the biomass remaining in the sea.

Results

The basic difference between the age composition of trawl and longline catches is that the age (size) of full recruitment to exploitable stock is one year earlier in trawl catches than in longline catches (Fig. 3). More prefishery juveniles are caught with trawls than with longlines, and consequently the amount of discards is higher from the trawl catch than from the longline catch. The amount of discards depends on several conditions. In our model the trawl was assumed to catch 26 percent of fish (numbers) younger than the fully recruited age class (3 year old). The corresponding value for longlines was assumed to be 17 percent (4 year old).

In the runs with prescribed catch amount both trawl and longline were assumed to catch equal given weight. However, if the catch is prescribed with number based fishing mortality coefficient F the amount (in weight) caught by the same F is not necessarily equal due to higher catch of young fish by trawl. The senescent (or natural) mortality remains higher than the fishing mortality even if fishing mortality (F) is 0.2.

If the recruitment to prefishery juveniles remains constant from one year to another (as was prescribed in the simulation runs), then with equal fishing mortality (F) a lower number of fish remain in the sea with trawl than with longline fishing (Fig. 4). This is mainly because the fishing mortality of trawl catches starts one year earlier than longline catches. The difference in fish biomass (weight) remaining in the sea after four years of fishing with trawls versus longlines is even more noticeable than the difference in numbers (Fig. 5).

With increasing annual catches the number of fish left in the sea decreases. By the same amount (weight) of catch this decrease is considerably greater when the stock is exploited by trawl compared with that of longlining (Figs. 6 and 7). Consequently the fish biomass in the sea decreases with increasing annual catch during the first 4 to 5 years. However, if the annual catch remains constant, the biomass left in the sea reaches an equilibrium level which is dependent on the size of the annual catch. At the same catch level this equilibrium biomass is higher in case of longline catches than trawl catches (Figs. 8 and 9).

Discussion

This numerical study demonstrates that the exploitation strategy may have a marked influence on the dynamics of a fish stock. In this case it is predicted that if a given catch quota of cod is taken by longlines, a higher biomass will remain in the sea than if the same quota is fished with trawls. This effect is mainly caused by the different selective properties of the two gears, as the first fully recruited year class in the trawl

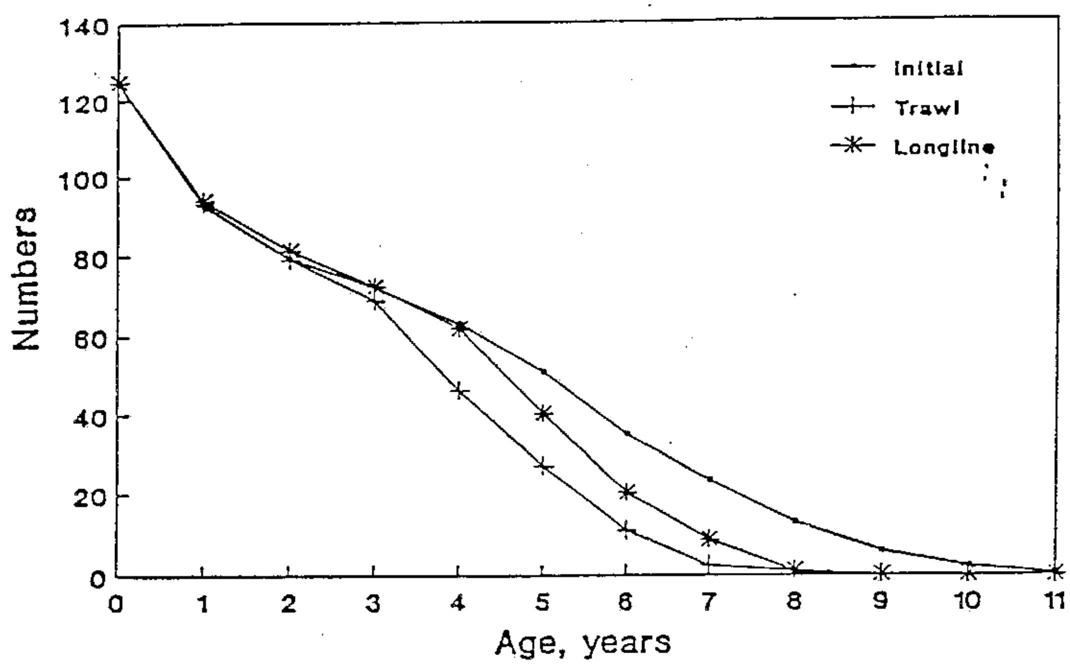

Figure 4. Number of fish in the sea of different age groups, initially and after four years of trawling or longlining (F=0.2).

