Foreign trade and price competitiveness in the French seafood industry [1]

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Abstract

In the early 1990s, two major crisis on the French fish market have led the fishermen to point out fish imports as the cause of the fall in prices. Therefore the determinants of trade in relation to the price levels became an important issue to address. Most related papers in the economic literature use a demand function of imports for a few product categories and focus on trade relations between two countries only (Tsoa & al. 1982, Arnason & al. 1994, Mazany & al. 1994). In the present research, we have used a gravity model at the bilateral level including many trade partners and many products, tested through panel data econometric methods along with three dimensions: products, partners and time. French imports appeared to be very sensitive to internal price competitiveness and nominal exchange rates. From that model, simulations show the consequences of the implementation of the single European currency on seafood trade.

1. Introduction

This paper is part of a global research on the foreign trade of seafood products in relation to price levels in Europe. The overall research started with a question addressed by the French fishermen during the market crisis of 1993 and 1994: are the imports of fish products responsible for the decrease in prices under the domestic fish auction markets? Behind this simple issue lies a request for better understanding the level of integration between domestic and foreign fish markets due to international trade of seafood products. In particular, the reciprocal influence of foreign trade on price levels is of great interest to analyse the complex interactions between demand and supply of goods based on natural resources.

Various aspects of the problem have been envisaged in order to highlight the main features of trade patterns within the European communities. Since the issue has been poorly addressed at the level of the European fishing industry except a few attempts (Arnason & Felixson 1994, Hannesson 1995), we had to start almost from scratch in order to first characterise the empirical determinants of seafood trade and secondly to estimate the

[1] This research has been carried out with the support of the Commission of the European Communities (FAIR programme). It does not necessarily reflect its views.

relationship between prices and foreign trade. However, substantial progress has been done in the field of testing import functions both from a theoretical and empirical point of view (Bergstrand 1989, Dagenais & Muet 1992, Goldberg & Knetter 1997).

Therefore, the first part of the work gives some insight to the main feature of trade patterns in Europe. Not surprisingly, the European communities with 12 countries show a huge deficit of the trade balance in seafood products vis-a-vis third countries, estimated too more than 6 billion ECU in 1994. All the European members face a deficit with third countries, except Ireland. Looking at the regional trade patterns indicates that the commodities are rather coming into the European markets from the northern countries downwards to the big consumption markets in the south of Europe. This situation is somewhat changing because of increasing relationship between Asian or south-American countries.
A panel data model of bilateral trade flows has been tested in several European countries, among which in France, showing great relevance of price competitiveness effects on seafood trade, although the nominal exchange rate has different impact on import levels from a country to another. This gravity model (Bikker 1987, Anderson 1979, Evenett & Keller 1997) suits to the case of seafood trade because the distance between countries appears to be particularly significant to explain the high travelling cost of perishable goods.

After a brief introduction of the main features of foreign trade in France, the specification and results of the model are given in a second part of the paper, then leading to a discussion in a third part.

2. The trade patterns of the French seafood industry

The French market is characterised by an increasing deficit of its trade balance of seafood products, valuing some 1.5 billion ECU by the mid 1990s, as shown in figure 1.

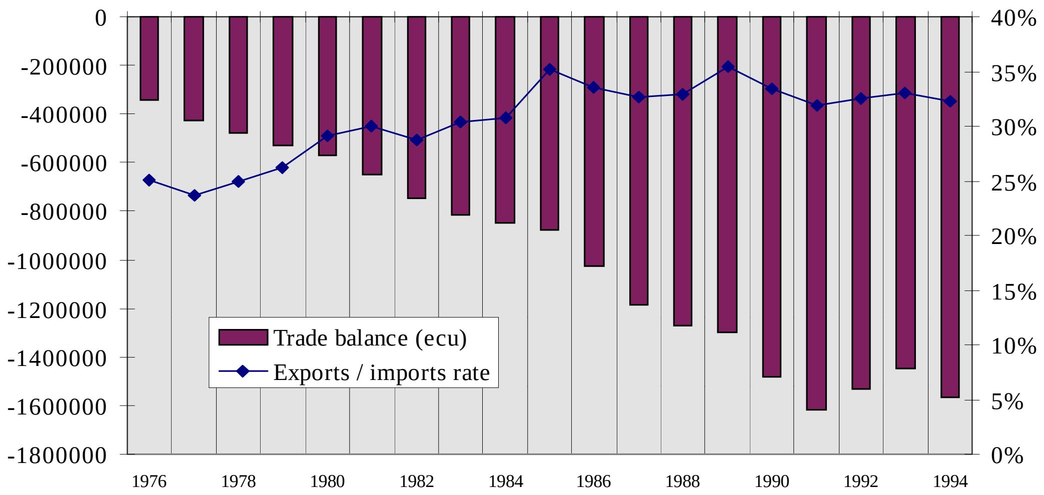


Figure 1 The trade balance and export/import ratio from 1976 to 1994

Very few products make the bulk of international trade of France: frozen shrimps and prawns (imported from Guinea and Madagascar, etc.), Pacific salmon (imported from various north European countries but coming mainly from Norway), and tropical tuna which is both imported and exported according to the degree of processing. As a matter of fact, the French tuna industry imports from its own plants settled overseas. For example frozen tuna is simultaneously exported to and imported from Ivory Coast. It looks as though the two-way bilateral trade is limited for tuna as France does export fresh tuna to Spain and Italy meanwhile French frozen tuna goes preferably to Ivory Coast, Thailand and the US market. All tendencies tend to demonstrate that the French seafood industry is changing little by little towards more processing and less fishing.

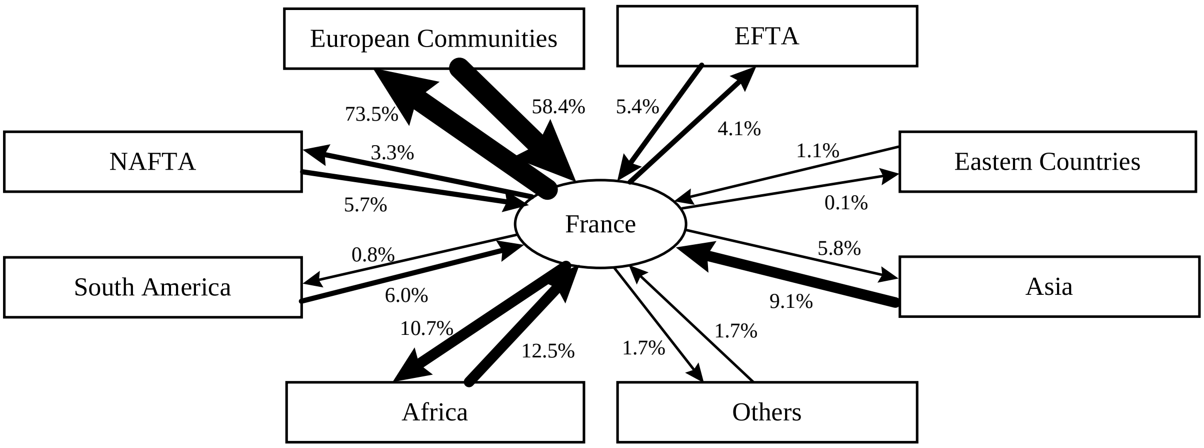


Figure 2a *Geographical trade patterns by big areas*

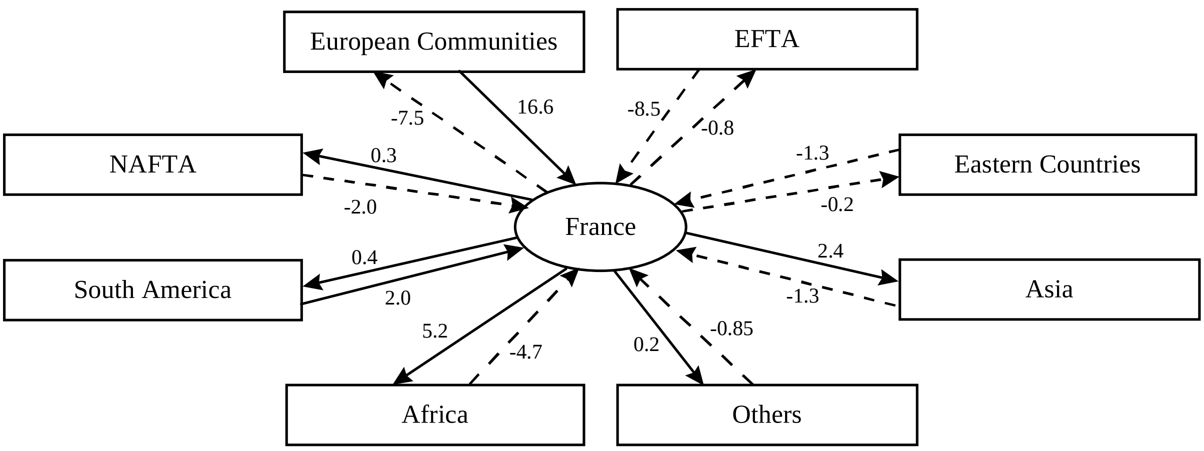


Figure 2b *Evolution of geographical trade patterns between 1988 and 1994 (in points)*

Concerning the regional pattern of trade and besides the long involved trade partners of France for seafood products (European Communities, Norway, west African countries, etc.), emerging partners have to be taken into consideration for the last few years, such as south American countries which represented 6% of total imports in 1994 (Chile, Argentina, Ecuador,...), as given by figure 2a and 2b. It appears that this new partnership provides more frozen shrimps or groundfish for the French processing industry.

In order to highlight the main determinants of trade for the French seafood industry, an econometric model has been specified and tested. Some of the results are introduced in the next section.

3. Specification and results of the panel trade model

3.1 The model

In most studies focusing on the econometric estimation of trade terminants (Tsoa & al. 1982, Mazany & al. 1994, Hannesson 1995, Schrank & Roy 1991), the import funtion takes the following form:

$$\ln Q_{i,t} = a_i + b_i \ln Q_{i,t-1} + \Sigma c_{ij} \ln P_{j,t} + d_i \ln P_{i,t} + e_i \ln I_{t-1} + \varepsilon_i$$

Where:
$Q_{i,t}$ is the quantity demanded of the ith product in time t
$Q_{i,t-1}$ is the production of the ith product lagged one period
$P_{j,t}$ is the price of the jth product ($j \neq i$)
$P_{i,t}$ is the price of the ith product
I_{t-1} is the disposable income lagged one period
c_{ij} is the cross-price elasticity between the ith product and the jth products
d_i is the own price elasticity of the ith product
e_i is the income elasticity of import demand lagged one period

The model is log-log specified so as to produce elasticities of the independent variables through the parameter estimates. Some extra-information through dummy variables (seasonal patterns, structural changes in demand, etc.) can be found in some of the models (Arnason & Felixson 1994, Jian 1995, Bjørndal & al. 1992). However, the model is often seen as bilateral between two trade partners (like the US and Canada, or the US and the UK), and for specific products (such as frozen blocks of cod fillets).

One can argue that foreign trade must be considered on a more aggregated basis, i.e. in a multi-product and multi-country context (Anderson 1979, Bergstrand 1989) allowing some insight to actual bilateral relationship. For instance, some variables related to the distance between countries, hence the gravity equation (Bikker 1987, Evenett & Keller 1997), as well as the tariff and non-tariff barriers affecting the level of trade, are likely to be taken into greater consideration. In that respect and by extending the import function model to panel data, the model tested took the following form:

$$\ln Q_{i,j,t} = a + b.\ln Q_{i,j,t-1} + c.\ln PIMP_{i,j,t} + d.\ln CONS_{i,t} + e.\ln PROD_{i,t} + f.\ln PPROD_{i,t} + g.\ln EQUI_{i,j,t} + h.\ln DIST_j + k.\ln CHG_{j,t} + \varepsilon_{i,j,t}$$

Where:
$Q_{i,j,t}$ is the quantity imported of the ith product from the jth country in year t (1000 tons)
$Q_{i,j,t-1}$ (or QMP in the results) is the quantity imported of the ith product from the jth country lagged one period (1000 tons)
$PIMP_{i,j,t}$ is the import price from the jth country in year t (unit values, in ECU, 1993=100)
$CONS_{i,t}$ is the domestic consumption of the ith product in year t (1000 tons)
$PROD_{i,t}$ is the domestic production of the ith product in year t (1000 tons)
$PPROD_{i,t}$ is the domestic production price of the ith product in year t (in national currency, 1993=100)
$EQUI_{i,j,t}$measures trade barriers (tariff + NTBs in tariff equivalent) of the ith product imported from the jth country in year t.
$DIST_j$ is the distance between the jth supplying country and the country of reference (distance is expressed in kilometres between the two economic centers of the considered countries)
$CHG_{j,t}$ is the nominal currency exchange rate between the country of reference and the jth country in year t (value of one unit of the foreign currency in terms of the national currency ; 1993=100)

The originality of this model lies in the panel data set that has been used for the estimation, including three dimensions:
- *a sectoral dimension* (various species crossed by several types of processing);
- *a spatial dimension* (the major partner countries) [1];
- *a temporal dimension* (seven years between 1988 and 1994).

Such a data set provides a wide quantity of information (29,000 observations in overall). The advantage is that the great number of observations improves the efficiency of the parameters. Moreover, multicollinearity problems are less important since, by offering many more degrees of freedom, the gap between the information requirement of the model and the information provided by the data is reduced (Hsiao, 1985). However, this multidimensional data set potentially introduces heterogeneity biases. Consequently, special econometric methods are required to separate these various dimensions and FGLS techniques (Feasible Generalised Least Squares) have been applied to a random effect model).

[1] The choice of the partner countries included in the model has been made as follows : partner countries which account for at least 1% of total seafood imports of the reference country, have been included. All the other countries are excluded from the model, unless they account for at least 20% of imports of the reference country for a particular seafood product.

