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MULTISPECIES FORECASTS FOR NORTH SEA FISH STOCKS, A PRESENTATION OF FURTHER EXPLOITATION SCENARIOS

by

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ABSTRACT

The Multispecies Assessment Working Group has reported the catch projections for various scenarios regarding the exploitation pattern and fishing intensity of specific fleet groupings. A further range of scenarios are presented here and discussed in relation to previous analyses.

INTRODUCTION

To date, the determination of a "key-run" of the North Sea multispecies virtual population analysis (MSVPA, see Gislason and Sparre, 1987) has been an important aspect of each meeting of the Multispecies Assessment Working Group (MSWG). Once established, the key-run provides a foundation for the examination of the multispecies model, for example through sensitivity analysis, and it also defines the current status of the stocks for prediction purposes. Predictions can be made assuming no change in the status quo and carried out for short- medium- or long-term purposes. These can then be used as a baseline for sensitivity analysis or against which predictions under alternative exploitation scenarios can be measured.

At its meetings so far, the MSWG has examined changes in both the pattern and level of exploitation for a variety of scenarios relating to various "fisheries" defined within the multispecies model (see Anon., 1986). Examples of the "fleets" defining such fisheries are those for roundfish, saithe, mackerel, herring, flatfish and industrial (both pelagic and demersal).

Although Pope (1991) gives a concise history of the MSWG and discusses some of the conclusions it has reached concerning various exploitation strategies, many details of the investigations remain accessible only in the reports of the Working Group. Due to the scope and amount of work conducted by the MSWG at its meetings it is not, therefore, surprising that sometimes even quite straightforward results of the predicted behaviour of the multispecies system can become submerged by the sheer volume of the Group's output.

The purpose of this work is to provide and discuss the realisation of some simple long-term exploitation scenarios, the results of which may not be explicitly or readily apparent elsewhere.

Simulations

The MSFOR program (Anon., 1987) was used for prediction. Essentially this provides a multispecies solution of the catch equation and exponential decay of cohorts forwards in time and across all species within the MSVPA model. It utilises the stock numbers, fishing mortality rates, predation parameters, consumption estimates, residual natural mortality levels and mean weights at age which are available from output of the retrospective MSVPA calculations. The input parameter values used here were taken from the key-run of the 1990 MSWG (Anon., 1991).

For the purpose of prediction, constant levels of recruitment were selected for all species, equal to their mean values over the time series of the MSVPA, and a realisation of the model at constant (current) levels of fishing effort in all fisheries provided baseline results against which others could be contrasted. Long-term forecasts were then made over a range of fishing mortality multipliers (0.0 to 2.0) to simulate effort changes in each fleet, assuming direct proportionality between effort and fishing mortality. The multipliers were applied to a single fishery whilst the other fisheries were held constant at current levels. This process was repeated for each fishery in turn and the results are presented as the percentage deviation of yield and spawning biomass from their baseline values.

The roundfish fleet had an 85 mm minimum mesh size in the most recent data year of the MSVPA (1989) and the results of the forecasts assume no change in selectivity since then, effectively ignoring the subsequent minimum mesh size increases to 90 mm and, most recently, to 100 mm (with certain derogations) within that fishery.

RESULTS

The results given here are represented by pairs of figures for effort changes in each fishery. The first shows the percentage deviations of yield potentially attributable to effort changes in the respective fisheries and the second indicates the percentage deviation from baseline of spawning stock estimates. Results are shown in Figures 1-16. The yield for each species is summed over all fisheries and, for the roundfish fishery, both human consumption landings and discards of the target species (cod, haddock, whiting and saithe) have been grouped together by species. Only species which are affected by the effort changes either directly as target species or indirectly through biological interactions are represented in the figures.

Industrial Demersal (Figs 1 and 2)

Increased effort: the major effects are on Norway pout and sandeel yields and to a lesser extent on those of whiting and herring where all show increases. The spawning biomasses of sandeel, Norway pout and whiting diminish.

Decreased effort: yields of the target species, Norway pout and sandeel, demonstrate the greatest reductions. Losses of yield elsewhere are trivial at worst. The yields of haddock in particular, but also of cod, are improved. This occurs despite the increase in spawning biomass of whiting, a major predator. The spawning biomasses of Norway pout, sandeel and haddock also increase as does that of cod albeit to a lesser extent.

Industrial Pelagic (Figs 3 and 4)

Increased effort: the main effect is to increase the yield of sprat but to diminish the yield of herring and the spawning biomasses of both herring and sprat.

Decreased effort: no dramatic yield increases occur although those of herring and haddock rise. However, this is set against dramatic increases in the spawning biomasses of herring and sprat.

Total Industrial (Figs 5 and 6)

Increased effort: the target species' yields are increased (Norway pout, sandeel and sprat) as is that of whiting, a by-catch species in the industrial fisheries. The spawning biomasses of these species decline along with that of herring.

Decreased effort: the yields of the target species fall as does that, to a lesser extent, of whiting. Those of cod, haddock and herring increase. These changes are set against some rather dramatic increases in the spawning biomasses of most species.

Saithe (Figs 7 and 8)

Increased effort: the yield and spawning biomass of saithe diminishes with increases in the yields and spawning biomasses of haddock and Norway pout.

Decreased effort: the yield and spawning biomass of saithe increases whilst the reverse is true for haddock, Norway pout and, to a lesser extent, cod.

Roundfish (Figs 9 and 10)

Increased effort: Norway pout and haddock yields are increased as are those of whiting and herring. The catch of saithe declines along with dramatic declines in the spawning biomasses of cod and saithe. The spawning biomasses of whiting and haddock also decline but those of Norway pout and herring increase.

Decreased effort: no greatly increased yields are apparent. Those of cod, haddock and whiting are all reduced as are those of Norway pout and herring. The latter two also show a decline in spawning biomass as do whiting and haddock at extreme reductions of effort.

Herring (Figs 11 and 12)

Increased effort: the only obvious impact is on herring itself where there is no impact on yield but the spawning biomass declines.

Decreased effort: again, the only obvious effect is to herring where yield declines but spawning biomass increases rather more dramatically.

Mackerel (Figs 13 and 14)

Increased effort: no significant gains or losses accrue except to the spawning biomass of mackerel which diminishes.

Decreased effort: the principal effect on yield is a decline for mackerel. However, its spawning biomass increases greatly whilst yields and spawning biomasses of the other species, notably sandeel, herring and sprat decline.

Flatfish (Figs 15 and 16)

Increased effort: the yields from both plaice and sole are diminished as are their levels of spawning biomass. Very little change in the total North Sea yield or biomass occurs.

Decreased effort: Yields increase to a maximum for both plaice and sole and then fall away to zero as effort declines further. Large increases in spawning biomass occur for both species for relatively modest reductions in effort. For both yield and biomass, these changes are large enough to be reflected by changes in total North Sea values.

DISCUSSION

It is clearly possible in forecasts such as these, that the predicted state of the system may be moved significantly away from that under which the retrospective MSVPA model was parameterised. It has been suggested that simulations which force stock size estimates away from their recent historical levels by more than a factor of 1.5 are likely to be unrealistic and must be taken only as illustrative (Anon., 1984). Given the broad range of effort multipliers used here it is worth emphasising that point once more. From the bounds at which stock sizes change markedly from their baseline values, the results can be interpreted only as being indicative of the behaviour of the model and does not necessarily represent the likely dynamics of the fish stocks or fisheries.

If expressed as absolute values rather than percentage deviations, the results given here could be thought of as multispecies yield-per-recruit and biomass-per-recruit curves. However, this is in the particular case of constant recruitment in all fisheries at specified mean levels. Gislason (1992) discusses a broader multispecies analogue to the single-species per-recruit model which takes account of changes in the mean level of recruitment across all species and from which more generalised results can be identified. Nevertheless, by treating the results given here as multispecies equivalent to single-species yield-per-recruit, it is clear that one objection to the single-species formulation has been addressed. Namely, that single-species models do not take account of biological interactions. That the curves may demonstrate unrealistic responses to large perturbations in effort is a further criticism but not one that is uniquely associated with the multispecies framework. Single-species per-recruit models often demonstrate unrealistically high stock biomasses if, for example, biomass-per-recruit values at zero or low effort multipliers are scaled to the mean level of recruitment observed in the stock. That a multispecies analogue is also prone to unrealism should not be surprising. In the former case biological interactions are not accounted for, whilst, in the latter, insufficient information on the response of predator and prey species to large scale changes in abundance suggest that they may not be accounted for correctly. Whether or not results should be presented for "unrealistic" extrapolations of the model is a question which applies irrespective of the framework, either single- or multispecies. The results given here follow ICES tradition in that they extend over a wide range of effort multipliers. Appropriate caution in their interpretation is required.