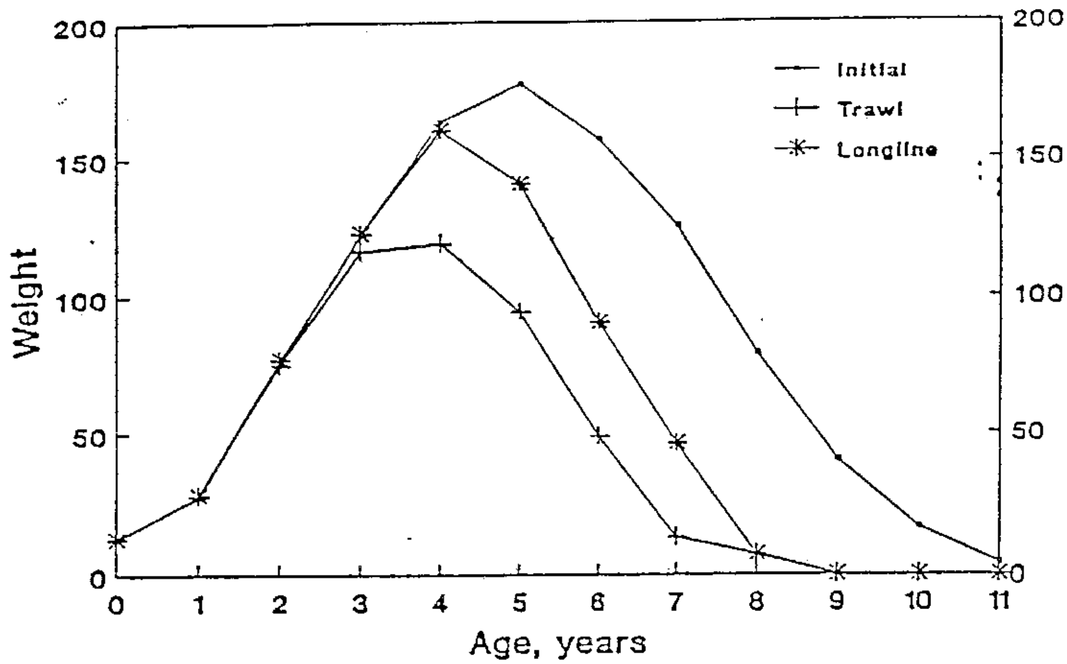

Figure 5. Weight of fish in the sea of different age groups, initially and after four years of trawling or longlining (F=0.2).