3.2 The results : the impact of price competitiveness on trade

Using FGLS (Feasible Generalised Least Squares) to cope with the problem of heterogeneity, we found out the following results at the French level :

Table 1 Parameter estimates of the trade model for all fish products 1988-1994 through FGLS regression procedure: The French import function of seafood products

Variable	**PARAMETER**	**T-ratio**	**Prob**
Consumption	0.028	5.374	0.000
Import prices	-0.375	-19.797	0.000
Domestic prices	0.071	1.748	0.080
Domestic pdtion	-0.002	0.436	0.663
Trade barriers	-0.012	-2.178	0.029
Distance	-0.100	-11.805	0.000
Lagged imports	0.865	326.455	0.000
Exchange rate	-0.540	-3.173	0.002
Intercept	0.706	9.142	0.000
Nb of observ.	28721		
F-value	17412.20	Prob>F :	0.00
r2 adj	0.80		
White X2	1621.74	Prob>X2 :	0.00
Cond.number	33.97		
LM test	4083.05	Prob value :	0.00
Hausman test	0.00	Prob value :	1.00
F-test for L.O.P.	52.71		0.00

* The long run (LR) elasticities have been estimated from the short-run elasticities (parameter estimates) through the equation $\alpha=\psi/(1-b)$ where is the long run elasticity, ψ is the short-run elasticity and b is the parameter of the lagged imported quantity.

Short run and long run elasticities are presented in table 2.

Table 2 Short run and long run elasticities

	Short run elasticity	Long run elasticity
Consumption	0.028	0,031
Import price	-0.375	-2.771
Domestic price	0.071	0,525
Domestic production	ns	ns
trade barriers	-0.012	-0.092
nominal exchange rates	-0.540	-3.990
Distance	-0.100	-0.742
internal competitiveness	*-0.334*	*-2.468*

Moving onto details of the results, all parameter estimates correspond to theoretical expectations: the introduction of a *lagged quantity* into the model has increased substantially the quality of the regression. This is to be explained easily by the important inertia of behaviours and the structural dependence of the French markets towards external suppliers. Whatever the price conditions or the shifts in the currency exchange rate, the domestic markets do need imported goods that represent more than 50% of total domestic consumption over the period.

As observed for other industries, the *distance variable* is very significant with a negative sign, as expected. Thus, seafood trade is substantially reduced by the geographical distance. This is traditionally explained by the fact that a higher distance increases transport costs, but in the case of seafood trade, another explanation may be found in the perishability of fresh products, as already mentioned.

More economic variables also have a significant impact on imports flows. For instance, the parameter estimate of the *import prices* is very consistent with theoretical expectations, with a negative sign and a high value. The short run price elasticity valuing -0.38 would mean that a shift in price of 1% would reduce import quantity by more than 1/3%. Looking at other empirical results in the literature shows that a model using quantity as the explained variable, gives much lower elasticities than when taking prices: 'We obtained, for frozen cod fillets, an estimated short run elasticity of -0.368 when quantity was the dependent variable, and of -9.21 with price the dependent variable. Regressions on other product types produced similar discrepancies'. (Roy, Tsoa, Schrank, in Schrank & Roy (Eds) 1991). Other research works gave for fillets and portions an elasticity of -0.88 when quantity is the dependent variable, and of -2.5 when price is the regressand (quotation in Roy & *Alii*, *op.cit.*). The only studies embracing all fish products produced elasticities of -0.65 and -0.79 with quantity as the regressand (Roy & *Alii*, *op.cit.*). The present results, regarding for example long run elasticities, is very close to results obtained in other studies (see for example the French demand for Norwegian salmon) [1].

The *production* variable does not present a significant parameter. This result is not surprising given that production and imports may be viewed as poor substitutes, because of the structural dependence of the domestic market towards external sources of supply. However, it is outstanding that the *domestic production price* has a significant and positive parameter, just as if the domestic consumer is comparing the world price and the domestic price before purchasing fish. Such a result would show that the French market is somewhat integrated with other markets at the industrial level.

More generally, the fact that both import prices and production prices are significant indicate that internal competitiveness is a crucial factor explaining import flows. This is checked by removing import prices and domestic prices from the model, and adding a variable which accounts for internal competitiveness (import price over dometic price). In this connection, separate estimations of *domestic price competitiveness* elasticities indicate a significant impact of this variable on imports, with short run and long run valuing re-

[1] Long-Run own price elasticity of -1.30 found for salmon over the period 1981-90 (Björndal, Salvanes and Gordon 1994).

spectively -0.33 and -2.47. This means that a decrease of 10% of price competitiveness would mean a rise of imports by 3.3% in the short run and 25% in the long run.

The *exchange rate* parameter appeared to be the most significant variable at 1% level, and consistent with theoretical expectations: an appreciation of the nominal exchange rate (FF vis-à-vis ECU) implies a reduction of the domestic competitiveness, and thus increases imports. Looking at exchange rate elasticities reveals that imports are very sensitive to exchange rate variations, with short run and long run elasticities respectively equal to -1/2 and -4. This indicates that French imports have been substantially affected by the appreciation of the FF vis-a-vis the ECU : from 1988 to 1994, the FF has appreciated actually by 6,5%. This would have pushed imports up by 3.5% in the short run and by 26% in the long run.

Trade barriers are also highly significant and present a negative sign. This means that although there is no barrier for many products, the remaining barriers are efficient by restricting imports from non-EU countries. However, although trade barriers are highly significant, elasticities are low. This is not very surprising, since more than 3/4 of French imports are tariff-free, and that the weighted average trade barriers in the European Union is about 7% over the period taken into consideration, but only 2% for fresh and frozen seafood products. The products with the highest charge are prepared products, which are less imported by France as compared to other seafood products. This indicates that further liberalisation of seafood trade would not have a huge impact on the French imports, at least at an aggregated level, though the impact would be higher for specific products.

The *consumption* variable presents the expected sign : the greater domestic demand, the greater the demand for imports. However, the corresponding elasticities are very low (respectively 0.03 and 0.11 in the short and the long run). This indicates that changes in consumption volumes barely affect import volumes.

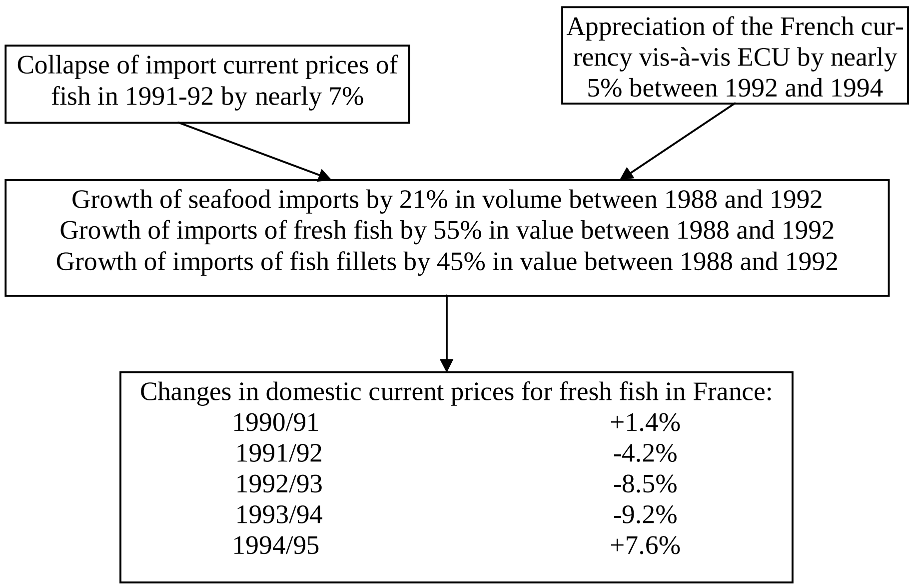
4. Discussion and conclusion

An important point to stress is that among EU countries, France is the country which is the most sensitive to changes in import prices and competitiveness. An implication of this is that the development (or the survival) of national production against imports may be achieved by the improvement of the French domestic competitiveness.

Another particularly interesting result is that French imports are also very sensitive to exchange rate variations. Simulations indicate that the appreciation of the French Franc against the other European currencies from 1988 to 1994 (+6,5%), also implied an important rise in imports (+26% in the long run). For some very sensitive import categories (fresh fish, prepared fish, and shellfish), the impact on import flows has been much higher (up to 78% in the long run). The other European countries are generally less sensitive to exchange rate variations. A major conclusion of the whole research is that the two French market crisis of February 1993 and February 1994 have found their origin in the changes of competitiveness: first with the decline of international prices since 1991, in a second step with the appreciation of the French currency, particularly since 1992. However, it must be emphasised that the internationalisation of the seafood industry has started long before and has been accelerated for the late 1980s. Therefore, only the combination of three effects can be considered as responsible for the market crisis, along with the following chronology and within the frame:

1. internationalisation by increasing imports (late 1980s);
2. collapse of international fish prices (in 1991);
3. appreciation of the French currency (since 1992).

Thus, one of the most striking results of the study is that in the period 1992-93, France simultaneously faced the decrease of world import prices, but also the appreciation of its currency against the other EU currencies. These two factors considerably depressed real domestic competitiveness, and thus strongly pushed imports up. Consequently, the French crisis observed in February 1993 and February 1994 may be at least partly explained by these factors as shown in the following mechanism with the actual figures.



Unlike France, Spain and the UK have not been affected, since the decrease in world import prices has been offset by the depreciation of their currencies (which increased import prices in their own currencies). The EU taken as a whole has experienced the decrease in import prices, but the value of the ECU vis-a-vis the US$ has not significantly changed over the period. An implication of these results is that the implementation of the EURO, by 1.1.99, will prevent intra EU imports to change substantially because of potential variations between EU currencies. Thus, the single currency should stabilise import variations inside the EU.

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Bio-economic Analysis of an Open Access Fishery: The Swedish trawl fishery for Norway lobster (*Nephrops Norvegicus*)

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Abstract

The Scandinavian Nephrops stock in Skagerrak and Kattegat is mainly shared by Danish and Swedish trawlers in a fishery, which roughly can be characterised as an open access regime. This paper focus on the Swedish trawlers and reports the results of a bio-economic analysis. Jones' length cohort analysis is linked to economic data of the Swedish Nephrops fishery. The analysis provides estimates of the open-access equilibrium effort level and the maximum economic yield effort level. Given the high levels of discarded, undersized individuals, which are exposed to high discard mortality rates, the future net benefits of an empirically tested gear selectivity regulation are assessed. The results show that a maximum economic yield equilibrium requires effort reductions by more than 50%, leading to a potential resource rent of almost US$ 3 million, compared to the open access situation in 1995. The existing minimum size regulation and the present 70 mm diamond mesh in use, implies a fishing practice where for each landed specimen three are killed due to discard mortality. Further increases of the resource rent is possible if a 60 mm square mesh all around the cod end of the trawl is introduced and enforced. To be successful such regulation depend not only on a binding total allowable catch, but more importantly on measures in accordance with economic theory including a management regime which promotes efficient use of the resources.

Introduction and overview

The Norway lobster (*Nephrops Norvegicus* Linneaus, 1758) is the most valuable crustacean landed in Europe. The Scandinavian stock is shared by three countries, see figure 1. Annual landings during the 1990s have been fully 4000 tons to a value of about US$

30.000.000 [1]. Danish fishermen take about 70%, Swedes almost 30%, while Norwegian landings amount to no more than a few percent of the total catch. A Total Allowable Catch (TAC) of 4200 tons was agreed upon in 1992, but has so far not been restrictive in any year. The concern of this study is the Swedish commercial trawl fishery for *Nephrops*, which amounts to 80% of the Swedish landings while the rest is landed by creel fishers and as by-catches for fish and shrimp trawlers.

The purpose of the study is to apply a bio-economic model to empirical data from the trawl fishery. For this objective a modified version of Jones' length based cohort model is linked to a net revenue function.

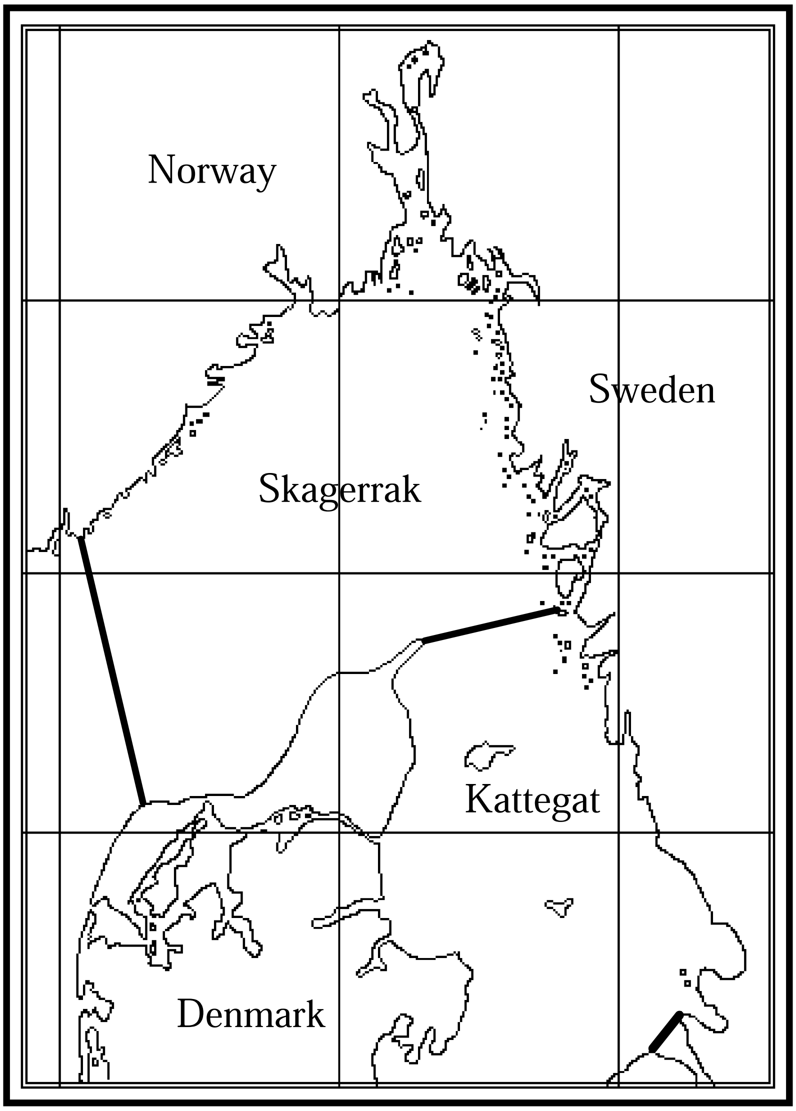

Figure 1 Map showing Skagerrak and Kattegat

[1] $1 = 8 SEK.

Trawl fishery for Nephrops in Kattegat and Skagerrak

The Swedish trawl fishery for *Nephrops* amounted to 366 tonnes in 1978 and then gradually increased to 1024 tons in 1984. During the period 1984-1991 the landings were stable despite an 100% increase in trawling effort. The increased landings are likely caused by the inshore move of the trawl border in 1984, the improvement of navigation equipment, and the introduction of twin trawls in 1989. The period of high landings was followed by some years of reductions and in 1995 landings were 803 tons, see figure 2.