At its 1985 meeting, the Working Group calculated yield and biomass curves along the lines of those presented here. The results given there (Anon., 1986) show changes in the logarithmic value of yield and spawning biomass derived from the "Shepherd" forecast model (Shepherd, 1984). The different style of presentation makes them difficult to compare with those given here although differences do seem to exist. For example, as effort is increased in the industrial demersal fishery, the earlier results suggest that Norway pout yield will increase but that of sandeel will remain relatively stable whilst the spawning biomass of sandeel will decrease and that of Norway pout remains stable. However, the current results suggest that as effort increases in the industrial demersal fishery both will undergo increases in yield but declines in spawning biomass. It is, of course, possible that these differences may reflect changes in the current status of the fisheries and stocks compared to the period in the early 1980s and these confounding effects make comparisons even more difficult.

On a more general basis, the results of multispecies forecasting have clearly demonstrated that, whereas under single-species assumptions stock biomasses will always decrease with increased fishing mortality, the same is not true under multispecies assumptions (Anon., 1986). In terms of yield it is apparent that single-species and multispecies predictions can, similarly, be at variance. In fact, the variety of scenarios examined by the MSWG at its meetings have suggested that, despite already high fishing mortality rates within the North Sea, further increasing the fishing pressure on important predators will generally increase the yield (but not necessarily the value) of total landings (Anon., 1988). Indeed, multispecies forecasts suggest that if mesh sizes are increased in the fraction of the roundfish fleet that fishes for cod and that, in the remaining fraction and in the industrial fisheries, the fishing mortality on whiting is doubled, then substantial increases in the spawning stocks of cod, haddock and herring are likely compared to those expected from a mesh size increase alone (Anon., 1989). In other words, in a currently heavily exploited system a measure to reduce fishing pressure in the cod fishery will perform "better" in terms of yields and biomasses of selected species if it is coupled to an increase in fishing pressure on predators in other fisheries.

It is difficult to conceive that the current search to determine the feasibility within the North Sea of a directed whiting fishery with minimal technical interactions with other species and fisheries has not been strongly influenced by such results. The divide between exploratory model analysis and the potential provision of management advice has been crossed. Nevertheless, as well as the caution necessary when interpreting the results of the multispecies forecasts it may be considered precipitate to implement such results in management without first evaluating other options either separately or jointly. In particular, it is not clear what potential exists for modifying fishery pressure on prey species. For example, when asked to "advise on the consequences for other fisheries of fishing large quantities of prey species, in particular, Norway pout and sandeel in the North Sea", the MSWG responded by simulating increased fishing mortalities of 50% in these fisheries (Anon., 1991) despite the fact that over one million tonnes of sandeel alone were caught in 1989 (Anon., 1992). This was ameliorated to some extent by formal sensitivity analyses where changes to the order of ±10% were applied and the response surface extrapolated to represent changes of ±30% (Anon., 1991). Unfortunately, it is not clear whether the results presented for 30% changes in fishing pressure apply to effort changes in the industrial demersal fishery or the roundfish fleet. The results shown here suggest that beneficial changes in the yield and biomass of other fish stocks are possible if fishing mortality rates on prey fish in the industrial fisheries are reduced.

The range of potential exploitation scenarios is enormous and, in consequence, only a limited set can be investigated. However, if the move towards the provision of long-term management advice under multispecies assumptions is to be consolidated then a broad spectrum of possibilities must be covered. It is towards that end that a number simple sections through the overall yield and biomass surfaces are presented here along with the suggestion that the possibility exists that in an already heavily exploited system it may be possible to reduce effort in order to improve the status of North Sea fish stocks.

ACKNOWLEDGMENT

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FIGURES

Percentage deviations from the baseline forecast are shown for yields and spawning stock biomasses. These are attributable to effort changes in the fishery with others held at current levels.

Figure 1. Effort changes applied to the industrial demersal fishery.

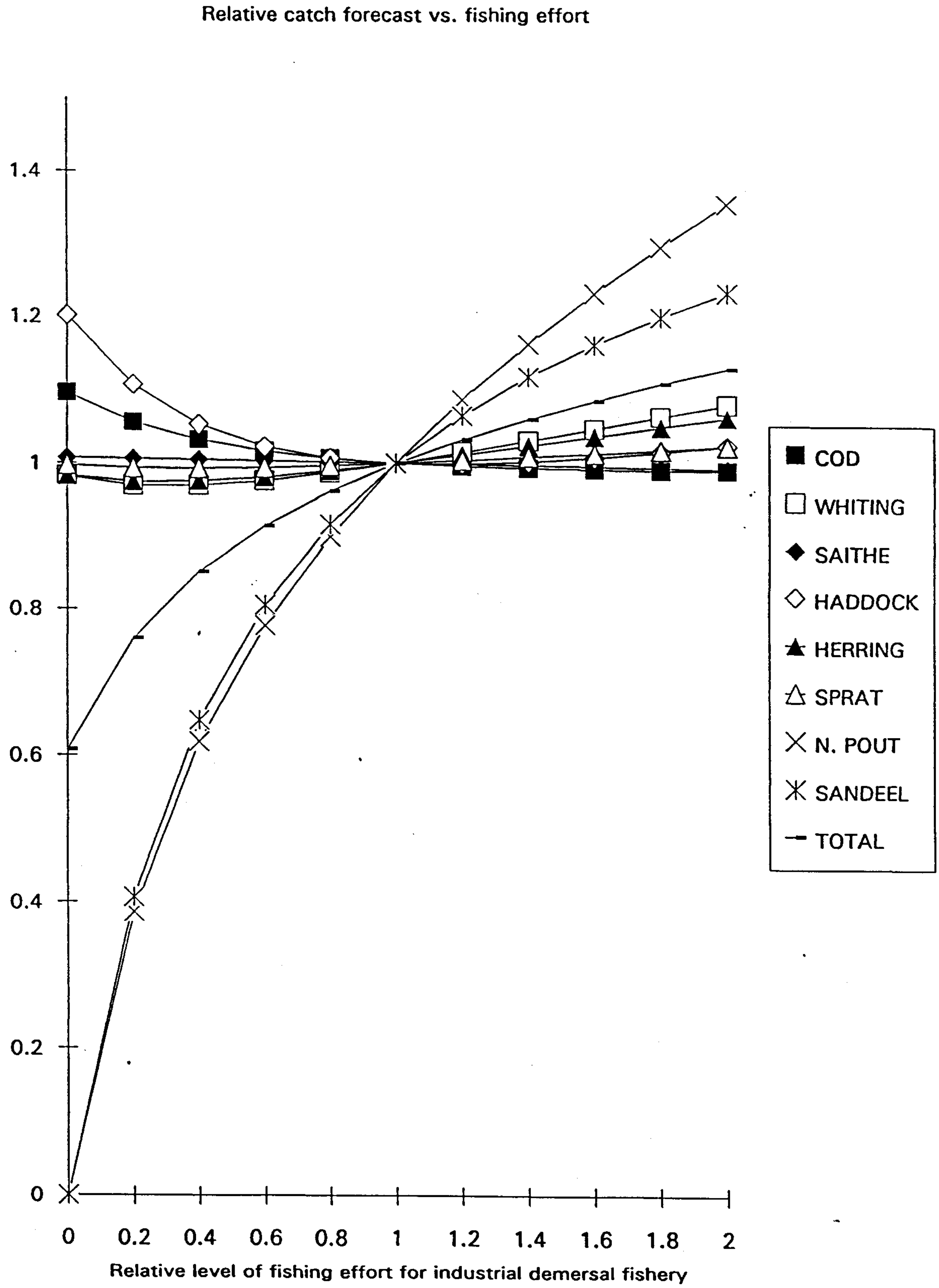

Figure 2. Effort changes applied to the industrial demersal fishery.