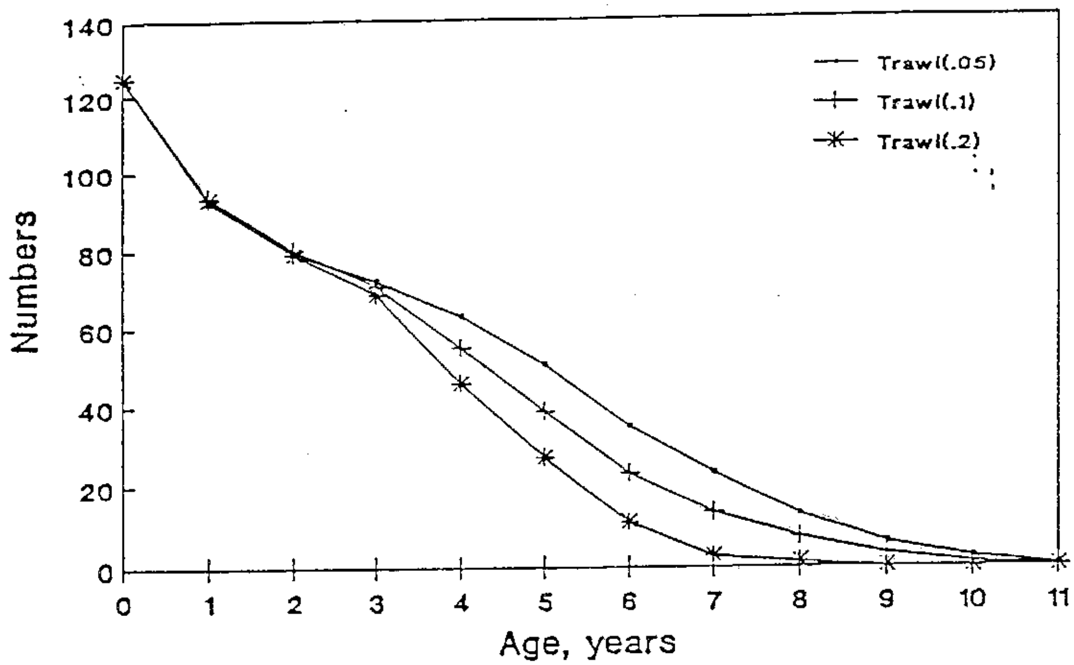

Figure 6. Age composition of fish in the sea after 4 years of trawling with different fishing mortalities (F=0.05, 0.10, and 0.20).

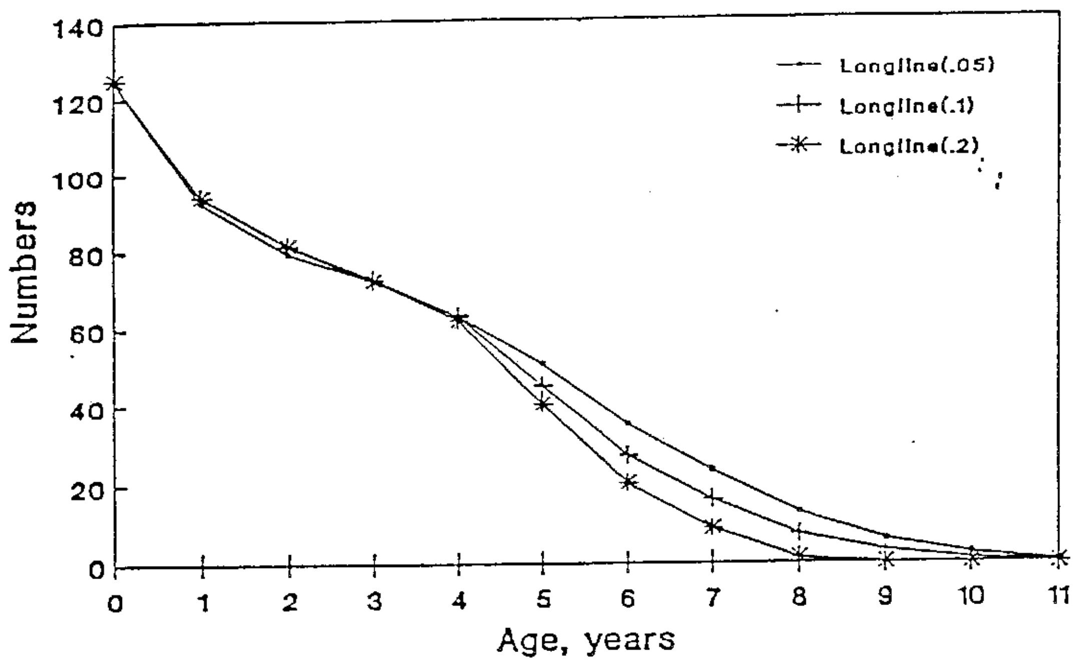

Figure 7. Age composition of fish in the sea after 4 years of longlining with different fishing mortalities (F=0.05, 0.10, and 0.20).