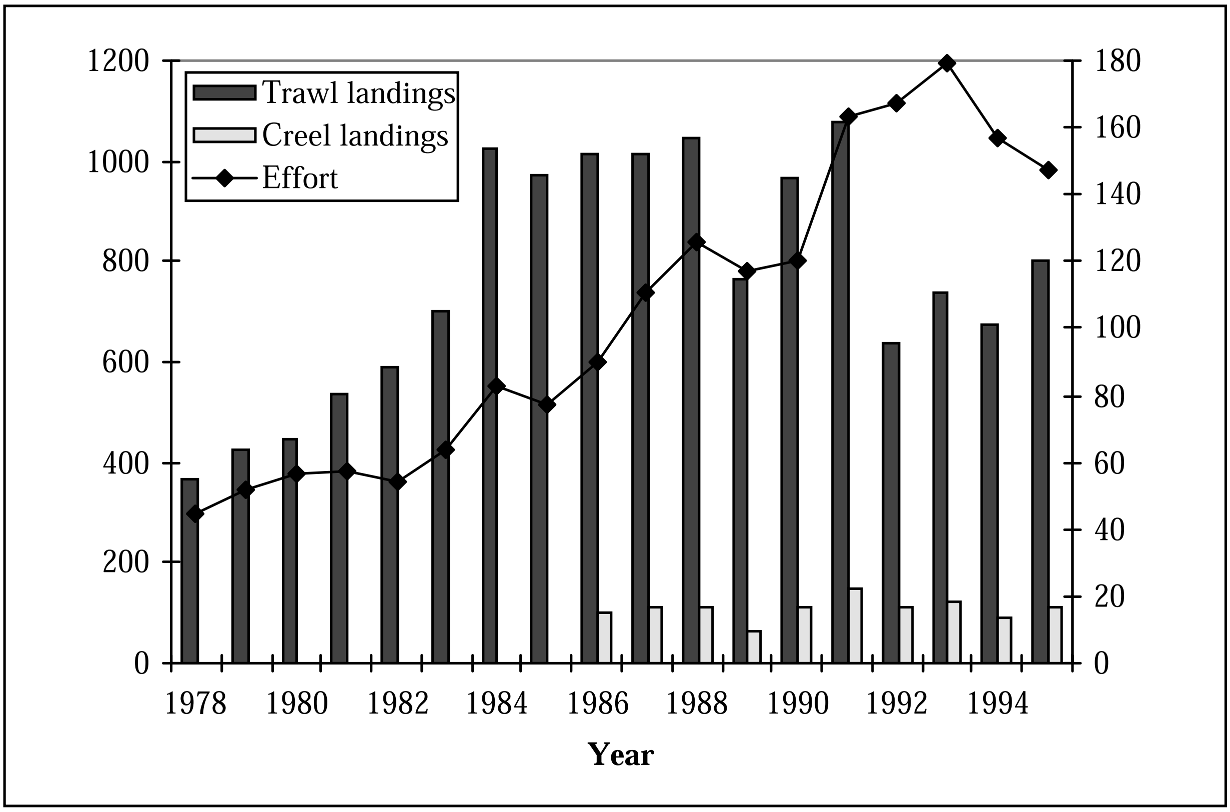

Figure 2 Landings and effort of Swedish Nephrops trawl fishery 1978-95.

The lives of *Nephrops* are still obscured to a large extent and stock assessments are uncertain. Yet, time series on overall landings per unit effort from Skagerrak/Kattegat log book data suggest a drastic reduction with landings from 10-12 kg/hour in the early 1980s and down to 3-6 kg/hour during 1992-95, see figure 3. During the same period annual trawling effort increased by about 200%.

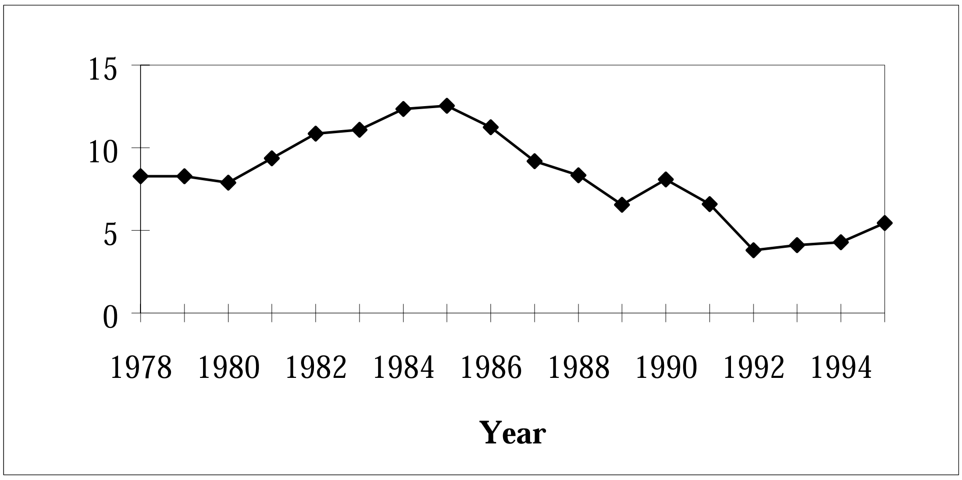

Figure 3 Landings per unit effort (kg/hour) 1978-95.

Regular measurements on size compositions from the Scandinavian commercial trawlers in Skagerrak/Kattegat show that 78% in numbers are undersized and discarded back to the sea. The discard mortality from trawl fishery is approximately 75%, which means that for every landed *Nephrops* almost three dies (Anon., 1998). In fact, the figure is even higher as 10% of the escapees die due to gear infliction leading to more than three dead specimens for each landed (ibid.). The figures for the Swedish trawl fishery are almost as alarming, the fraction of undersized *Nephrops* amounts to about 55% in numbers. The high by-mortality in addition to the likely stock reduction imply that the present 70 mm diamond mesh in use means a drastic cutback of the potential harvest in the future. The minimum landing size of 40-mm carapace length in the Skagerrak-Kattegat area is the result of a historical regulation but is, see figure 4, supported by recent studies of the length at onset of females' sexual maturity. A reduction of the minimum landing size would lead to a larger fraction of female *Nephrops* being caught without reproducing a single time.

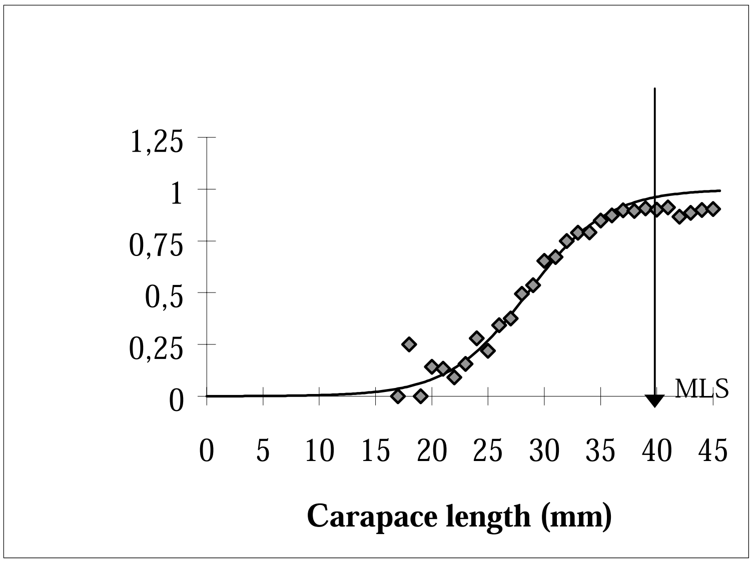

Figure 4 *Onset of sexual maturity (green ovary) for female Nephrops (N=11 514). Minimum landing size (MLS) = 40 mm carapace length.*

To improve the gear selectivity different adjustments, like square meshes and size sorting grids, have been tested. The most promising approach is to install an eight-meter section with 60-mm square mesh all around the cod end of the trawl. The proportion undersized *Nephrops* in the currently used 70-mm diamond mesh trawls amounts to 55% in number, which corresponds to 35% in weight. Preliminary results show that for the 60 mm square mesh, the fraction of undersized *Nephrops* is reduced to about 20% in weight and by-catches of other species like whiting, haddock and cod are drastically reduced (Ulmestrand and Valentinsson, in prep.).

The biological model

Virtual Population Analysis (Gulland, 1965) and its approximation, Cohort Analysis (Pope, 1972), are standard techniques for stock assessment when historical catch-at-age data are available. In absence of age data, which is the case for *Nephrops*, Jones (1979, 1984) suggested a Length-Cohort Analysis (LCA) in which length-frequency data are used to construct a synthetic cohort. This method has its limitations (Lai and Gallucci, 1988; Hilborn and Walters, 1992), but has been established for assessment of *Nephrops* stocks. The International Council for Exploration of the Sea (ICES) Working Group on *Nephrops* Stocks use a modified version of LCA, when age data are missing, as an instrument for their management considerations to the Advisory Committee for Fisheries Management.

The crucial assumptions underlying LCA are constant recruitment, that the numbers caught can be used to calculate annual removals per length group, that the input length composition is representative of a steady state situation, and that the growth of the species can be characterised by a von Bertalanffy curve. A steady state length composition is not likely to occur in practice, but according to Jones: 'a useful approximation can be obtained by determining the average length composition over a period of as many years as possible. In this way the effect of fluctuations in year-class strength and mortality rates should be minimised'. (Jones, 1984, p. 27). This study uses length composition data from the years 1992-96, which was sampled from commercial trawlers.

Computation in the LCA starts with the largest individuals, λ, in a length-frequency histogram and uses (Lai and Gallucci, 1988)

$$N_\lambda = C_\lambda Z_\lambda / F_\lambda \qquad (1)$$

and

$$N_l = N_{l+\Delta l} A_l^{M/k} + C_l A_l^{M/2k} \qquad (2)$$

and the corresponding fishing mortality over each length interval (l, l+Δl)

$$F_l \Delta t_l = \ln(N_l / N_{l+\Delta l}) - M\Delta t_l \qquad (3)$$

where

N_λ is the number of individuals attaining terminal length λ
N_l is the stock size at the beginning of the length interval (l, l+Δl)
C_λ is the catch in number of individuals in the terminal length interval (λ, L_∞)
C_l is the catch in number assumed to occur at the middle of the length interval (l, l+Δl)
$Z_l\Delta t_l$ is the total mortality of individuals in the terminal length interval (l, l+Δl)
M is the instantaneous natural mortality rate assumed constant over all length intervals
F_λ is the instantaneous fishing mortality rate of individuals in the terminal length interval (λ, L_∞)
A_l = $(L_\infty - l) / [L_\infty - (l, l+\Delta l)]$
Δt_l = $\ln A_l / k$, which is the time required for a fish to grow from length l to l+Δl.

where

L_∞ and k are von Bertalanffy growth parameters.

With a constant fishing effort and a steady state stock, the numbers caught and the average numbers in sea will remain constant over the years for each length class. The model take into account by-mortality caused by discard practice due to the minimum size regulation of *Nephrops*.

The growth of a single lobster is assumed to follow the von Bertalanffy growth function, where the length at age t, l_t, is estimated by

$$l_t = L_\infty [1 - e^{-k(t - to)}] \qquad (4)$$

where t_0 is the age at which growth according to the growth equation is initiated. The length data can be converted to weight data by using the relationship

$$W_t = a\, l_t^{\ b} \qquad (5)$$

Where W_t is the weight at age t, while a and b are constants to be estimated. Using equation (4) the length groups can be converted to age groups. Then an algebraic formulation of the yield, following the modified Thompson and Bell yield per recruit model by Christensen and Vestergaard (1993) is:

$$Y = \sum_i R_i [1 - e^{-(FiSi + M)}] F_i S_i / (F_i S_i + M) w_i \qquad (6)$$

where

R_i is recruitment at age i
F_i is fishing mortality rate at age i
S_i is gear selectivity at age i
w_i is average weight at age i

The recruitment for year class i+1 can be expressed as:

$$R_{i+1} = R_i * e^{-[Fi(Si*D) + M]} \qquad (7)$$

Where D takes on the value 0.75 for year classes smaller than 40 mm CL to account for discard mortality and 1.0 for year classes larger than 40 mm CL.

The fishing mortality values for year classes smaller than 40 mm, do not add to the yield but lead to an extra mortality on top of the natural one. In this study we follow the approach described by Jones (1984) where the various computational steps are combined into a single sequence. The figures for male and female Norway lobsters differ and have been estimated for the area (Anon., 1997). L_∞ is 78 and 67 mm, respectively, k_{male} is 0.16 and k_{female} is 0.1 while t_0 is -0.05, a is 0.00045 and 0.00108 and b is 3.11 and 2.85, respectively. The terminal F is assumed to be 0.3 for both sexes. The figures of natural mortality, M_{male} and M_{female}, for the area are still not accurately determined, which leaves us with the estimates from the Scottish *Nephrops* fishery (Anon., 1997), $M_{male} = 0.3$ and $M_{female} = 0.2$. The necessary input data are values for L_∞, the values for M/k, and a value for F_λ / Z_λ.

Standardisation of fishing effort

The link between the biological model in the previous section and the economic model is provided by the fishing mortality, F. A proportional relationship between fishing mortality and effort is assumed. The Swedish *Nephrops* trawling fleet encompasses approximately 200 vessels with various characteristics. Gross register tons (GRT) span from 3 to 200 GRT, crew from one to three people and horse power from 50 to 500 hp. In empirical studies an aggregate measure of fishing effort for the whole fleet is often used, while sometimes a group of similar reference trawlers can be identified to calculate the total effort as the ratio between total landings and landings per unit effort (LPUE) for the reference fleet. In this study we use the latter approach described by Gulland (1983).

A thorough examination of the 67 vessels that landed more than 5000 kg *Nephrops* in 1995 showed that the LPUE is independent of boat size, see figure 5. The fluctuation in LPUE around the average of 8.5 kg/trawl hour is approximately the same for different vessel sizes. Since 1989 an increasing part of the fleet have shifted from single to twin trawls and in 1995 roughly half of the trawl landings came from twin trawl vessels. The LPUE ratio between twin and single trawls is constant at about 1.7 and the twin trawl effort has been converted to single trawl effort and summed to a total Swedish trawl effort (Anon. 1997). The average specialised *Nephrops* trawler spent 1280 standardised trawl hours, landing 10 880 kg in 1995.