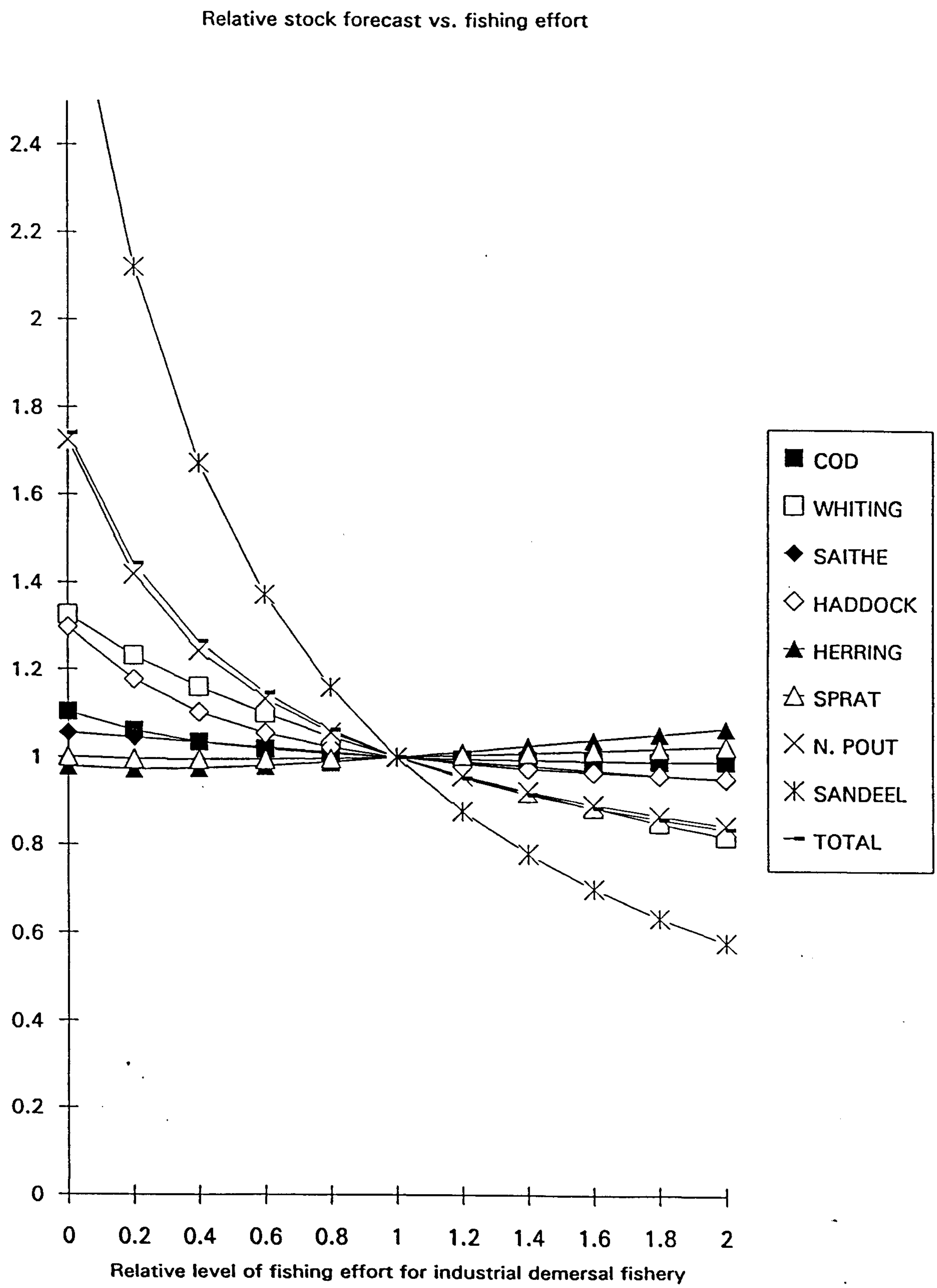

Figure 3. Effort changes applied to the industrial pelagic fishery.

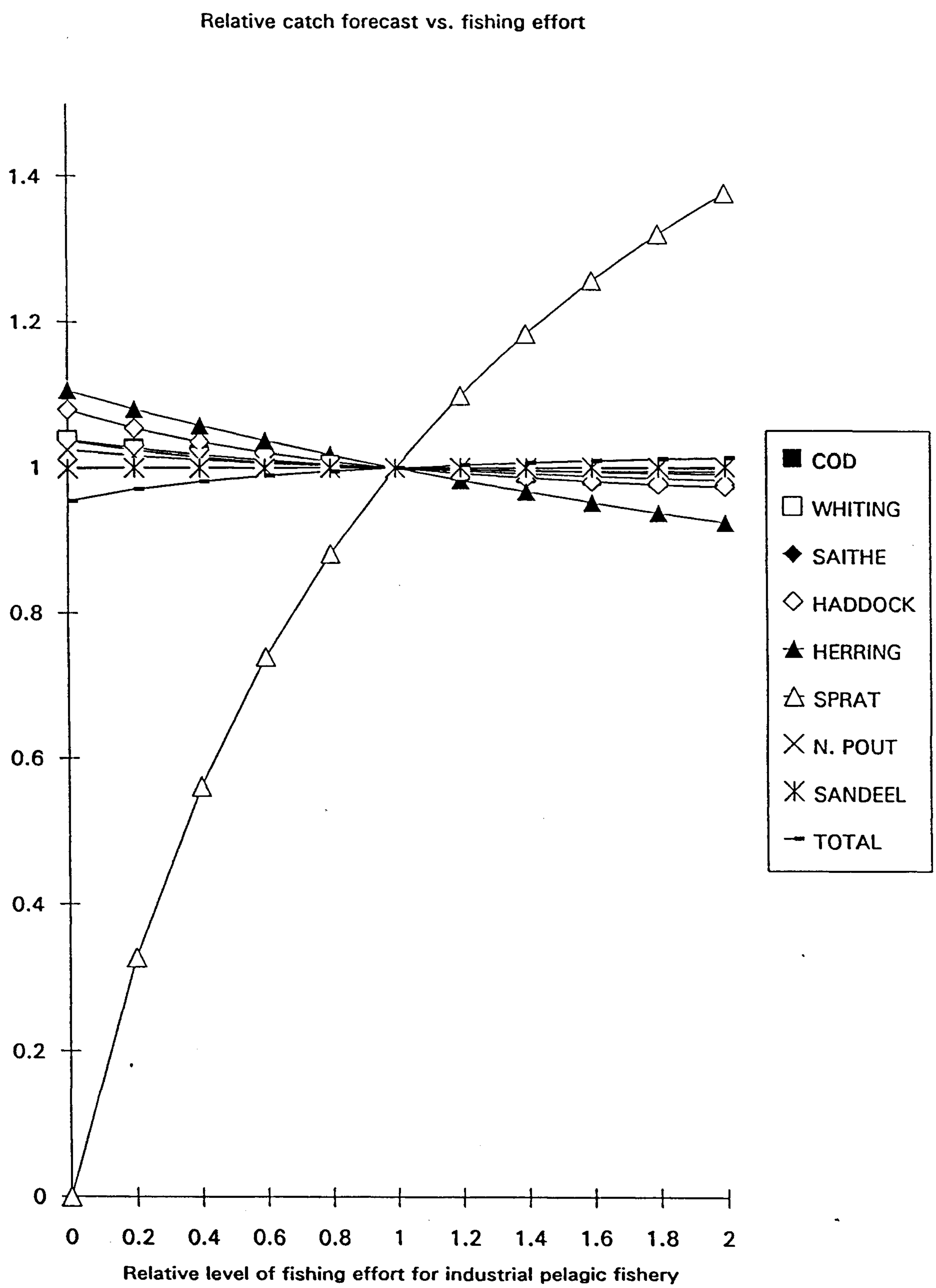

Figure 4. Effort changes applied to the industrial pelagic fishery.