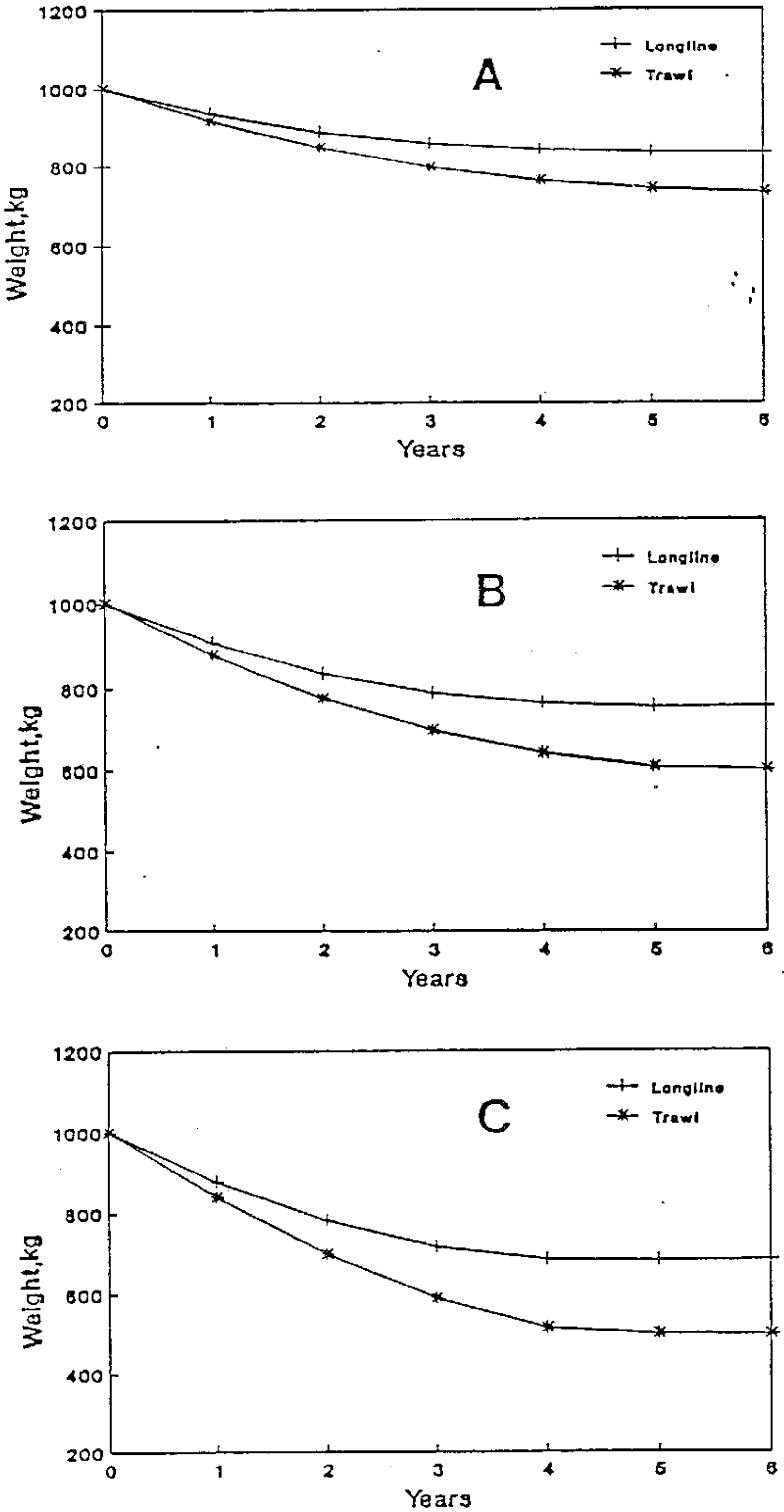

Figure 8. Biomass reduction during six years of trawling or longlining with fishing mortalities of 0.1 (A), 0.15 (B), and 0.2 (C) (initial biomass = 1000 kg).