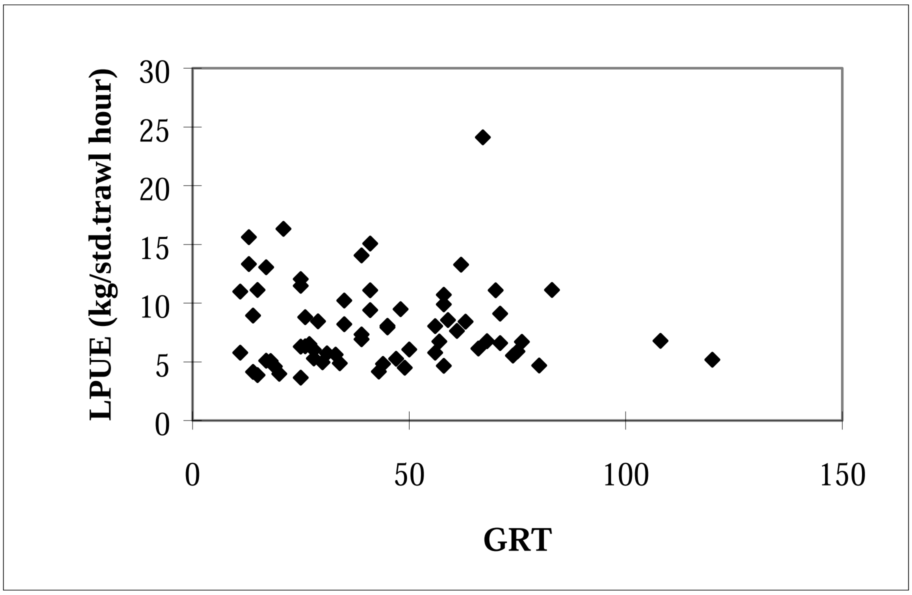

Figure 5 LPUE vs vessel size (GRT)

The economic model

A fish stock can be considered a capital stock. Abstaining from fishing can be seen as an investment in the stock and vice versa. Since the paper by Clark and Munro (1975) much attention have been given to discussions on the optimal path to the optimal stock level. As noted above LCA is based on the assumption of a Steady State equilibrium, for the case of *Nephrops* a change in effort or selection pattern will lead to a new equilibrium after five or six years. Here, the focus is on determining the long-run optimal steady state stock. For the purpose of this analysis, we assume that the resource is managed by a sole owner whose objective is to maximise the net revenue and that all costs are variable.

Detailed information on costs of and revenues were collected from a sample of 20 trawlers with an average LPUE of 8.5 kg *Nephrops*/ std trawl hour, where *Nephrops* landings accounted for more than 40% of total earnings. These figures were used to determine the costs of a trawler specialising in *Nephrops* fishery, on average 60% of the income comes from *Nephrops* while the rest is from demersal species where cod is the single most important species. We use the simplifying assumption of perfect foresight, i.e. fishermen allocate their effort in the same proportion as the actual landings in monetary terms. The consequence is that 60% of the total costs are assumed to correspond to the annual landings of *Nephrops*.

Table 1 Costs of the reference trawler 1995 ('000US$)

	Low	High
Capital cost	15'	15'
Operation cost		
Fixed	34'	34'
Variable	25'	25'
Labour cost	25'	50'
Total	99'	124'
60%	59.4'	74,4'

Table 1 summarises the cost figures for a representative *Nephrops* trawler, which on average earned US$ 124 000. The user cost of capital is calculated by using the average insurance value of the vessels, assuming linear depreciation over 20 years, and calculating the imputed opportunity cost for a real interest rate of 5%.[1] Operation costs are average values including maintenance, fuel, water, ice, administration etc. As in most fisheries wages in the *Nephrops* fishery are based on a share system, remuneration of US$ 50 000 per vessel with two persons on board correspond to a monthly salary of about US$ 1600. This is a quite low figure compared to fully US$ 1800 for an average Swedish non-skilled worker in 1995 (Statistics Sweden, 1997). Two major factors that may explain these conditions are the accounting of capital and operation costs and unreported landings. The cost

[1] The average real rate of return on Swedish government bonds during 1990-96 was 5%.

figures for some of the vessels covered 1992-96 and showed that the real insurance value was constant. This observation was also supported by personal communication with several fishermen and despite the limited second hand market for trawlers, a few actual transactions took place and were settled at prices close to the insurance value. In 1995 the scrap premium from the European Union was US$ 1500/GRT which implied a scrap value close to the insurance value for most vessels. The oldest vessel in the fleet was almost 70 years old while the average age was 30 years. The overall impression is that individuals do not perceive a depreciation cost, but also that the capital cost may be overestimated from a social point of view. Possible reasons are that part of the maintenance costs are in fact reinvestments and the cost of increased risk for breakdown with age is borne via a higher insurance premium. The scrap premium has probably influenced the second hand price of vessels. However, in 1996 the scrap premium was reduced by 35% but neither a change in insurance values nor in transaction prices was observed. There is of course a social depreciation cost but partly it may be double accounted as reinvestment and higher insurance premiums are not identified properly. We have no reason to believe that the actual cost figures are exaggerated, but possibly underestimated as some maintenance work may be carried out by the fishermen themselves or as non taxed work. A major part of trawl landings, 60-70%, come from vessels located in the northern part of the Swedish west coast, which is entitled to rural support according to the European Union. Given that alternative employment opportunities are scarce, the social opportunity cost of labour is significantly lower than the actual earnings. The low cost alternative represents such a situation where only half of the actual labour cost is accounted for.

On the revenue side our figures are more likely to be uncertain. The occurrence of unreported landings have been much debated in Sweden recently (Hultkrantz et al, 1997). Exact assessments are absent, but there is a consensus of the existence. Trawl fishermen can be said to have quite high opportunity cost of time, but for a valuable species like *Nephrops* the profits from selling without paying tax, social insurance etc. are high. A 7-8% unreported landings of *Nephrops* would correspond to a monthly salary before tax of about US$ 2000, which is significantly higher than the average Swedish non-skilled worker. It should be noted that potential unreported landings do not affect the stock assessment, which are based on data from repeated length analysis of the complete catches including under sized individuals. These data have been collected monthly from a sample of fishermen since 1991. There is no enforcing element in the length analysis reports as the link to total catches is hard to establish and with no incentive for misreporting, the underlying figures for the biological parameter estimates are judged to be precise.

The open access equilibrium is determined as the zero profit case for the high cost alternative, while maximum economic yield is achieved from maximising the profit for the static case. Sandal and Steinshamn (1997) have recently shown that in case of inelastic demand and/or increasing marginal cost, a higher discount rate can imply a larger standing stock and the same applies for Hannesson's (1986) model which takes capital dynamics into account. But for a valuable species, assuming linear effort costs and a constant price the result of Clark (1990) that a positive discount rate implies a smaller standing stock is most likely to be valid. In this study no discounted equilibrium are determined, but for policy guidance it can be concluded that the MEY figures represent minimum figures for optimal effort levels. As a comparison Clarke, Yoshimoto and Pooley (1992) calculated the optimum effort for various discount rates for five different simple stock growth models. The 5% discount rate level compared to the zero case implied increases in the optimum effort level, ranging from one to eight percent.

Results

The estimated revenue curves are shown in figure 7 together with two different cost curves. The yield curves 60 square and 60b square represents the higher and the lower limits from the results of square mesh tests, respectively. We find that the Swedish *Nephrops* trawler fleet applied an effort of 94.000 standard trawl hours, leading to landings of 803.000 kg at a value of US$ 5.6 million which corresponds to an open access equilibrium where profits are zero. If we relax the assumption of perfect labour mobility in and out of the fishery and assume the existence of persistent unemployment, the low cost alternative might be a more accurate description of the current situation. In such a case this fishery does indeed entail a positive net welfare contribution to society, but this social resource rent could be increased if effort is reduced and /or if the square mesh is introduced. Using the high cost figures, Maximum Economic Yield is found at a level of 35 000 standard trawl hours where the resource rent is estimated to US$ 2.9 million. If a square mesh regulation is introduced, we expect the MEY to be found in the interval of 38.500-43.500 std trawl hours and the resource rent to be slightly increased to US$ 3 million. However, using only a mesh regulation, long-term effort and landings are likely to increase, producing a value of US$ 6-7 million but with the rent still completely dissipated.

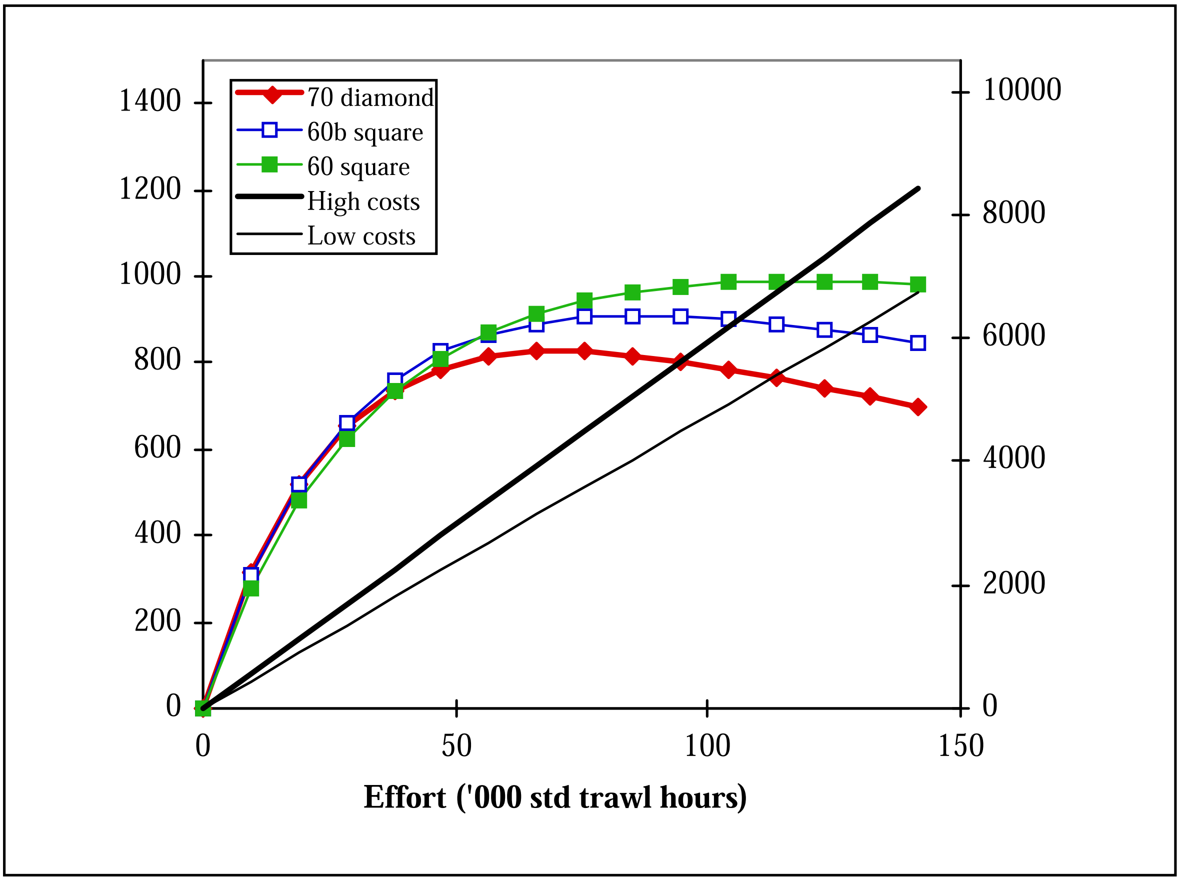

Figure 7 Estimated yield and cost curves for M=0.2/0.3

Table 2 provides sensitivity testing of the robustness of the results with respect to the natural mortality. In case of a higher natural mortality than the assumed 0.2/0.3, MEY effort levels are slightly higher, while the potential rent is drastically reduced. Even for the highest natural mortality level combined with the low cost figures, MEY requires a drastic reduction of the effort level and there is a significant potential resource rent to be earned. It should be stressed that the natural mortality and the von Bertalanffy parameters are assumed constant, regardless of stock size. In reality increased natural mortality and reduced individual growth are likely effects of a major increase in stock size, which imply a higher Maximum Economic Yield effort level and a lower rent.

Table 2 Maximum economic yield effort levels, Long-term increase in landings, and Long-term resource rent for different values of the natural mortality rate and two levels of costs

		Maximum Economic Yield effort (standard trawl hours)			Long-term annual resource rent ($US thousand)		
M (fem/male)	Costs	70	60b	60	70	60b	60
0.1/0.2	High	28.500	31.000	35.000	5.050	5.370	5.520
	Low	24.000	25.500	28.000	5.180	5.420	5.480
0.2/0.3	High	35.000	38.500	43.500	2.920	3.060	2.920
	Low	39.500	43.000	50.500	3.370	3.550	3.490
0.3/0.4	High	38.000	41.500	43.000	1.700	1.720	1.370
	Low	45.500	51.000	57.000	2.200	2.270	1.960

Lai and Gallucci (1988) derive the analytical expressions for the errors in stock abundance and fishing mortality that would result from different deviations of estimates from true parameter values. The most sensitive parameter is the natural mortality, where a difference of ±0.1 in M leads to a 40-50% error in the estimates. It is obvious that LCA results must be taken with great caution and that the MEY figures of effort levels and rent are most uncertain. Still, with all reservations in mind, a large body of empirical studies imply that the value of M is within the range given in table 2 and the evidence for a reduction in effort is unambiguous.