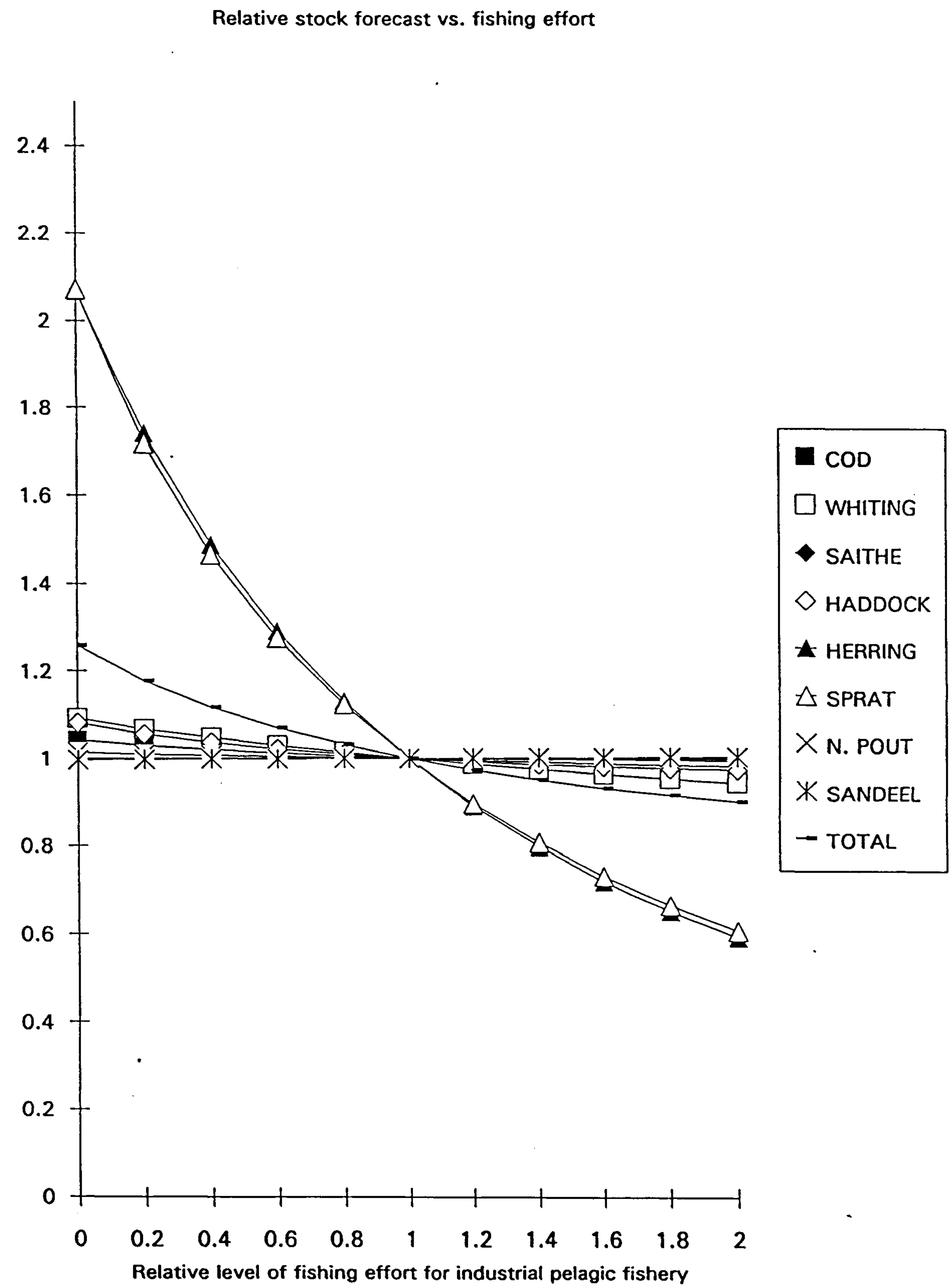

Figure 5. Effort changes applied to the total industrial fishery.

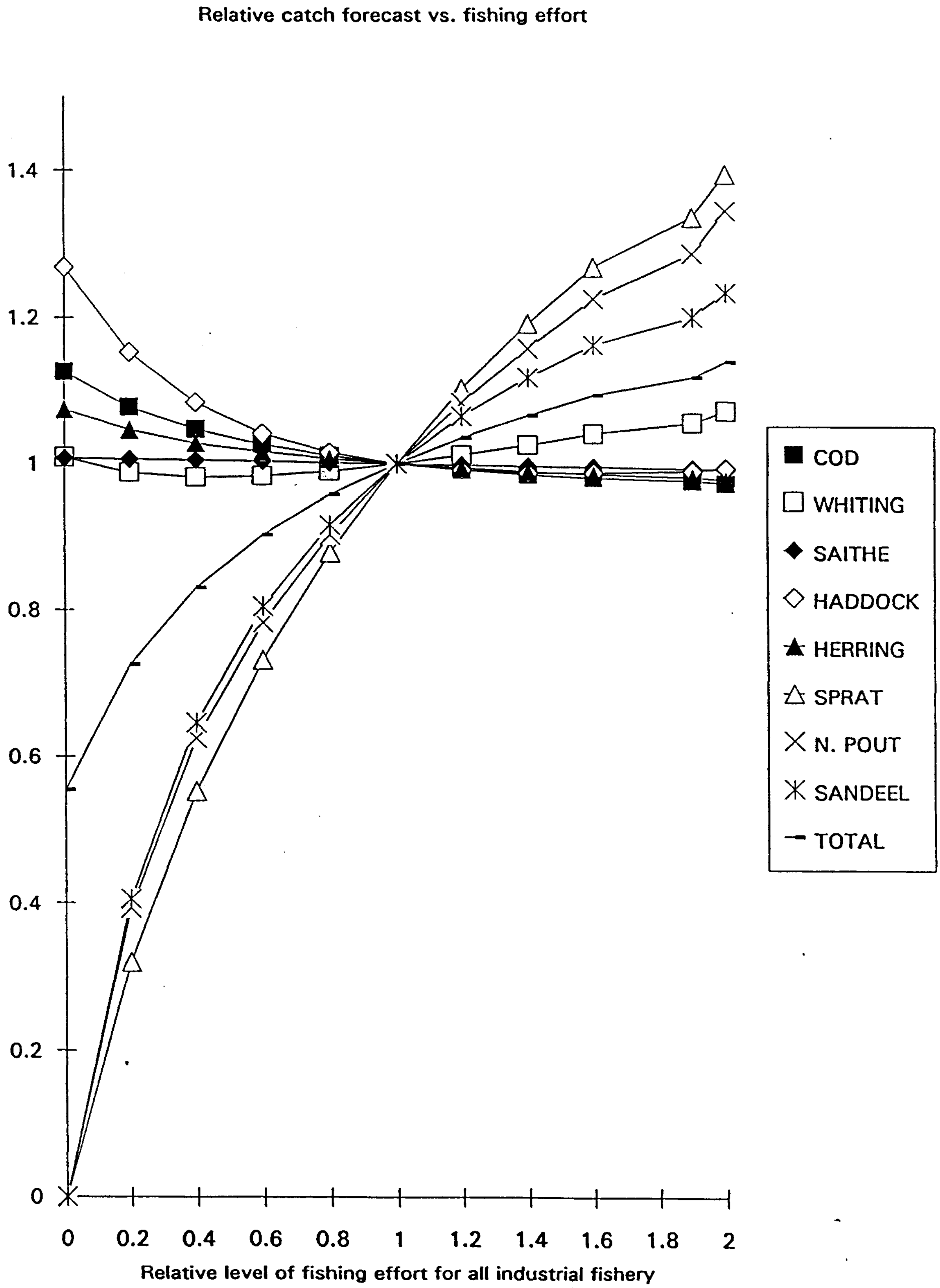

Figure 6. Effort changes applied to the total industrial fishery.

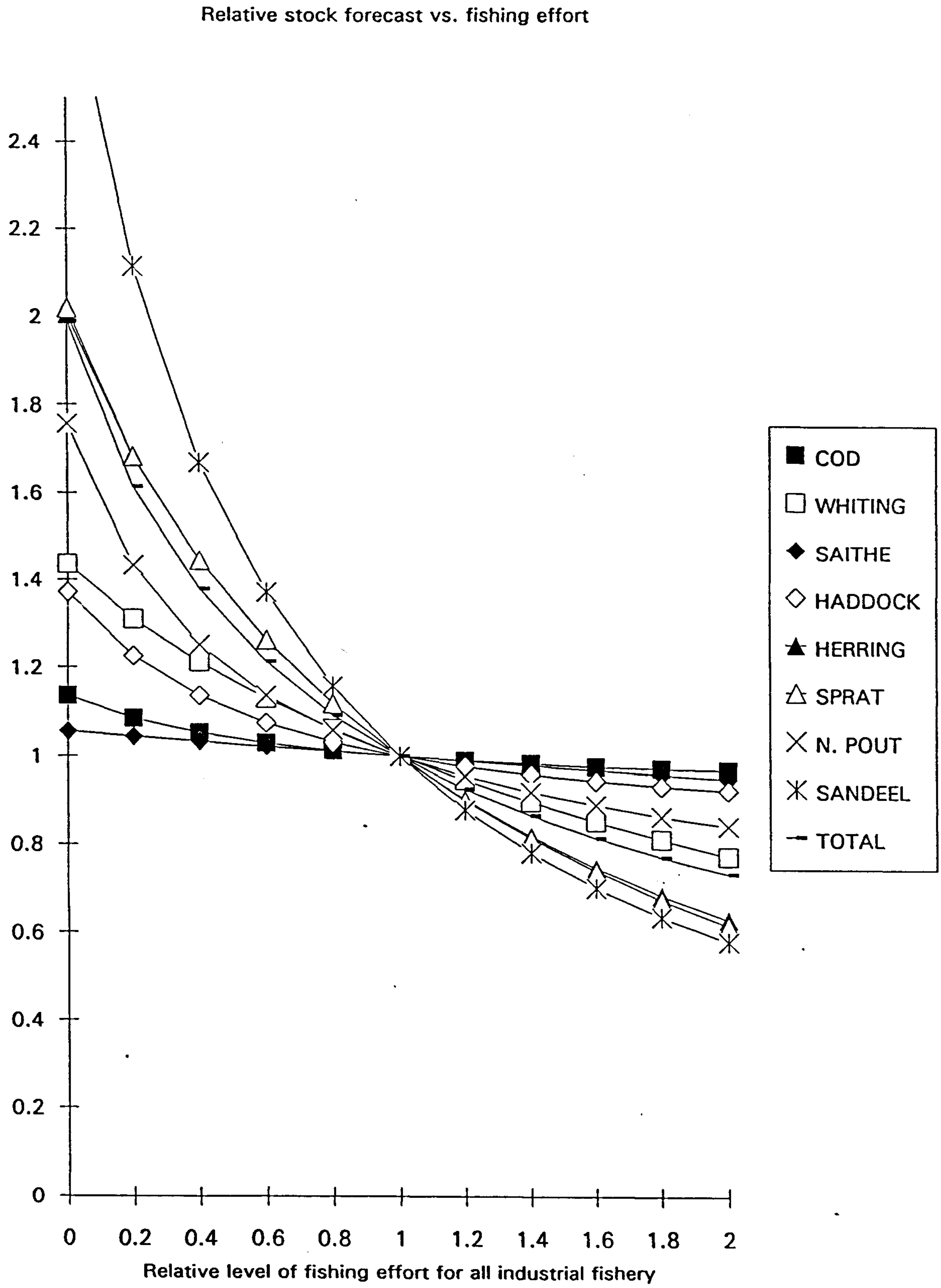

Figure 7. Effort changes applied to the saithe fishery.