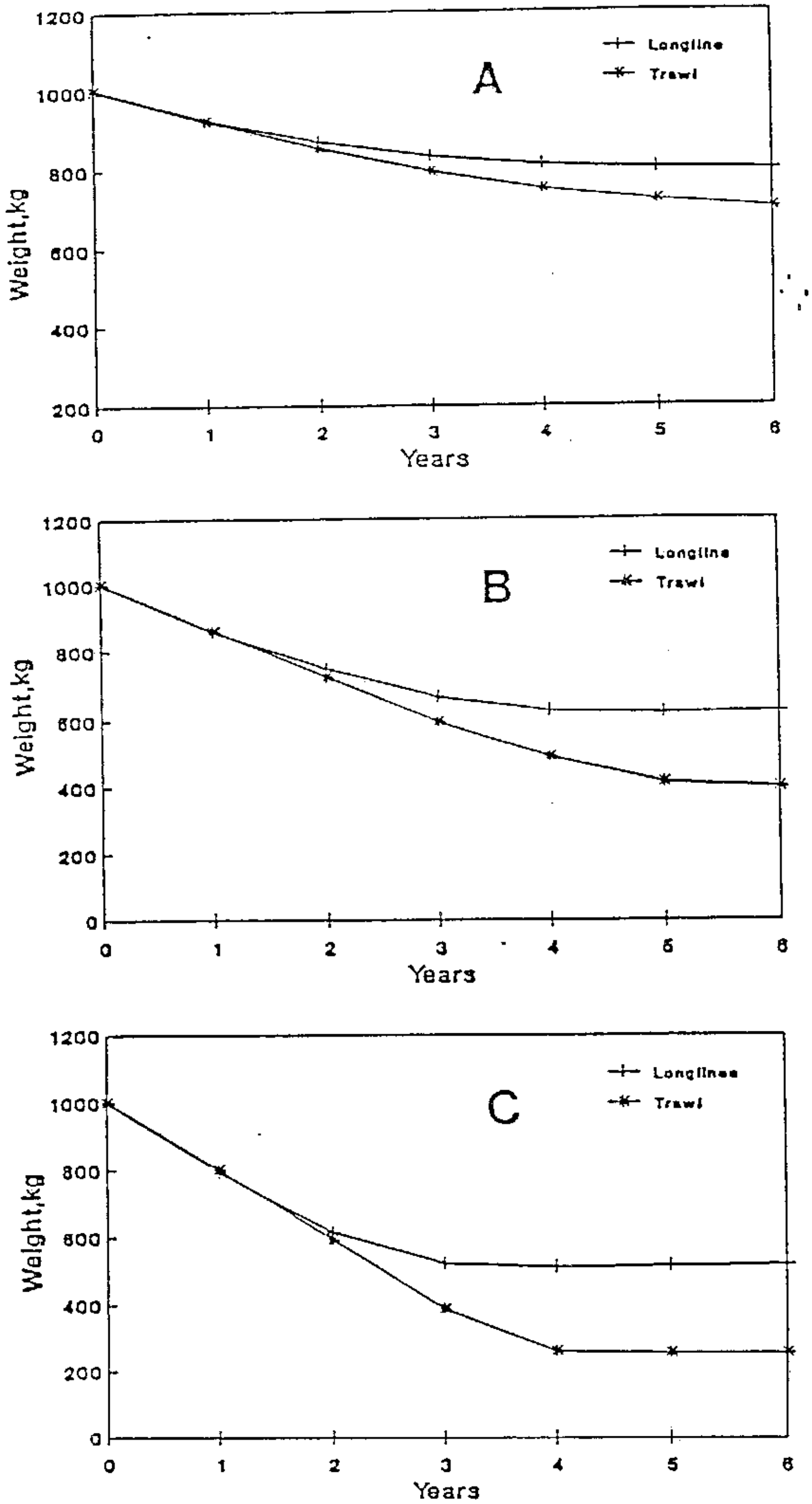

Figure 9. Biomass reduction (from original 1000kg) of longlining or trawling at 3 different catch levels, a) 80kg, b) 160kg, and c) 240kg.

catches is one year younger than in the longline catches. Cod also become more piscivorous with increasing age. As the longline catches include more large fish, longlines do thus remove more piscivorous and potentially cannibalistic individuals. If recruitment to the exploitable population is largely influenced by predation on juveniles, then longline fishing may also be more beneficial to recruitment.

After sustained fishing the model predicts that the biomass do stabilize around a certain equilibrium level, determined by fishing method and exploitation level. With reference to Figs. 8 and 9, it is apparent that the choice of catching strategy is relatively unimportant at low catch levels or in periods with good recruitment. However, with increasing exploitation rate, care should be taken with respect to choice of fishing gear and catching strategy. The trends that are predicted in Figs. 8 and 9 also suggest that this simulation model can be used to determine the total allowable catch taken by different gears, if a biologically or economically determined minimum level of remaining biomass is prescribed.

This study clearly indicates that the catching strategy should be taken into consideration for proper management of fish stocks. In this case the model is used in a fairly simple approach on one stock that alternatively is exploited by two different gears. As a management tool it could be extended for application on different multigear and multispecies situations.