Discussion and conclusion

The Swedish *Nephrops* fishery is the country's most valuable coastal fishery. It encompasses a great variety of vessels, from 200 GRT trawlers down to single operated 3 GRT boats. For the trawl fishery we estimate a potential annual resource rent of almost US$ 3 millions for the Maximum Economic Yield equilibrium. This would require a reduction of the effort level by more than 50%, compared to the open access situation in 1995. Given the uncertainty of the biological parameters and the likely political resistance to carry out such drastic reductions of effort, a first regulation maybe should aim at a reduction of 30-40%. In case of a successfully enforced gear regulation, leading to an overall use of the 60-mm square mesh, a further increase of the rent is possible. Bearing in mind that the current fishery is roughly characterised as an open access regime, a single management measure of a mesh regulation would only lead to an increased long-term effort level where the higher landings will be offset by larger costs and the resource rent will remain completely dissipated. The mesh regulation is in itself amiable but should be accompanied by a set of measures. At present new vessels are heavily subsidised by 25% grants from the European Union and the scrap premium of US$ 1000/GRT is still practised, such policies are not in accordance with economic theory. They are also likely to increase the average size of the vessels while the economic figures collected for this study show that smaller vessels may well outperform the large ones. Most of the *Nephrops* trawlers are partly dependent on landings of other demersal species, with cod as the most valuable one. As cod repeatedly has been objected to a binding TAC, an increase of catch capacity would be unfortunate. Combining the mesh regulation with a reduction of the existing *Nephrops*

TAC of 4200 tons, hints an increase of the potential resource rent. Still, given a significant stock enhancement thanks to such measures, the existence of a positive resource rent will lead to a race to catch and reinforce the problem of overcapitalisation.

What is called for is a management regime that promotes efficiency and can be effectively enforced at defensible costs (See e.g. Rodgers and Valatin, 1997). The last remark probably implies a necessity of a fairly well established consensus among the major actors on the fisheries arena, i.e. Fishing authorities, fishermen and the fishing industry. Individual Transferable Quotas is an often advocated management regime in the literature, another suggestion is Territorial Use Rights in Fisheries which could be allocated among local fishing communities. It is beyond the scope of this study to judge which management regime is the most adequate for the Scandinavian *Nephrops* trawl fishery (A general discussion and further references are found in Eggert, 1998). Yet, given that the suggested mesh regulation is imposed in both Denmark and Sweden, it is an important task for future research to investigate which management regime is the most suitable for this specific fishery.

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Policy alternatives for the fishery sector

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Summary

This paper discusses overexploitation in fisheries. After a short description of the problem, a number of policy instruments are discussed. All traditional instruments or combinations of instruments have serious shortcomings. In relation to this, two alternatives are brought to the fore. The main part of the article has a theoretical focus, but remarks about reality are made occasionally. The end of the paper focuses on policies in the Netherlands and the European Union.

Introduction

At present many fisheries in the world are overexploited [2]. From a theoretical perspective, the problem can be analysed with the help of the so-called Gordon-Schaefer curve (see Figure 1). The curve concerns the catch of one species. The X-axes gives the 'effective effort'. Effective effort is a difficult concept, but in the context of this paper it may simply be regarded as the product of the following five factors: the number of fishing boats, the average size of a boat, the average engine power, the average number of days at sea, and a factor that reflects the state of the technology.[3] Figure 1 is based on the assumption of a constant price of fish. In relation to this, the Y-axes is a measure of both physical production and (after a change in the scale) of financial returns. This concerns the production and the returns that are realised in the long run when effective effort is kept constant for a number of years.

The Gordon-Schaefer curve can be based on different biological theories. A well-known one runs as follows. When effective effort is zero, the fish population is at its maximum, and the rate of natural growth is zero. When effective effort increases from zero to a small value, the catch of fish reaches a positive but small value. The average catch (the catch per unit of effective effort) is high. After some time the catch of fish causes a small decrease in the population. This implies that natural conditions for the remaining fish improve. Because of this, the rate of natural growth becomes positive. After some time natural growth will counterbalance the catch of fish, so that the rate of growth of the population becomes zero.

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[1] Faculty of Public Administration, University of Twente, The Netherlands. The author wishes to thank Martijn van Vliet and Andries Nentjes for their helpful comments.

[2] FAO, 1995, *The State of the World Fisheries and Aquaculture*, Rome.

[3] For a more rigourous treatment of the concept see: S. Cunningham, M.R. Dunn and D. Whitmarsh, 1985, *Fishery Economics. An Introduction*, New York, St. Martin's Press.

When effective effort is further increased, the catch of fish will increase in the short run. If effective effort is not too high, the catch will also increase in the long run. However, the increase in the long run will be smaller than in the short run, because of a further decrease in the population. The fact that there is nevertheless some increase in catch in the long run, is related to the decrease in the population. This decrease in the population implies an increase in the rate of natural growth. This larger natural growth makes it possible to have a larger catch of fish in the long run without further decreases in the population. However, the decrease in the population which has occurred in the short run implies that the average long-run catch decreases.

A further increase in effective effort will cause a further increase in catch in the short run. However, when the increase in effective effort is large enough, it will cause the population to become so small that the natural rate of growth decreases. This is related to the fact that a strong reduction in the population will cause the production of eggs to decrease to an important degree. The smaller rate of natural growth implies that the catch in the long run -to which figure 1 applies- decreases. It is even possible that the population falls below a critical level so that the fish stock collapses (a process which is not shown in figure 1) [1]. Finally, it can be remarked that the level of effective effort e_s, which is shown in the figure, is the level which leads to 'maximum sustainable yield'.

According to another theory there are always sufficient eggs, because one fish can produce millions of eggs. This implies that the number of young fish is independent of the number of older fish. In this case the form of the curve in Figure 1 can be explained as follows: with a large effective effort many fish are caught before they reach full maturity. This implies that the catch, as measured in tonnes of fish, decreases [2].

The total cost curve, *C1*, also applies to the long run. The long run is now defined as the period in which the number of boats is variable while the technology is still given. All boats are -the discussion remains a theoretical one for then time being- identical. On each boat the various inputs are used and combined in an efficient manner. Changes in effective effort in the long run are caused by changes in the number of boats. Therefore, total costs are proportional to effective effort. When effective effort is below e_r, total costs are lower than total financial returns. This implies that all fishermen make a profit. As a result, new boats will enter the fishery, until the level of effective effort is equal to e_r. In that case there are no (above-normal) profits.

A level of effective effort of e_o leads to 'maximum economic yield' (a maximum difference between financial returns and costs). As was stated above, the level of effective effort that will be realised is e_r. In other words, a non-regulated fishery will experience 'economic overexploitation'.

In the 'very long run' the technology is no longer given. Technological change will cause the total cost curve to turn downwards [3]. There will be investments in new technology, which implies an increase in effective effort. In relation to the downward shift of the cost curve, fishermen will make profits in the short run. This will lead to investments in new boats,

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[1] This theory has been described in Cunningham et al., op.cit.
[2] See M. Holden 1994, *The Common Fisheries Policy. Origin, Evaluation and Future*, Oxford, Blackwell.
[3] Technological improvements cause - with a given number of boats, a given average engine power, etc.- an increase in effective effort. Because of this the costs per unit of effective effort decrease.

implying a further increase in effective effort. In the long run, the investments will cause the profits to disappear again. Technological improvements may lead to an increase in the catch of fish in the long run; however, they can also lead to a total cost curve such as C*2*, which implies a lower catch in the long run.

The theoretical literature pays more attention to subjects such as the price of fish, the difference between the short and the long run, the role of the discount rate, etc. These refinements do not change the main conclusions of the theory [1]. Of course, theory is not a perfect reflection of reality. In reality, for instance, not all fishermen are the same, and some fishermen make more profit than suggested by the theory. Nevertheless, in reality one often finds economic overexploitation. Nowadays there are also situations in which catches decrease with increasing levels of effective effort, this being related to technological change. Thus, the main predictions of the theory are confirmed by empirical observations [2].

Policy objectives

A possible objective for public policies is maximum economic yield. Socials concerns, for instance relating to employment, could make the government aim for a level of effective effort that is somewhat higher than the one related to maximum economic yield. In practice, however, policies are generally not based on clear socio-economic objectives [3]. In many cases the government aims for maximum sustainable yield, or for a level of effective effort that prevents the stock from collapsing.

Whatever the objectives of fisheries policies, in most cases they imply a reduction in effective effort. The question then is in which way a certain reduction can best be realised. The remainder of this paper deals with this question.

Policy instruments

The effects of a policy instrument on the economic position of pressure groups affects its feasibility [4]. In relation to this, the following analysis will not only pay attention to the effects of instruments on total welfare, but also to the effects on the position of fishermen. The analysis will disregard instruments that are specifically aimed at the reproduction of fish of at the size of the fish that are caught. Besides, the problem of the optimal time-path of the reduction, which is not relevant for the main conclusions drawn below, will not be discussed [5].

In the first instance the analysis will be based on the following assumptions. There is only one country. The government of this country has perfect information regarding all rele-

[1] See the literature in footnote 2 and 4.

[2] For a comparison between theory and empirical observations see: OECD Ad Hoc Expert Group on Fisheries, 1996, *Synthesis Report for the Study on the Economic Aspects of Marine Living Resources*, Paris.

[3] This is one of the points of criticism of Holden, op.cit., regarding the Commmon Fisheries Policy.

[4] For a general analysis of this point, see A. Nentjes en B. Dijkstra, The Political Economy of Instrument Choice in Environmental Policy, in: M. Faure, J. Vervaele en A. Weale, *Environmental Standards in the European Uniion in an Interdisciplinary Framework*, Antwerpen, Maklu, pp.197-216.

[5] For a discussion of these points see Cunningham et al., op cit.

vant biological and economic factors. The transaction costs of public policies (costs of research, administration, control and enforcement) are zero, and there are no implementation problems. The starting point for the analysis is a situation in which the total costs of the fishery equal the total benefits.

In view of these assumptions, there are three instruments which can reduce the level of effective effort to the desired level in an efficient way. The first one consists of individual transferable quotas (ITQs). An ITQ in the fishery generally is a right to catch a certain percentage of an aggregate quota, the latter being determined by the government. In those countries where ITQs have been introduced (among others New Sealand and The Netherlands), the initial allocation has essentially been based on historical catches. Besides, the quotas were given away by the government; the fishermen did not have to pay for them [1].

In the short run ITQs imply a reduction of the catch. This affects the position of the fishermen in a negative way. The lower catch may be counterbalanced to some extent by a higher price. Some fishermen will sell their quotas and leave the fishery. In case they did not have to pay the government for the quotas in the first instance, they can possibly leave the fishery with a certain wealth. In the long run the aggregate catch -and therefore the aggregate quota- may increase [2]. In the long run economic rent [3] will be created. This is related to the reduction in effective effort (and therefore in costs), and possibly also to an increase in catch. If the quotas are given away in the first instance, the fishermen obtain the economic rent. If, however, the government sells the ITQs in the first instance, the government will reap all or part of the economic rent (depending on the price). This would, however, meet resistance from the fishermen, and could be politically difficult to realise. A compromise might be that the government puts a yearly levy on the use of ITQs [4].

The second instrument is a tax on fish. This will move the curve of the financial returns (for the fishermen) of figure 1 downwards. The third instrument is a tax on inputs. This will turn the cost curve from figure 1 upwards and to the left. For both types of taxes it holds good that the effect on the effective effort is smaller in the short run than in the long run. The reason is that the capacity of the fleet is given in the short run. In view of the assumption of perfect information, the tax rates can be set at such a level that the desired level of effort is reached in the long run. The tax will cause the fishermen to incur losses. Some fishermen will leave the fishery. In the long run the fishermen who remain will no longer incur losses, but they will neither make profits; the economic rent is for the government. Because of the relative negative effects for the fishermen the tax instrument is rarely used in practice [5].

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[1] Government of New Zealand, 1995, *Fisheries Management Techniques, Country Report, New Zealand* en Dubbink, W. and L.M. van Vliet, 1995, *From ITQ to Co-management? Comparing the Usefulness of Markets and Co-management Illustrated by the Dutch Flatfish Sector*. (Both: Issue Paper distributed at the 10th Session of the ad hoc Expert Group on Fisheries, OECD, 3-6 October.)

[2] This is dependent on the question at which point on the Gordon-Schaefer curve the fishery was in the first instance. If, without ITQ's, the fishery is close to maximum sustainable yield, the catch will also decrease in the long run.

[3] Economic rent is defined as the difference between social costs and social benefits.

[4] In New Sealand owners of quotas contribute to the costs of enforcement by paying a certain amount of money to the government each year.

[5] Cunnningham et al., op.cit., pp.64-65.

There are also instruments which -in view of the assumptions that are still valid at this point- are less efficient than the instruments discussed above, but which are nevertheless important in practice [1]. The reasons for the popularity of these instruments will be discussed later. One of these instruments is a yearly (of for instance three-monthly) quota for the fishery as a whole. When the quota is reached, the fishery is closed for the remainder of the season. An important disadvantage is that the instrument, as has been shown in reality, leads to a race for fish. This implies that large investments are done in order to catch much fish in a short time. From a social point of view these investments have no value.

Another popular instrument consists of individual non-transferable quotas. These are used in among others most European countries. As is well-known from economic theory, this instrument is less efficient than transferable quotas. With this instrument, however, more independent fishermen may remain in the fishery than with transferable quotas.

Each country uses certain measures regarding the use of inputs, such as restrictions on the number of boats (by means of licences, or by means of subsidies for the withdrawal of boats from the fishery), restrictions on the size of boats, engine power restrictions, restrictions on the number of days at sea, etc. Of course, these measures are harmful for the efficiency of the fleet; the costs per unit of effective effort will be higher than necessary. Sometimes these measures are beneficial for employment. The reduction in effective effort is lower than expected in many cases, because fishermen replace inputs which are subject to regulation by other inputs [2]. Most input restrictions do no generate economic rent. There are exceptions however, such as restrictions on the number of boats by means of licences.

Finally, it can be mentioned that the assumption of one country and one species of fish are abandoned at this point [3]. Besides, from this point onwards implementation problems and transaction costs are taken into account.

Implementation problems and transaction costs

Implementation problems and transaction costs are important for the choice of policy instruments [4]. This also applies to the fishery. For instance, the introduction of ITQs in the Netherlands has given rise to massive violations of quota, especially in the seventies and eighties. Such violations have three consequences. First, the optimal level of effective effort is not realised. Second, violations need to be countered, implying an increase in enforcement costs. Third, there are broader social implications, such as decreasing respect for social norms.

The behaviour of fishermen at sea is difficult to control. Control in the harbours can also be difficult. Besides, a fisherman who is confronted with quotas in his own country which are strictly enforced, may try to sell his fish in other countries or to tranship his fish at

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[1] OECD Ad Hoc Expert Group on Fisheries, op.cit.
[2] OECD Ad Hoc Expert Group on Fisheries, op.cit, p.90 a.f.
[3] For an analysis which takes account of the existence of more countries and more species of fish see the literature in footnote 2 and 4, and Meltzer, E., 1994, Global Overview of Straddling and Highly Migratory Fish Stocks: The Non-Sustainable Nature of High Seas Fisheries, *Ocean Development and International Law*, Vol 25, pp.255-44.
[4] Vollebergh, 1994, Transaction Costs and European Tax Design, in: M. Faure, J. Vervaele en A. Weale, op.cit., pp.135-153.

sea to a boat from another country [1]. Policies can be further frustrated by political factors. For instance, problems may arise when it is in the interest of local authorities not to have a very strict control in their own harbour [2]. Problems can also arise when a number of countries agree to reduce catches, while it is in the interest of each single country not to limit its own catch [3].