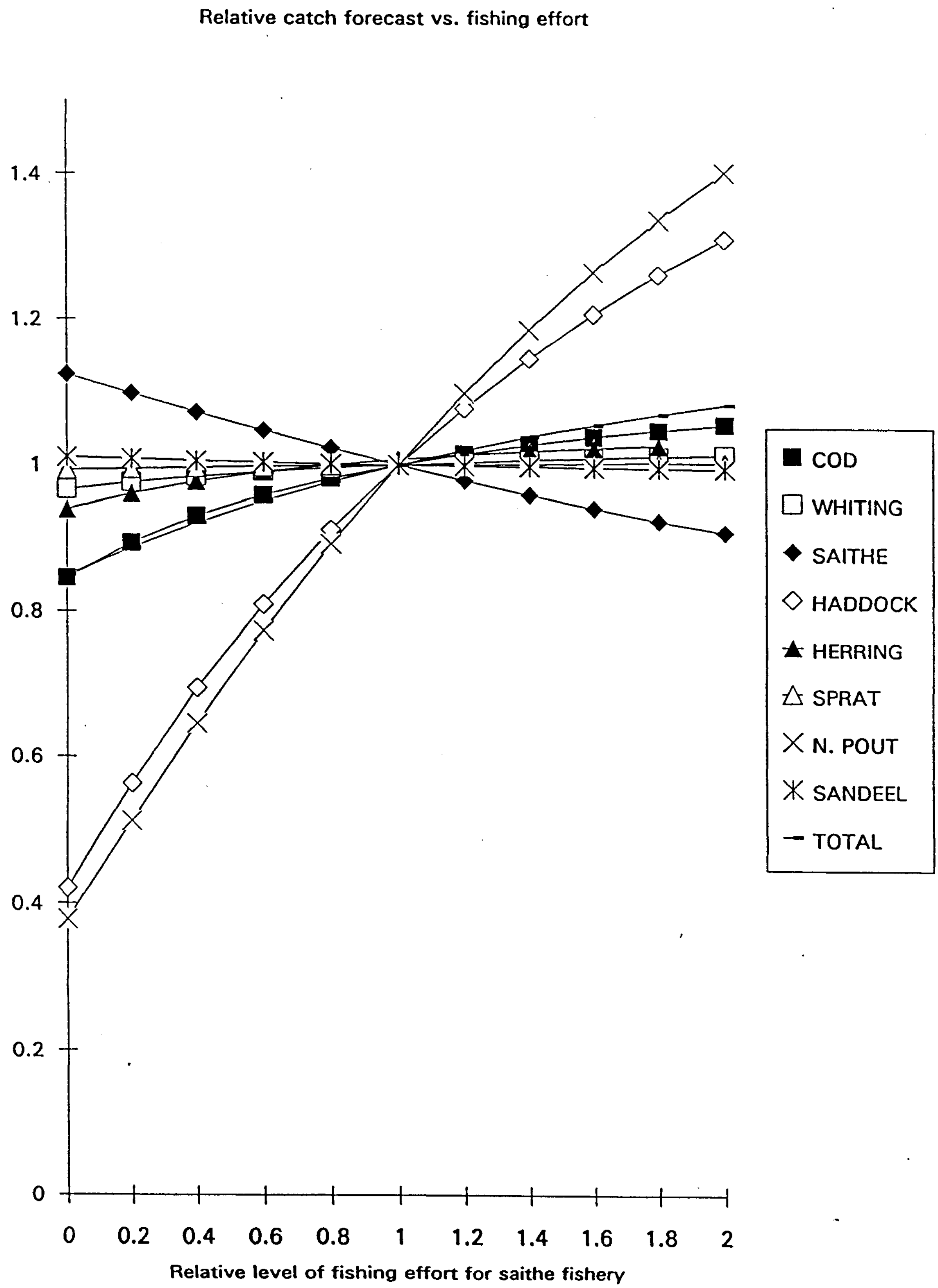

Figure 8. Effort changes applied to the saithe fishery.

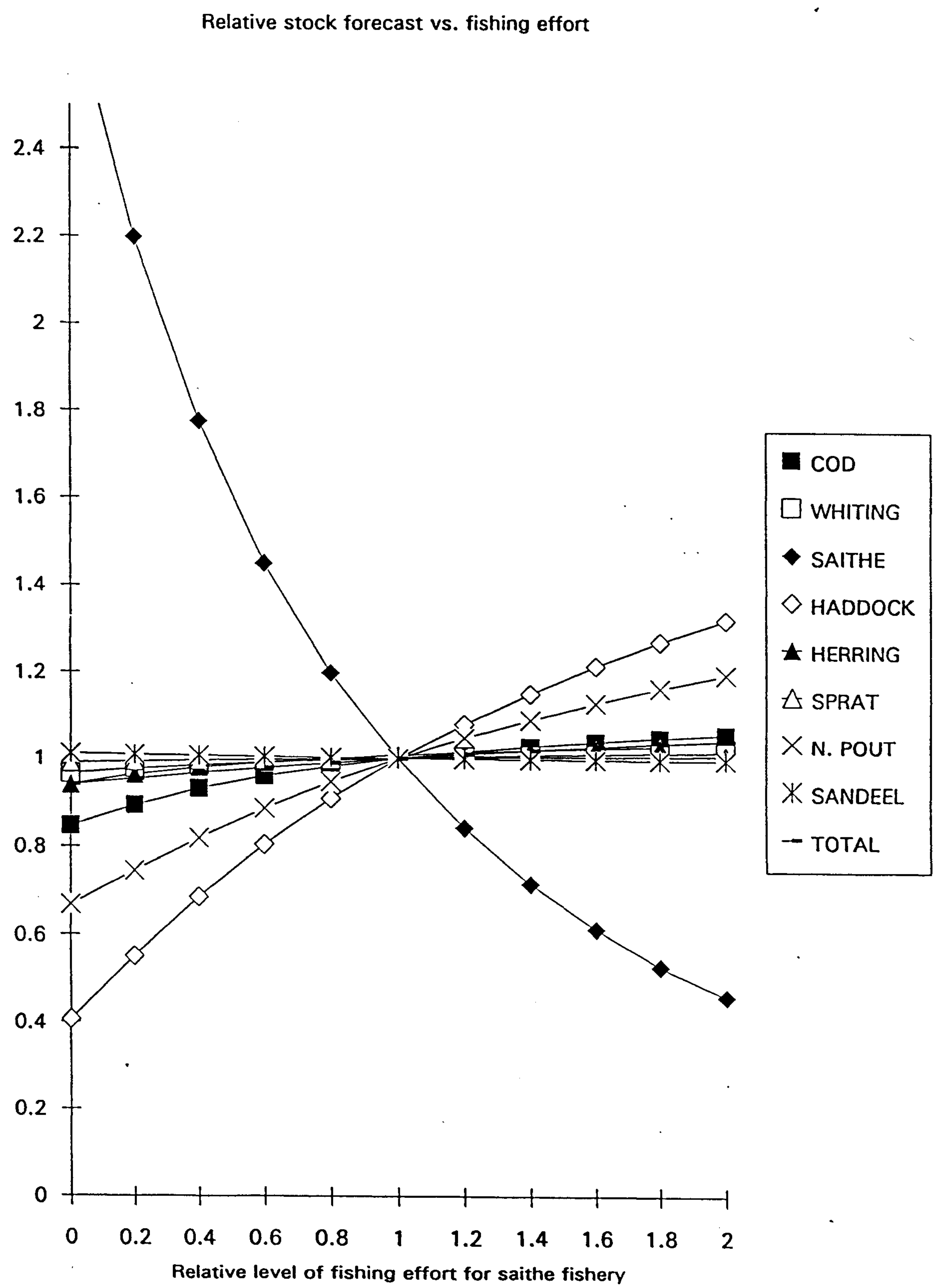

Figure 9. Effort changes applied to the roundfish fishery.

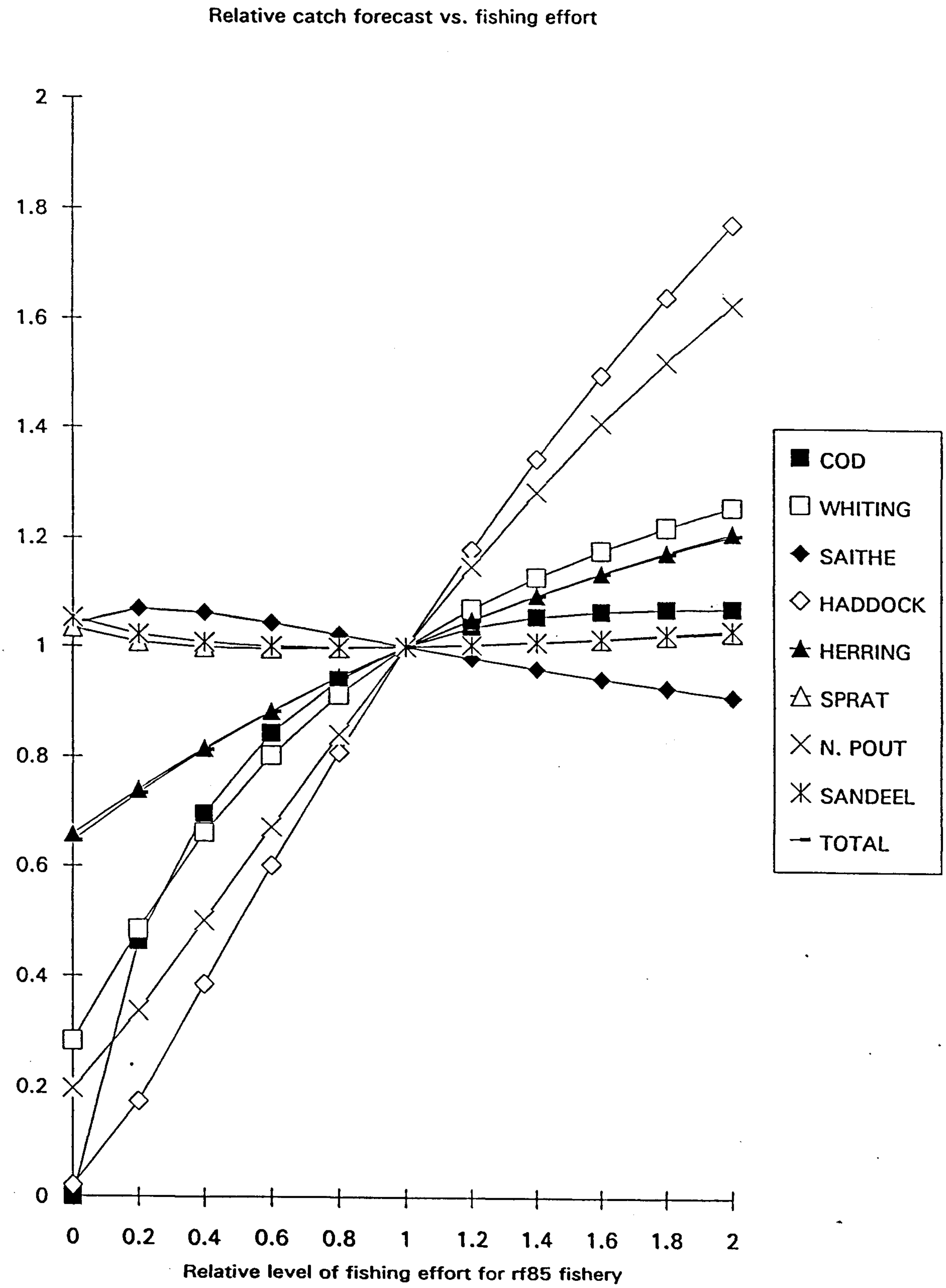

Figure 10. Effort changes applied to the roundfish fishery.

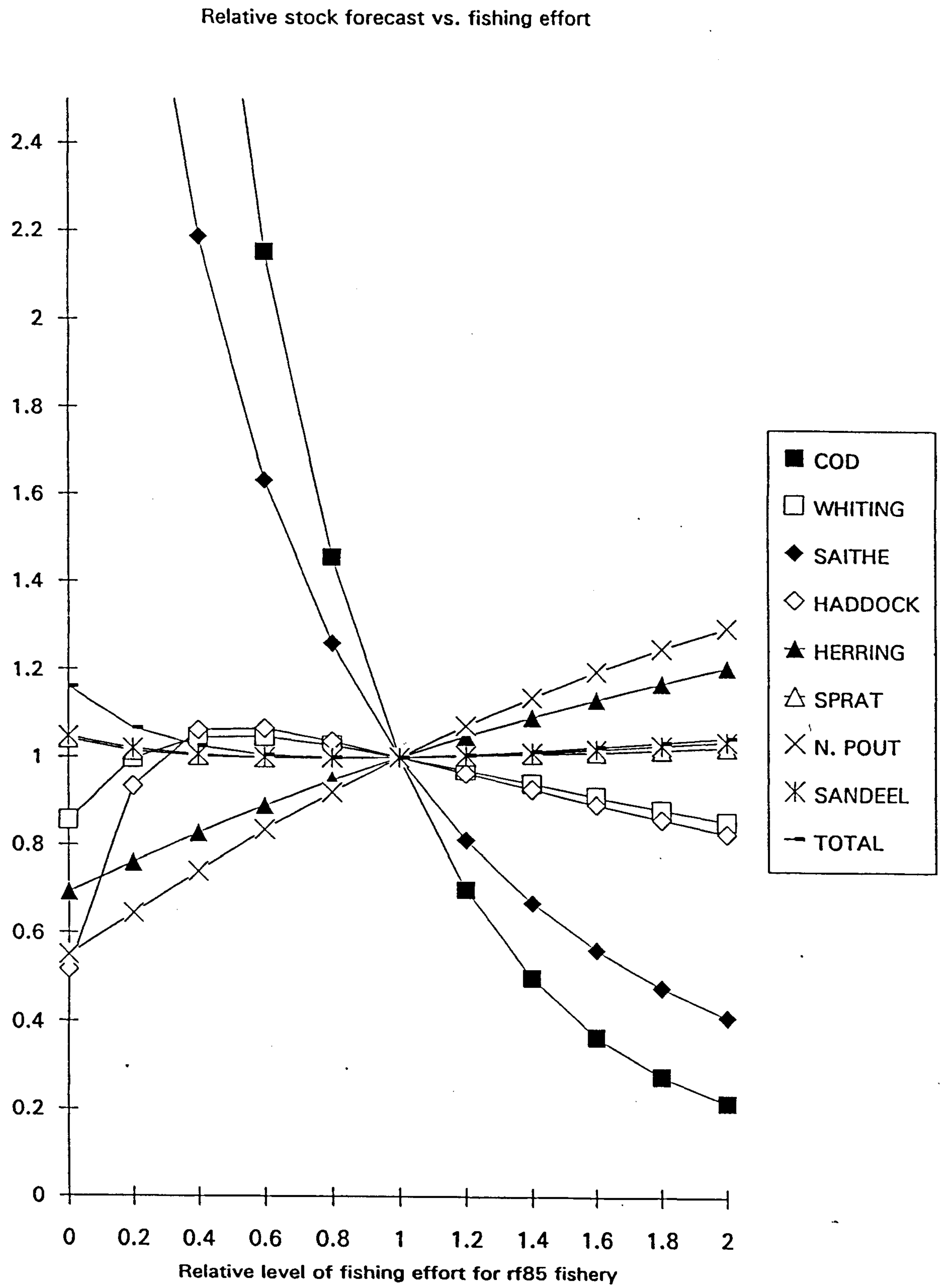

Figure 11 Effort changes applied to the herring fishery.