Another problem is that of 'discards': part of the catch is thrown back into the sea, a process which causes many fish to die. For a part, the discards are caused by the low market value of some specimen (for instance small specimen). Another part is caused by quotas and regulations regarding the minimum size of fish caught. A well-known practice is that fishermen catch more fish than their quota allows them to, in order to throw the less valuable specimen back into the sea. It has been estimated that worldwide 27% of the commercial catch are thrown back into the sea [4]. Which part of this is caused by government regulations is unknown.

The transaction costs of government regulations can be high. For instance, the transaction costs of fishery policies in the U.S. for 1983 have been estimated at 300 million dollars. At the same time the potential benefits of the policies were estimated at 500 million dollars. Despite the high transaction costs many fishermen were breaking the rules [5].

ITQs compare badly with other instruments regarding implementation problems and transaction costs. An aggregate quota, with closure of the fishery as a whole when the quota has been reached, compares more favourably. Some input restrictions also compare favourably. For instance, a limitation of the number of boats by means of licences can be enforced relatively easily.

Taxes also involve implementation problems and transaction costs. With regard to some (increases in) taxes, however, these remain relatively modest. An example is an increase in the value added tax on fish and fishery products from the low tariff of 6 % which is presently levied on fish in the Netherlands to the high tariff of 18 % which is levied on many other goods. Such an increase in the tariff of an existing tax involves little transaction costs. Besides, it is difficult for the fishermen to evade value-added taxes, because this presupposes that other parts of the chain (e.g. fishmongers) are willing to do the same. An advantage of (higher) taxes in the fishery is that they make it possible to decrease taxes in other sectors of the economy. This implies that implementation problems and transaction costs elsewhere de-

[1] It has been reported that fish caught by Dutch fishermen has been transhipped at sea to trawlers from eastern Europe (Subcommissie Visquoteringsregelingen, The Hague, Tweede Kamer der Staten-Generaal). At present Scotch fishermen are accused of the same offence (De Volkskrant, 29 June 1996). For an analysis of the elusion of public rules see: Holden, op.cit., en Sutinen, J.G. and P. Andersen, 1985, The Economics of Fisheries Law Enforcement, *Land Economics*, Vol.61. No.4. pp.387-397.

[2] For instance, the Subcommissie Visquoteringsregelingen, op.cit., states that Dutch municipial auctions have not fully cooperated with the national government in the field of enforcement because of the fear of loosing market share.

[3] De Subcommissie Visquoteringsregelingen, op.cit., p.80, concludes with regard to the failing controls of Dutch fishermen by Dutch authorities: 'The interests of the fishermen and of economic sectors dependent on the fishery were identified as national interests, en partly in relation to this the fact that obligations to the European Union were not met was not regarded as a problem'.

[4] OECD Ad Hoc Group on Fisheries, op.cit., p.13.

[5] Sutinen, J.G. and P. Anderson, op.cit., p.388-89.

crease. Moreover, taxes cause distortions in most economic sectors, while taxes in the fishery sector increase economic efficiency.

Sometimes implementation problems and transaction costs are a reason for combining ITQs with input restrictions. This makes enforcement of the quotas easier. However, in this case the whole is not an improvement compared to the sum of the parts. If the input restrictions are so strict that everyone remains within his quota, one could better have a policy of input restrictions only. To the extent that the input restrictions do not quarantee that everyone remains within his quota, there is again reason to violate the quotas.

Fluctuations in the population and uncertainty

For natural reasons the fish population varies from year to year. In relation to this, the optimal catch also varies. Quotas can easily be changed from year to year. A yearly change in tax tariffs, however, is less easy to implement. Yearly adjustments of catches by means of quotas is therefore more practical than yearly adjustments by means of taxes.

Until now the analysis has been based on the assumption of perfect information. However, in reality the estimates regarding the size and the growth of the fish population are surrounded by large uncertainties. The knowledge regarding costs and benefits and the behaviour of fishermen is also limited. This means that the optimal catch cannot be exactly determined. As a result no instrument can lead to the realisation of the optimal catch. This problem is, of course, aggravated by the existence of infringements and discards. Since the optimal catch cannot be exactly determined and exactly realised, the fact that quotas make yearly adjustments of catches possible becomes less important; fine-tuning can only be beneficial when it is based on good information. Nevertheless biologists still think that yearly changes in catches are sensible [1], so that the advantage of quotas regarding yearly adjustments of catches still applies to a certain extent.

From a more general perspective it can be remarked that it is only during the last fifteen years that economic theory has paid attention to the problem of uncertainty in the fishery. However, as yet this has not led to a clear conclusion regarding the question whether taxes of quotas are the best answer to uncertainty [2].

Co-management

The involvement of fishermen in the formulation and implementation of policies can be useful. The possible advantages are a better policy design and a decrease in the size of implementation problems and transaction costs.

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[1] Holden, op.cit., pp.88-91.

[2] See a.o. Koenig, E.F., 1984, Controlling Stock Externalities in a Common Property Fishery Subject to Uncertainty, *Journal of Environmental Economics and Management*, nr.11, pp.124-138, en Androkovitch, R.A. and K.R. Stollery, 1991, Tax versus Quota Regulation: A Stochastic Model of the Fishery, *American Journal of Agricultural Economics*, Vol. 73, No.2, pp.300-308.

In the Netherlands, for instance, there exist so-called 'Biesheuvel-groups'. These groups consist of about 20 to 90 fishermen. The fishermen have their own individual quotas, but the group has a certain responsibility for the management of these quotas. For instance, the group acts as a mediator for fishermen who want to hire or hire out quotas. This helps increase the flexibility of the fishermen. The groups can also prosecute fishermen who exceed their quotas under private law. In principle this implies a very efficient method of control, since fishermen know a lot about their colleagues. However, the system presupposes that fishermen report colleagues from their own group, and this for an offence which is harmful mainly for fishermen outside the group. The Biesheuvel-system has been introduced in 1993, and it is too early to pass a judgement on this system [1].

In other countries too, there is participation of fishermen in policies. Some authors, however, argue that fishery policies are still based too much on a top-down approach [2].

Summary

At this point a summary can be given of the advantages and disadvantages of the instruments which have been discussed thus far, and of their effects on the financial position of the fishermen and the government. Let us start with ITQs. An advantage of this instrument is that it allows yearly adjustments of catches. The disadvantages concern the illegal landings of fish, the discards, and the high transaction costs. In case ITQs are given away in the first instance, the fishermen reap the economic rent. In the short run, however, the limitation of the catch is a disadvantage for the fishermen. To some extent this may be counterbalanced by a higher price of fish. Besides, fishermen get the possession of quotas, which they may sell. On balance ITQs which are given away in the first instance are beneficial for the fishermen, especially in the long run. In case the government auctions the ITQs in the first instance, the effects for the fishermen are less beneficial. This could make it more difficult politically to introduce ITQs.

The advantage of taxes, or at least of some (increases in) taxes, is that the implementation problems and the transaction costs are relatively limited. Besides, taxes make it possible to decrease taxes in other economic sectors. Taxes are not suitable for yearly adjustments of catches. The economic rent is for the government. Because of the adverse financial effects for the fishermen, the introduction of taxes may be politically difficult.

In some cases the implementation problems and the transaction costs that are related to input restrictions are relatively limited. In other cases this is different. Some input restrictions are suitable for yearly adjustments of catches, others are not. The disadvantage of input restrictions is that they are inefficient. Nevertheless a certain amount of economic rent may be created in some cases. In these cases the economic rent is for the fishermen. With regard to combinations of ITQs and input restrictions, it holds good that the whole is not much better than the sum of the parts.

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[1] Because of a small fish population, relatively high quotas and input restrictions in 1993 only 63% of the Dutch quota for plaice and sole has been caught, and in 1994 only 72% (Produktschap voor Vis en Visprodukten, Jaarboek 1993, en Visserijnieuws, 7 april 1995). Partly in relation to this, it is not yet possible to say that the system is succesful in controlling fraude.

[2] See for instance Dubbink and Van Vliet, op.cit.

Alternative policies

This section discusses two alternative combinations of instruments. The first combination consists of ITQs which are initially given away and a tax on fish. The effects of this policy alternative are presented in figure 2, which concerns the short run. *D* is the demand for fish. q_o is the aggregate quota. The supply curve with quota but without tax is *S1*. This curve is based on the assumption that there are no moral objections to fraude. The supply curve shifts at q_o because violating the quota implies additional costs for a fisherman (cost are incurred to avoid being detected, and the expected value of penalties is positive). The amount of fish sold, q_1, is above the quota. The tax on fish moves the supply curve to *S2*. The resulting amount of fish sold, q_2, is above the quota, but to a lesser extent than with supply curve *S1*. In reality, of course, there are people with moral objections to fraude. Nevertheless the figure shows that the tax makes fraude less attractive for the fishermen. Therefore, with a given enforcement policy, or in other words with a given probability of being detected and convicted and with a given penalty schedule, infringements will diminish. It is also possible to decrease the probability of being detected and convicted, and in relation to this the enforcement costs, with infringements still diminishing on balance.

The tax entails transaction costs and possibly tax evasion. It has been argued earlier that these disadvantages can remain limited with regard to some (increases in) taxes. In this context an increase in value added taxes has been brought to the fore. An advantage of this policy alternative is that it makes it possible to decrease taxes elsewhere in the economy.

In comparison with a combination of ITQs and input restrictions this policy alternative also has advantage that no inefficiencies are created, so that economic rent is not affected. Assuming that the tax rate is not so high that the quotas become superfluous, the economic rent is partly for the fishermen and partly for the government. In the short run however, the financial position of the fishermen deteriorates to an important degree; not only are catches reduced, but is also a decrease in the price for the fisherman. Besides the ITQs are now less valuable than with a policy of ITQs only. Therefore the first alternative may be politically more sensitive than a policy consisting only of ITQs that are initially given away. On the other hand it may be less sensitive than a policy consisting only of ITQs that are auctioned.

The second policy alternative is more favourable for the fishermen. It consists of the following elements: first, ITQs which are initially given away; second, a tax on fish; and third, a premium for each tonne fish which a fisherman catches and for which he has a quota. To simplify the exposition it is assumed that the premium is that high that the effect of the tax for the fisherman is exactly counterbalanced -to the extent that the fisherman remains within his quota. In principle, however, the size of the premium may be different. The premium is financed out of the general budget of the government.

Figure 3 presents the effects of this alternative. *S1* is the same supply curve as *S1* in figure 2, en results in quantity q_1. The tax moves the supply curve upwards on all points. The premium moves the supply curve downwards on all points to the left of q_o. The result is curve S_3 and quantity q_2. Figure 3 shows that the third alternative, like the second alternative, makes fraude less attractive. This will cause the infringements to be more limited than with a policy of ITQs only, while the enforcement costs may also be decreased.

In principle the tax and the premium could be further increased, such that the supply curve becomes *S4*. In this case one could consider the possibility of making it legal to exceed the quotas. Quotas would then only serve as a basis for payments of premia, and enforcement would become superfluous. Although it would not be attractive for a fisherman to try deliberately to fish more than his quota, it is still possible that he will land by-catch for which he has no quota. This effect -which is not shown in the figure- would diminish the waste caused by discards.

Compared to the first alternative this alternative involves additional transaction costs which are related to the payments of premia. These transaction costs, however, will be low; one only needs to combine available information about quotas with available information about registered catches, and to provide payments on the basis of this information [1].

With regard to the transaction costs of raising taxes and the evasion of taxes it was argued earlier that an increase in the VAT on fish and fish products from the low tariff of 6 % that exists presently in the Netherlands to the high tariff of 18 % is a suitable option. In this context the following can now be remarked. The increase in the VAT equals 12% of the price of the final product. This is in the order of magnitude of 50% of the price of fish on the auction, or perhaps more [2]. In view of the assumption that the total amount of the premia equals the total amount of the additional tax revenues, this implies a large difference between the returns of fish caught within the quota and the returns of fish caught outside the quota. Thus, fishing outside the quota has become much less attractive [3].

Perhaps the implementation problems and the transaction costs could be lowered if the task of raising the taxes and paying the premia was given to organisations of fishermen. In that case the word 'tax' should be replaced by another word, for instance 'levy'. The levy then concerns the price of fish on the auction. The Dutch government could, for instance, oblige the 'Biesheuvel-groups' to collect the levy from their own members, and use the total revenues for the payment of premia. In that case the premium on fish caught within the quota would be higher the higher the registration of fish caught outside the quota (a higher registration implying higher payments of levies). This means that it would be in the interest of individual members of the group to help realise a situation in which colleagues let the catch of fish outside the quota be registered [4].

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[1] If a fisherman who has no quota left lets his catch be registered as catch of another fisherman, there would be no problem. This procedure is comparable to the hiring of quota.

[2] According to J.Smit of the 'Landbouw Economisch Instituut' (personal communication) the order of magnitude of the ratio between the price for the fisherman and the price of the final product in the Netherlands is 1:4 for cod and 1::10 for herring.

[3] Figure 3 concerns the market for the final product. This implies that, as far as the VAT-increase is concerned, the vertical part of the supply curve is equal to the costs for the fishermen of exceeding the quota plus 12% of the price. However, one could also draw a figure with the Y-axes showing the price of fish on the auction excluding taxes. The increase in the VAT then causes an downward shift of the demand curve. The premia cause a downward shift of the supply curve to the left of q_o. The height of the vertical part of the supply curve is then equal to the costs of exceeding the quotum plus about 50%, or more, of the price of fish.

[4] A group should also collect levies on fish caught by fishermen from another group, to the extent that this is not done by this other group (for instance because this group has no representation in the relevant harbour). The revenues should then be given to the board of the other group. The advantage for the group which collects the levies would be that in this way overfishing is checked. Of course transaction costs should be compensated for.

The second alternative does not imply a financial benefit for the government on balance. In relation to this, it will not be possible to decrease taxes in other sectors of the economy. On the other hand the position of the fishermen improves; they get the economic rent that is generated. If desired, this could be changed by decreasing the premia in the long run. One could even consider abandoning the premia in the long run altogether, which would imply that the second alternative becomes similar to the first alternative in the long run. In the mean time the payments of premia in the short run prevents short-term financial problems for the fishermen.