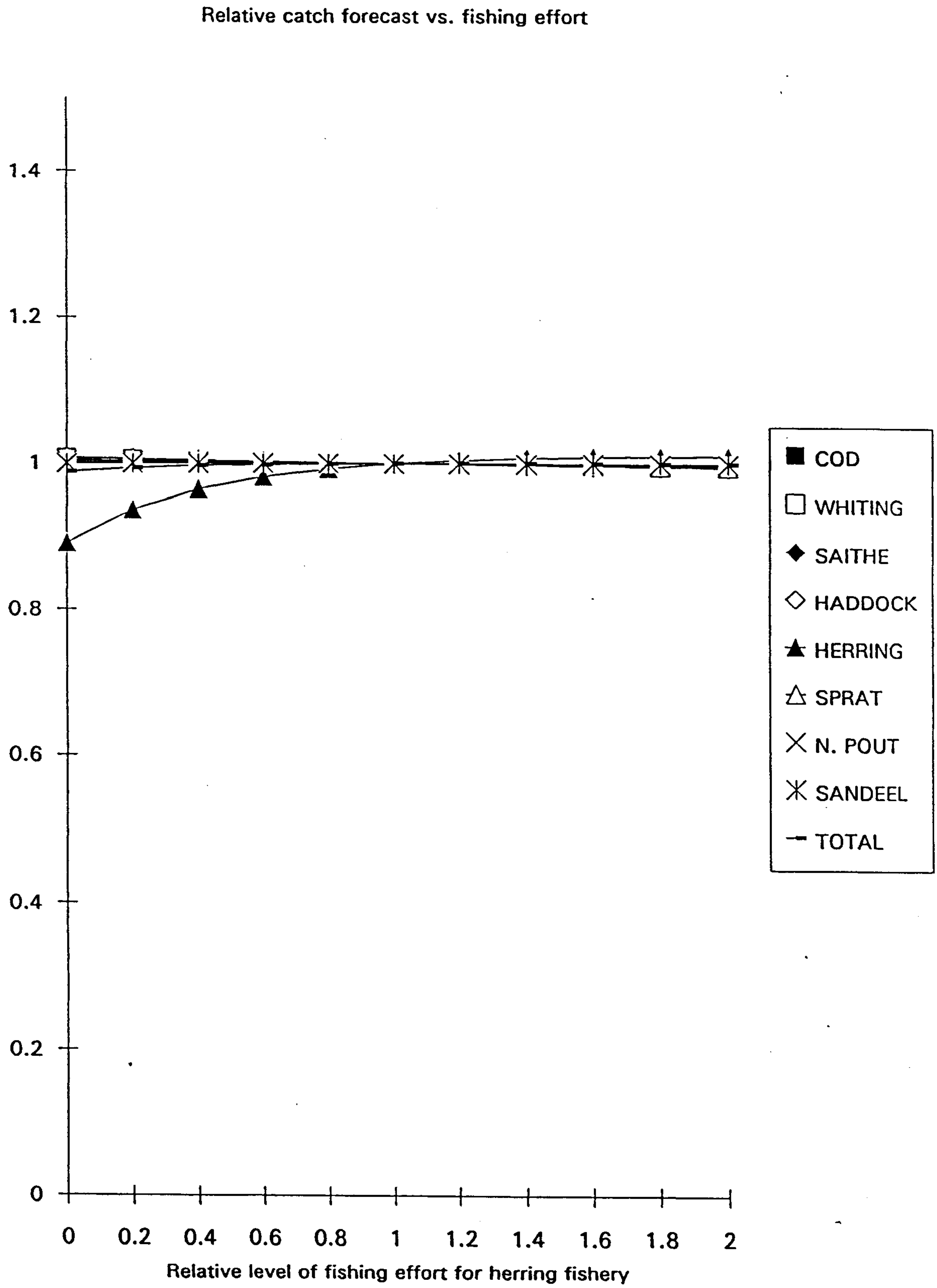

Figure 12. Effort changes applied to the herring fishery.

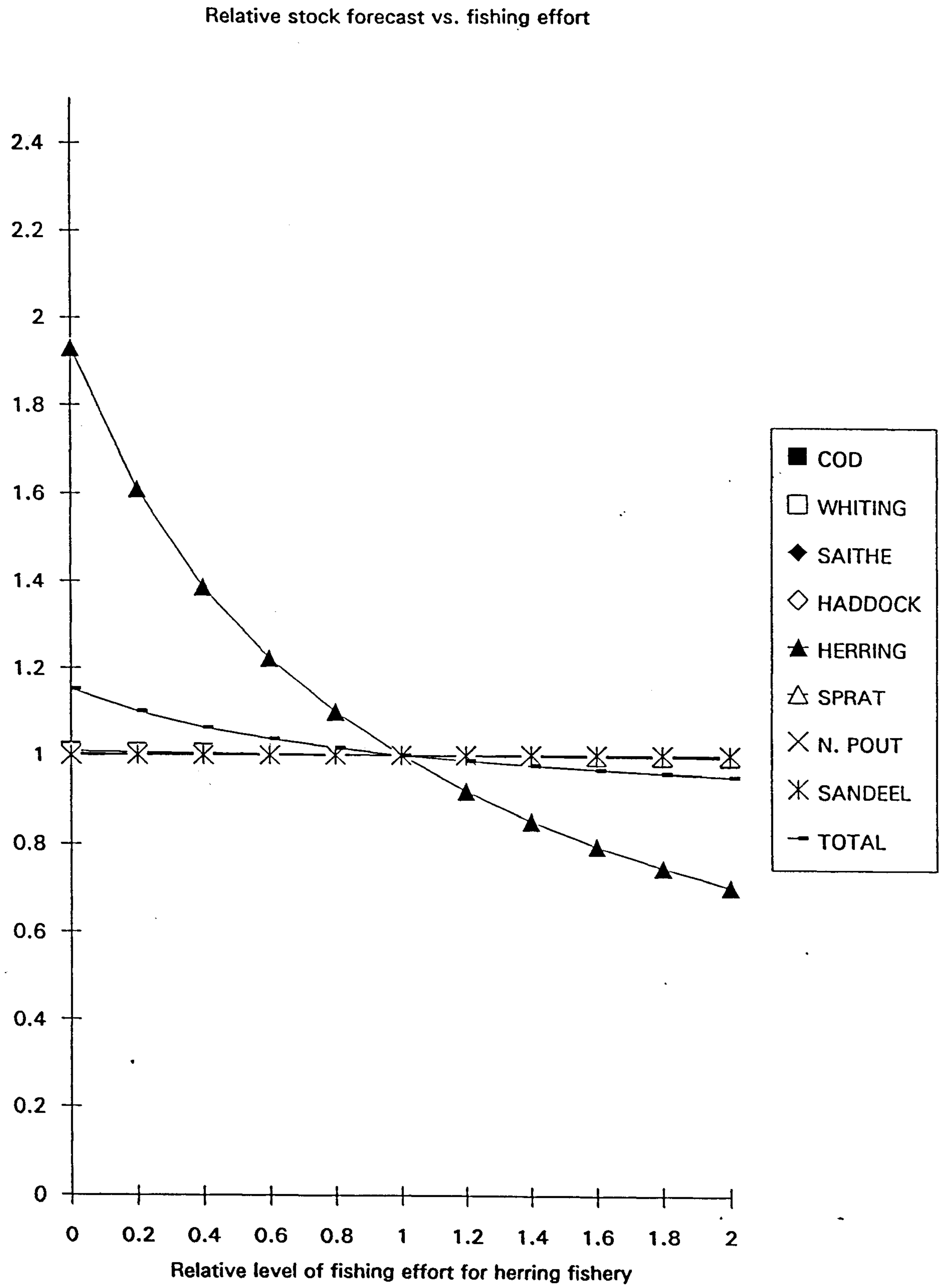

Figure 13. Effort changes applied to the mackerel fishery.

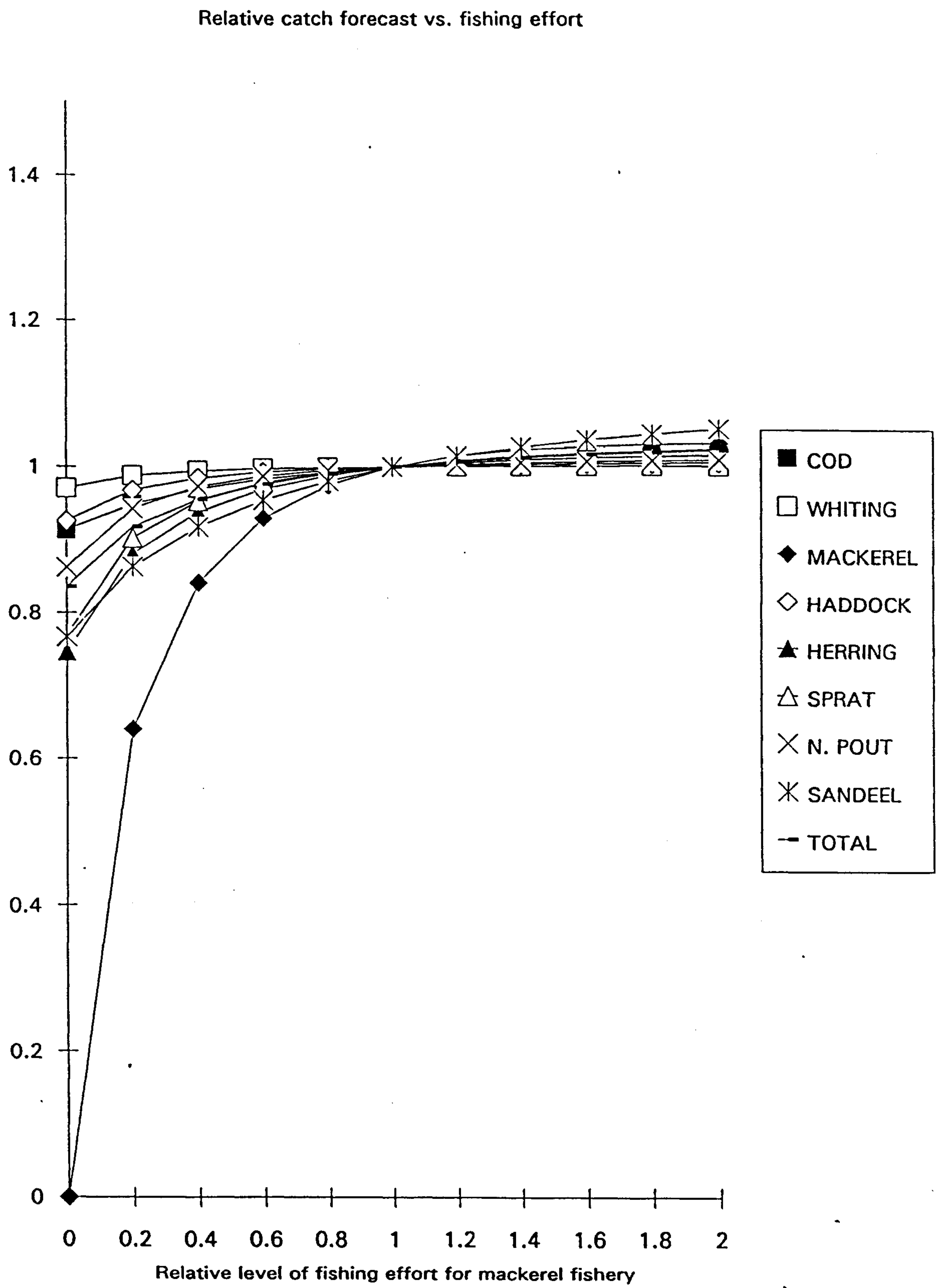

Figure 15. Effort changes applied to the flatfish fishery.

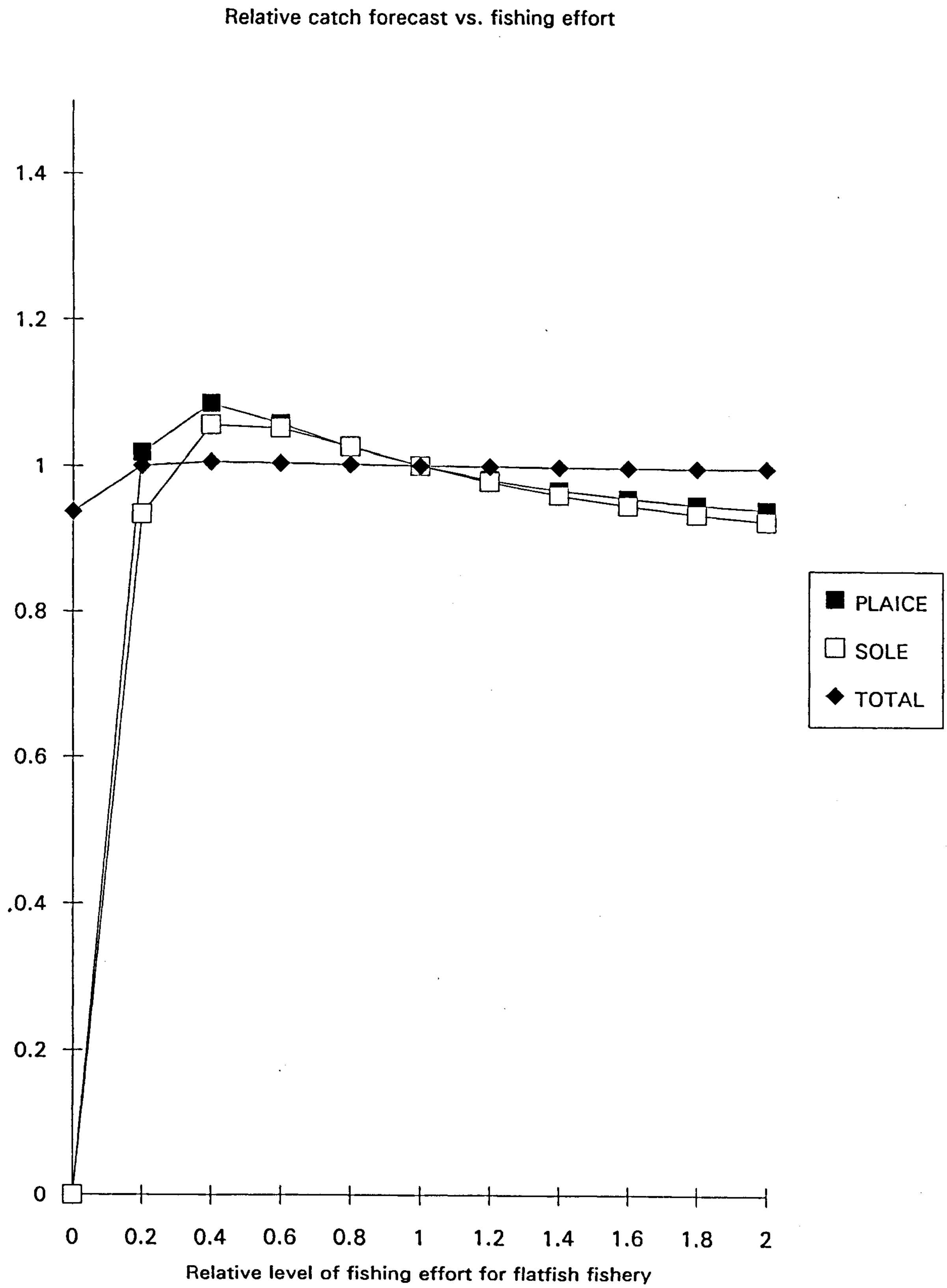

Figure 16. Effort changes applied to the flatfish fishery.

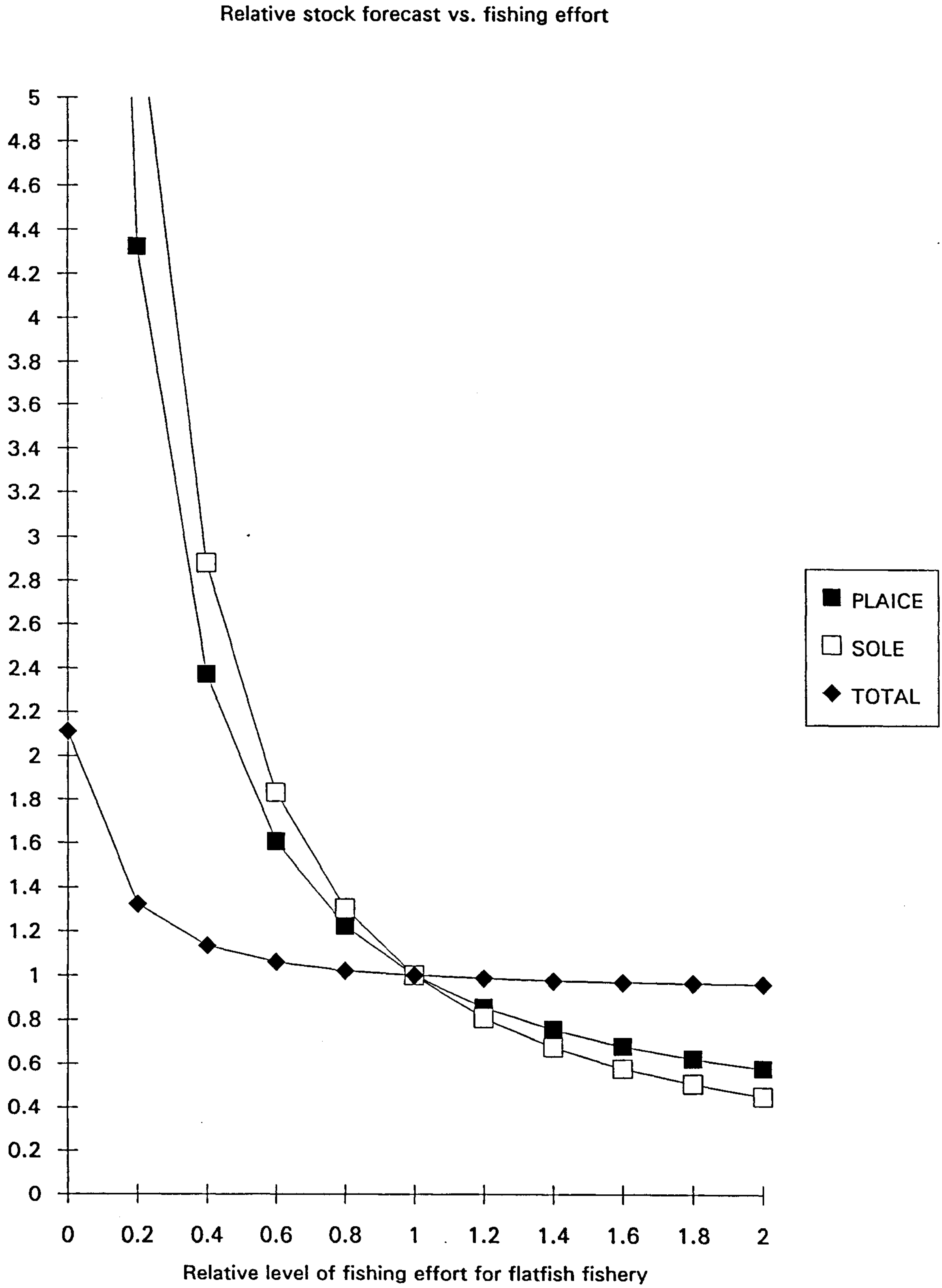

Figure 14. Effort changes applied to the mackerel fishery.