Both alternatives might, in certain situations, be combined with input restrictions. For instance, a combination with restrictions on days at sea could be useful in the short run, in which the effect of taxes is limited.

To summarise, both alternatives allow for yearly adjustments of catches. The disadvantages of ITQs regarding implementation problems and transaction costs are softened. The first alternative is financially attractive for the government, but for the fishermen it is less beneficial. This could cause political problems. The second alternative is less attractive for the government and more attractive for the fishermen. It will therefore meet less resistance from the fishermen. It can be remarked that it is possible to make the second alternative somewhat more attractive for the government by decreasing the premia in the long run. It can be concluded that both alternatives justify further research.

The Common Fisheries Policy

In view of the previous discussion, some remarks can be made regarding the Common Fisheries Policy. Each year the European Union determines for each species and for different areas the Total Allowable catch (TAC). The national quotas of the Member States are fixed percentages of the TAC. Each country is free to decide which policy it uses to prevent the national quota from being violated. Policies in different countries consist of different combinations of instruments, among which ITQs, individual non-transferable quotas, closure of the fishery and input restrictions [1].

It will be clear that each combination of these instruments has disadvantages. Partly in relation to this, national quotas are often exceeded. A point which is also important in this context is that national governments are not always fully loyal to European policies, a point which is reinforced by the fact that there are no strong sanctions from Brussels [2].

The tax instrument is not used in Europe, and it is rarely the subject of discussion. However, it has been argued in this paper that a combination of ITQs and taxes, and also a combination of ITQs, taxes and premia, justify further research. At this place some remarks can be made regarding the effects of these combinations of instruments in the European context. The starting point for the discussion is that the tax instrument concerns a VAT-increase, and that, with regard to the second alternative, the premium is paid by the government of the country where the fisherman is registered.

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[1] Europeche, 1995, Inventory of the different systems for managing fishing efforts and quota's in E.U. Member States. Brussels, Europeche.

[2] Holden, op.cit.

For national governments it will be difficult to evade the obligation to raise the VAT-tariff on fish and fish products. Besides, with the second alternative it is not attractive for national governments to pay premia on fish that is caught outside the quota. This would imply that the government participates in an active way in fraude. Moreover, it would imply a financial cost for the government. Therefore, national government can be expected to cooperate in a more loyal way with the alternative policies than with present policies.

A higher VAT on fish will decrease European imports of fish. This is favourable for the balance of payments. Besides, it could lead to a decrease in overexploitation in fisheries outside the European Union. This could also be beneficial for European fishermen. To summarise, both policy alternatives have additional advantages in a European context.

These advantages can be added to the advantages which have been discussed before. Regarding the latter, the main point is that the catch is reduced in an efficient manner while the implementation problems and the transaction costs remain limited. It is also important that the second alternative has less negative effects for the fishermen, which increases the political feasibility. Of course, more attention would have to be paid to the further design of the policies. Research into the precise magnitude of the implementation problems and the transaction costs of the various policy alternatives would also need to be done. However, at this point already it can be concluded that it seems likely that for the present policies sensible alternatives are available.

Improving management advice by financial treatment of biological data

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This paper assumes that management's objective is to move the rate of exploitation of fisheries as close as possible to that providing maximum sustainable profit, (subject as far as possible to preservation of reasonable levels of employment in the fishing communities).

The poor level of fisheries management in many European Union (EU) fisheries is by now well known, being obvious from decreases in landed weight accompanied by increases in fishing mortality (F) in most EU exploited stocks since the present Common Fisheries Policy system of management by total allowable (landed) catch (TAC) and quota was put in place in 1983.

In addition, the annual advice coming from the International Council for the Exploration of the Seas (ICES) and Scientific, Technical and Economics Committee of Fisheries (STECF) to the EU Commission is undesirably pessimistic because (1) it fails to cover a long enough period for the improved returns resulting from reduced exploitation rates to be seen, and (2) it fails to quote predictions of profits which will show a greater improvement than catch weight because (a) the normally higher value of medium and large fish which will increase with improved management of the fishery will boost revenue more than weight, and (b) reduction of the exploitation rate will cause reduction of fishing costs to boost profits more than revenue.

This paper concludes that advice to the EU Commission should include predictions of revenue and profit, with input assumptions carefully specified and explained which should cover a period of at least five years, in order to show the substantial gains in revenue and profit which can result from reducing fishing mortality (F) in overfished fisheries. It substantiates this view with examples from some EU fisheries, notably that for Irish Sea cod.

Introduction: the background

There is abundant evidence to the effect that EU fisheries management under the Common Fisheries Policy, with TAC and Quota regulation as its main method, has fared poorly, with catch per unit effort having declined to lower levels since the regime was introduced in 1983 than those obtaining before. Fishing mortality rose sharply during 1983-1990, - though it has since fallen somewhat with decommissioning, - and stocks have dwindled so that it is necessary to take a higher percentage of the stock, (with correspondingly increased fishing costs) to realise catches of the same size as were taken with much less effort before this trend began. In nearly every major EU demersal fishery, catch obtained per unit of fishing mortality inflicted has declined, in many cases severely.

Table 1 shows that out of 19 stocks for which comparisons are available, the mean three year yield per unit F (fishing mortality coefficient), having risen by 9% between 1972/3/4 and 1982/3/4, - the last ten year period before the introduction of the Common Fisheries Policy TAC and Quota management system, - declined by 21.4% up to 1992/3/4, i.e. over the first ten years in which it was in operation, while for all 31 stocks for which records are available for the latter period the decline was 13.0%. The stocks for which the decline was worst were the more important stocks, for which the records go back further.

The Problem

Reasons for this decline are quite well known and rest on the disadvantageous game theoretic situation of the Nash Equilibrium/Prisoners' Dilemma (Nash, 1953) whereby fishers cannot leave fish in the sea to catch at a larger and more valuable size with lower fishing costs later without the risk that the fish will in fact be caught by other fishers in the meantime.

In a democracy, fishers inevitably draw their political representatives into this scenario on their (short-term) behalf. This can be seen by the amounts by which the EU Council has in the past frequently increased TACs to give 'Agreed TACs' considerably greater than the 'Recommended TACs' advised by the biologists of the International Council for the Exploration of the Sea (ICES) Working Groups and Advisory Committee for Fisheries Management (ACFM). Table 2 shows that out of 222 cases involving 29 stocks for which a reasonable time series existed quoted in the 1996 ICES ACFM Report, (Anon. 1997), this happened in 222 cases as opposed to 19 reductions (with 52 instances of no change) the mean increase, for all 29 stocks, being 29.5%.

The attitude of the fishing industries to newly announced TACs for the ensuing year are, quite simply, the larger the better; headlines in fisheries industry newspapers judge ministers on how much they have been able to obtain from the EU Council Meeting (using phrases such as 'our Minister did not let us down'). The possibilities of substantial medium and long-term improvement in returns through the correction of overfishing do not appear to be taken into account in the political environment in which these decisions are taken. The inevitable result however is that it does make the fishery function so that much potential revenue is lost due to too many fish being caught before they can undergo their profit-maximising amount of growth ('growth overfishing'), and increases the possibility of impairing the breeding stock's fecundity ('recruitment overfishing'). Hence, a solution to this problem will release increased revenue into the fishery, though its distribution remains a further substantial problem. Various aspects of the problem in the EU in recent times have been discussed in some detail by Holden (1994) and Corten (1996).

In the majority of cases, the fish stocks being managed are being overfished, often seriously, and will yield best results (other than in the very short term) if fishing mortality is reduced. The standard advice of the ACFM of ICES to the EU Commission in the form of the 'Recommended TAC' has grave shortcomings as it deals only with catch weights over the ensuing year resulting from a range of fishing mortality levels ('F' values) and for each the resultant spawning stock biomasses (aggregate weights) at the outset of the next spawning season. Figure 1, using Irish Sea cod as an example, illustrates the form which this advice takes, showing for a comprehensive range of levels of fishing mortality catch weight in the following year, total stock biomass (aggregate weight) surviving at the start of the next year after that, and spawning stock biomass surviving at the onset of its spawning season.

Proposals for Improved Motivation to Optimise Profit

Potential solutions to this intractable problem depend to some extent on the fishers and the politicians who serve them as representatives getting a clearer view of the advantages to be obtained from reduction of fishing mortality.

Great strides towards the achievement of this could be made by changing the advice to the EU Commission so as to include:

Catch weights *projected for longer periods than one year*, to give annual weights in and cumulative weights after years 1, 2, 3, 4, 5, 10 and probably 15 and 20, to show to the industry improved catch weights resulting from recovery of the fishery in response to TACs reducing fishing mortality optimal levels.

Catch revenues, based on best estimates of fish prices**,** predicted to accrue from the F values considered over the periods envisaged at (1) above, to show increases in revenue resulting from reduced fishing mortality, which for most species will exceed those in catch weights, due to the unit value of medium and large fish exceeding that of the small fish which predominate in catches from heavily overfished stocks.

Estimates of *profit***,** calculated from revenue and best available estimates of fishing costs. Increases in profit resulting from reducing F will be much higher than those of revenue due to the reduction in operating costs of fishing (and overhead costs in the case of F reduction by fleet reduction) which reducing F will entail. Since F reduction implies fleet reduction which would normally tend to imply reduction in employment which may well be politically undesirable, it is suggested that it is also relevant to consider F reduction without fleet reduction (which is theoretically possible by various forms of effort or catch quota).

Figure 2 shows that with a 50% reduction in F, medium and long-term increases in revenue are greater than those in weight, increases in profit are greater than those in revenue and increases in profit with fleet reduction (as from decommissioning) are greater than increases in profit without fleet reduction. Weight, revenue and profit with fixed fleet size first show increases in year three, and profit with fleet reduction does so from year two.

The projections in this and other figures which follow and in table 3 are based on inputs calculated for the EU assisted study of Irish Sea fisheries 94/04, of which the draft report was submitted to the EU Commission in 1997 (Hillis and Keogh, 1997).

Growth overfishing, defined above as fishing so that revenue is lost due to too many fish being caught before they can undergo the optimum amount of growth, can be fairly clearly demonstrated, and Figure 3 shows changes in annual catch weight to be obtained from reducing F on Irish Sea cod by 10%, 30%, 50%, 70% and 90%, and it will be seen that from year 7 onwards accumulated yield increases with decreasing F down to F = 0.3 but no further, F = 0.1 showing a situation of underfishing.

The cost-benefit analysts' technique of Marginal Rate of Time Preference (MRTP) future discounting can be applied analyse the reluctance of fishers to participate in any effort reduction programme, despite the very substantial returns which can be predicted from our knowledge of the population dynamics of the stocks involved.

In examining time-paths of the restoration of depleted fisheries, it is necessary to consider accumulated as well as annual returns in revenue and profits, as they represent changes over a period longer than a year, and comprise the only realistic way to consider a fleet's position after a period longer than one year when latterly increased annual returns must be considered in conjunction with the decreased returns of earlier years. Plots of annual returns after a decrease in F will show values tending to become uniform with zero discounting, and decreasing towards zero with MRTP discounting, at a rate corresponding to the value of the rate, so plots of accumulated returns rise indefinitely with zero rate discounting and tend to become uniform as the annual addition is discounted towards zero where discounting is present.

Using inputs including EU guide prices in ECU's and overhead costs, operating costs and value added of 25%, 40% and 35% respectively of revenue at current levels of operating (Hillis and Keogh 1997), Figure 4 projects revenue from Irish Sea cod over 20 years resulting from reduction of F to 0.5 of initial value immediately and by five equal annual decrements of 0.1, discounted at 0% and at 25%, and Figure 5 shows the results of the same treatment applied to profits. Table 3 shows the accumulated revenue and profit (with fixed fleet size) in years 1, 2, 5 and 10 resulting from reduction of F to 0.5 of initial values of five major species in the Irish Sea, plus a category 'whitefish' which is the sum of cod, whiting and plaice, all discounted at 0%, 10%, 25% and 50%. The data show how much more profit increases than revenue, and the extent to which immediate reduction of F usually (apart from sole) yields higher increases than gradual reduction in the long-term, with 0% discounting. As discounting is applied at progressively higher rates, however, the medium and long-term advantage of immediate reduction decreases, and disappears with 50% discounting in the cases of cod and Nephrops, (the only species where long-term changes remain increases at the 50% discount rate).

Discussion

This paper does not aspire to discuss how to implement a fishing mortality reduction programme; as its title states, it strenuously urges improvement on the current form of management advice because part of the problem of non-implementation of recommended fishing mortality reduction in overfished fisheries is that of the largely unnecessary unattractiveness of the limited advice currently offered. The coverage of current advice is restricted to the following year, the least attractive year where F is to be reduced, - and to catch weight, which is less relevant to the industry and shows less gain in response to reduced F in depleted fisheries than catch revenue, which in turn is much less relevant and shows much less gain than profit.

The virtual population analysis (VPA) of the fish population to be managed which the working groups and ACFM of ICES produce is a sophisticated and efficient base for biological prediction of how the population will fare with different levels of fishing mortality, yet fisheries management based on it remains manifestly ineffective. It is suggested that predictions of revenue and profit based on this system would have much to offer, as they would assist planning of resource exploitation to an extent unknown in the current wasteful and ineffective scenario, and would make the prospects on offer to fishery managers much more palatable than they are now.

There are however certain problems to be guarded against in seeking to improve forecasting procedures by extending the time-horizon and including revenue and profit. Economic data are inevitably more sensitive than biological data, and there may be (surmountable) confidentiality problems inherent in collecting them. Boat-owners asked for revenue details may well feel that their rights to privacy are being compromised, and those asked in addition for details of their fishing costs may feel that the questioner is setting out to learn everything about their financial situation. There is some truth in these views and such data should always be kept strictly confidential and only published in grouped form covering numbers of operators so that the individual cannot be identified, but its acquisition is still necessary for predicting the course of proposed F reduction programmes as it will affect the fleet.

A further problem is that of the difficulty of prediction with any accuracy over periods of anything very much longer than one year. With increase of the time-span over which any predictions are made, there is naturally an escalation of imponderables. As far as possible, all predictions should be qualified by the inputs to the calculations underpinning them being clearly stated, and they should also be revised frequently, probably yearly, so as to minimise the effect of developments unforeseen by earlier predictions. Uncertainty analysis techniques, such as the Monte Carlo simulation, should be used where appropriate to help solve this problem.

Finally, the whole campaign of any depleted fishery restoration project will depend heavily on good statistics. It must be obvious that this must be the case, - what is reported to be happening must actually be what is happening, - but reports of deterioration in quality of statistics abound, often hearsay, but sometimes surfacing in semi-official mode, e.g. as when ICES working groups and ACFM refuse to base their calculations on official national statistics. To be accurate, predictions of future catch, revenue and profits must be based on accurate statistical bases.

However, the fact remains that, - unlike the current advice limited to the unattractive statistic of catch weight in year 1, - advice covering periods lasting until recovery of the fishery starts to become apparent (usually three to five years) and based on revenue and profit as well as catch weight would open up vistas of improved financial returns of which many in management are not currently aware.

Acknowledgement

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Table 1 *Changes in mean Yield (Y), Fishing Mortality (F) and Y/F, 1972-'73-'74 (~73~) to 1982-'83-'84 (~83~) to 1982-'83-'84 to 1992-'93-'94 (~93~) in main species asessed by ICES Advisory Committee of Fisheries Management*

Years	Y	F	Y/F	Years	Y	F	Y/F	Years	Y	F	Y/F	Years	Y	F	Y/F
Cod			IV	Cod			VIa	Cod			VIIa	Cod			VIIf,g,h
~73~	269	0,724	367	~73~	13,5	0,598	22,6	~73~	10,43	0,651	16,2	~73~	3,12	0,520	6,00
~83~	263	0,896	294	~83~	21,4	0,793	27,2	~83~	10,59	0,848	12,4	~83~	6,71	0,716	9,49
~93~	116	0,931	124	~93~	15,8	0,845	18,9	~93~	6,90	1,176	5,9	~93~	8,46	0,868	9,75
83/73	0,979	1,237	0,800	83/73	1,579	0,054	1,204	83/73	1,015	1,303	0,766	83/73	2,15	0,188	1,580
93/83	0,439	1,039	0,423	93/83	0,741	1,065	0,695	93/83	0,651	1,387	0,474	93/83	1,26	1,212	1,027
Haddock			IV	Haddock			VIa	Whiting			IV	Whiting			VIa
~73~	344	0,955	362	~73~	43,7	0,840	51,4	~73~	253	0,927	270	~73~	25,3	1,201	21,7
~83~	238	0,898	273	~83~	40,8	0,551	76,1	~83~	149	0,813	186	~83~	22,1	0,624	36,7
~93~	155	0,938	166	~93~	27,4	0,675	40,2	~93~	107	0,750	142	~93~	26,6	0,618	42,8
83/73	0,694	0,941	0,753	83/73	0,9	0,010	1,480	83/73	0,590	0,876	0,687	83/73	0,873	0,028	1,692
93/83	0,652	1,044	0,609	93/83	0,7	1,226	0,528	93/83	0,716	0,923	0,765	93/83	1,207	0,991	1,167
Saithe			IV	Saithe			VIa	Plaice			IV	Plaice			VIIa
~73~	248	0,476	531	~73~	33,0	0,334	98,8	~73~	122	0,371	330	~73~	4,63	0,707	6,68
~83~	178	0,629	288	~83~	24,8	0,298	83,7	~83~	152	0,416	365	~83~	3,71	0,574	6,54
~93~	100	0,514	198	~93~	14,5	0,586	24,8	~93~	117	0,506	232	~93~	2,45	0,547	4,43
83/73	0,715	1,322	0,542	83/73	0,8	0,010	0,847	83/73	1,243	1,122	1,106	83/73	0,80	0,812	0,980
93/83	0,565	0,817	0,688	93/83	0,6	1,970	0,297	93/83	0,774	1,215	0,636	93/83	0,66	0,952	0,678
Sole			IV	Sole			VIIa	Sole			VIIe	Sole			VIIf,g,h
~73~	19,5	0,436	45,1	~73~	1,40	0,385	3,64	~73~	0,44	0,222	2,02	~73~	1,26	0,284	4,47
~83~	24,4	0,505	48,5	~83~	1,19	0,378	3,15	~83~	1,44	0,369	3,92	~83~	1,26	0,396	3,18
~93~	31,1	0,503	62,0	~93~	1,22	0,413	2,96	~93~	0,74	0,247	3,02	~93~	0,97	0,427	2,32
83/73	1,255	1,159	1,074	83/73	0,85	0,260	0,866	83/73	3,25	0,839	1,938	83/73	1,00	0,309	0,713
93/83	1,273	0,995	1,278	93/83	1,02	1,093	0,938	93/83	0,51	0,668	0,770	93/83	0,77	1,078	0,729
Herring			IV	Herring			VIa,S	Herring			VIIf,g,h				
~73~	419	0,958	468	~73~	32,7	0,329	99	~73~	28,4	0,630	45,1				
~83~	357	0,346	1045	~83~	26,6	0,281	95	~83~	21,6	0,843	25,6				
~93~	626	0,694	914	~93~	34,2	0,316	108	~93~	19,7	0,634	31,1				
83/73	0,853	0,361	2,234	83/73	0,813	0,854	0,952	83/73	0,761	1,338	0,568				
93/83	1,754	2,005	0,875	93/83	1,286	1,125	1,143	93/83	0,912	0,752	1,213				

Table 1 Continue

Whiting			VIIa	Whiting			VIIf,g,h	Plaice			VIId	Plaice			VIIe
~83~	15,23	1,1	13,8	~83~	9,68	1,28	7,7	~83~	5,02	0,502	10,05	~83~	1,58	0,548	2,893
~93~	9,99	1,41	7,1	~93~	13,17	0,73	18,8	~93~	5,93	0,511	11,81	~93~	1,4	0,688	2,036
93/83	0,66	1,282	0,514	93/83	1,36	0,57	2,452	93/83	1,18	1,018	1,175	93/83	0,89	1,256	0,704
Plaice			VIIf,g,h	Sole			VIId	Herring			VIa,N	Herring			VIIa
~83~	1,220	0,609	2,009	~83~	3,41	0,320	10,74	~83~	72,2	0,465	155	~83~	4,28	0,201	21,3
~93~	1,123	0,499	2,258	~93~	4,43	0,394	11,32	~93~	29,0	0,100	290	~93~	4,84	0,171	28,3
93/83	0,92	0,820	1,124	93/83	1,30	1,231	1,054	93/83	0,402	0,215	1,868	93/83	1,131	0,851	1,329
Norway Pout			IIIa, IV	Hake			VIIc, IXa	Sandeel			IIIa, IV	Sardine			VIIIc, Ixa
~83~	413	0,540	765	~83~	20,3	0,292	69,5	~83~	605	0,497	1217	~83~	196,0	0,357	549,0
~93~	220	0,443	497	~93~	11,1	0,266	41,7	~93~	733	0,443	1655	~93~	132,6	0,493	268,9
93/83	0,533	0,820	0,649	93/83	0,547	0,911	0,600	93/83	1,212	0,891	1,359	93/83	0,676	1,381	0,490

Changes in Landings per unit F.		All	Gads.	Flats	Herr'g	Etc.
Mean [1982/3/4]/[1972/3/4]	N=19	1,094	1,035	1,113	1,252	
Mean (same stocks) [1992/3/4]/[1982/3/4]	N=19	0,786	0,667	0,838	0,824	
Mean (all stocks) [1992/3/4]/[1982/3/4]	N=31	0,870	0,803	0,909	1,286	0,775

Table 2 *Factors of change applied torecommended TACs to give Agreed TACs in EU fisheries, 1987-1996 (Anon. 1997)*

Area	Species	Mean Increase	Total number of cases	Increases	No change	Decreases
North Sea	Cod	1,066	5	2	1	2
	Haddock	1,083	4	1	3	0
	Whiting	0,994	3	1	0	2
	Saithe	1,036	10	3	6	1
	Plaice	1,155	8	8	0	0
	Sole	1,087	10	5	5	0
	Herring	1,099	10	7	1	2
Eastern. English Channel	Plaice	1,229	9	7	2	0
	Sole	1,081	10	7	2	1
West of Scotland	Cod	1,147	4	4	0	0
	Haddock	1,090	4	3	1	0
	Whiting	1,112	4	3	1	0
	Saithe	1,275	8	6	1	1
	Herring	1,087	9	7	2	0
North-west & West of Ireland	Herring	0,989	10	3	2	5
Irish Sea	Cod	1,312	10	8	2	0
	Whiting	1,322	9	7	0	2
	Plaice	1,082	10	4	5	1
	Sole	1,186	10	8	1	1
	Herring	1,159	10	8	2	0
Western English Channel	Plaice	3,361	8	6	2	0
	Sole	1,094	10	5	5	0
Celtic Sea	Plaice	1,096	4	3	1	0
	Sole	1,094	8	5	3	0
	Herring	1,157	9	4	4	1
Bay of Biscay	Sole	1,128	7	7	0	0
Widespread Northern	Hake	1,260	8	8	0	0
Widespread Southern	Hake	3,388	8	8	0	0
Widespread Western	Horse Mack-erel	1,400	3	3	0	0
Mean/Totals		**1,295**	**222**	**151**	**52**	**19**

Discount Rate (%)	Species	Revenue: Immediate to 0.5 of initial F. Year 1	Year 2	Year 5	Year 10	Revenue: F decreasing by 0.1 annually to 0.5 Year 1	Year 2	Year 5	Year 10	Profit (Fixed fleet size): Immediate to 0.5 of initial F. Year 1	Year 2	Year 5	Year 10	Profit (Fixed fleet size): F decreasing by 0.1 annually to 0.5 Year 1	Year 2	Year 5	Year 10
0	Cod	0,607	0,724	0,977	**1,134**	0,934	0,924	0,930	**1,061**	0,483	0,764	**1,353**	**1,793**	0,928	0,944	**1,081**	**1,520**
	Whiting	0,612	0,717	0,907	**1,018**	0,935	0,925	0,896	0,983	0,509	0,750	**1,252**	**1,569**	0,930	0,948	**1,025**	**1,370**
	Plaice	0,549	0,601	0,739	0,877	0,917	0,887	0,819	0,87	0,332	0,470	0,807	**1,164**	0,884	0,857	0,824	**1,051**
	'Whitefish'	*0,598*	*0,701*	*0,916*	***1,040***	*0,931*	*0,918*	*0,901*	***1,006***	*0,465*	*0,711*	***1,231***	***1,623***	*0,921*	*0,982*	***1,058***	***1,232***
	Nephrops	0,592	0,712	**1,002**	**1,239**	0,930	0,922	0,937	**1,139**	0,384	0,755	**1,789**	**2,585**	0,912	0,954	**1,225**	**2,088**
	Sole	0,550	0,597	0,716	0,818	0,917	0,887	0,923	0,983	0,197	0,359	0,769	**1,143**	0,862	0,834	0,990	**1,151**
10	Cod	0,607	0,719	0,944	**1,070**	0,934	0,925	0,929	**1,022**	0,483	0,752	**1,273**	**1,612**	0,928	0,943	**1,062**	**1,372**
	Whiting	0,612	0,711	0,880	0,971	0,935	0,925	0,900	0,959	0,509	0,737	**1,177**	**1,431**	0,930	0,947	**1,014**	**1,259**
	Plaice	0,549	0,598	0,720	0,827	0,917	0,888	0,828	0,859	0,332	0,463	0,761	**1,031**	0,884	0,858	0,829	0,983
	'Whitefish'	*0,598*	*0,695*	*0,887*	*0,987*	*0,931*	*0,918*	*0,904*	*0,976*	*0,465*	*0,699*	***1,159***	***1,463***	*0,921*	*0,930*	***1,009***	***1,274***
	Nephrops	0,592	0,706	0,975	**1,153**	0,930	0,923	0,935	**1,079**	0,384	0,735	**1,640**	**2,270**	0,912	0,952	**1,185**	**1,808**
	Sole	0,550	0,595	0,700	0,794	0,917	0,889	0,919	0,965	0,197	0,350	0,717	**1,016**	0,862	0,836	0,974	**1,104**
25	Cod	0,607	0,709	0,887	0,961	0,934	0,925	0,929	0,972	0,483	0,729	**1,140**	**1,326**	0,928	0,942	**1,032**	**1,181**
	Whiting	0,612	0,701	0,834	0,889	0,935	0,926	0,907	0,933	0,509	0,713	**1,052**	**1,198**	0,930	0,945	0,995	**1,112**
	Plaice	0,549	0,593	0,689	0,748	0,917	0,891	0,842	0,854	0,332	0,451	0,684	0,829	0,884	0,918	0,927	0,953
	'Whitefish'	*0,598*	*0,686*	*0,838*	*0,904*	*0,931*	*0,920*	*0,908*	*0,941*	*0,465*	*0,679*	***1,038***	***1,206***	*0,921*	*0,929*	*0,988*	***1,115***
	Nephrops	0,592	0,695	0,905	**1,009**	0,930	0,923	0,932	**1,001**	0,384	0,700	**1,395**	**1,751**	0,912	0,948	**1,121**	**1,426**
	Sole	0,550	0,591	0,673	0,726	0,917	0,891	0,912	0,937	0,197	0,335	0,628	0,802	0,862	0,838	0,945	**1,024**
50	Cod	0,607	0,687	0,782	0,797	0,934	0,927	0,929	0,934	0,483	0,681	0,899	0,933	0,928	0,939	0,983	**1,005**
	Whiting	0,612	0,681	0,750	0,760	0,935	0,928	0,919	0,922	0,509	0,665	0,833	0,859	0,930	0,942	0,965	0,981
	Plaice	0,549	0,584	0,632	0,643	0,917	0,897	0,873	0,874	0,332	0,426	0,546	0,571	0,884	0,866	0,852	0,860
	'Whitefish'	*0,598*	*0,667*	*0,747*	*0,760*	*0,931*	*0,922*	*0,916*	*0,920*	*0,465*	*0,634*	*0,822*	*0,852*	*0,921*	*0,928*	*0,956*	*0,974*
	Nephrops	0,592	0,672	0,779	0,799	0,930	0,925	0,928	0,937	0,384	0,627	0,971	**1,034**	0,912	0,939	**1,019**	**1,062**
	Sole	0,550	0,582	0,624	0,633	0,917	0,897	0,905	0,909	0,197	0,304	0,459	0,492	0,862	0,844	0,895	0,911

Figure 1. Form of current ICES one year prediction withmanagement options, Irish Sea cod.

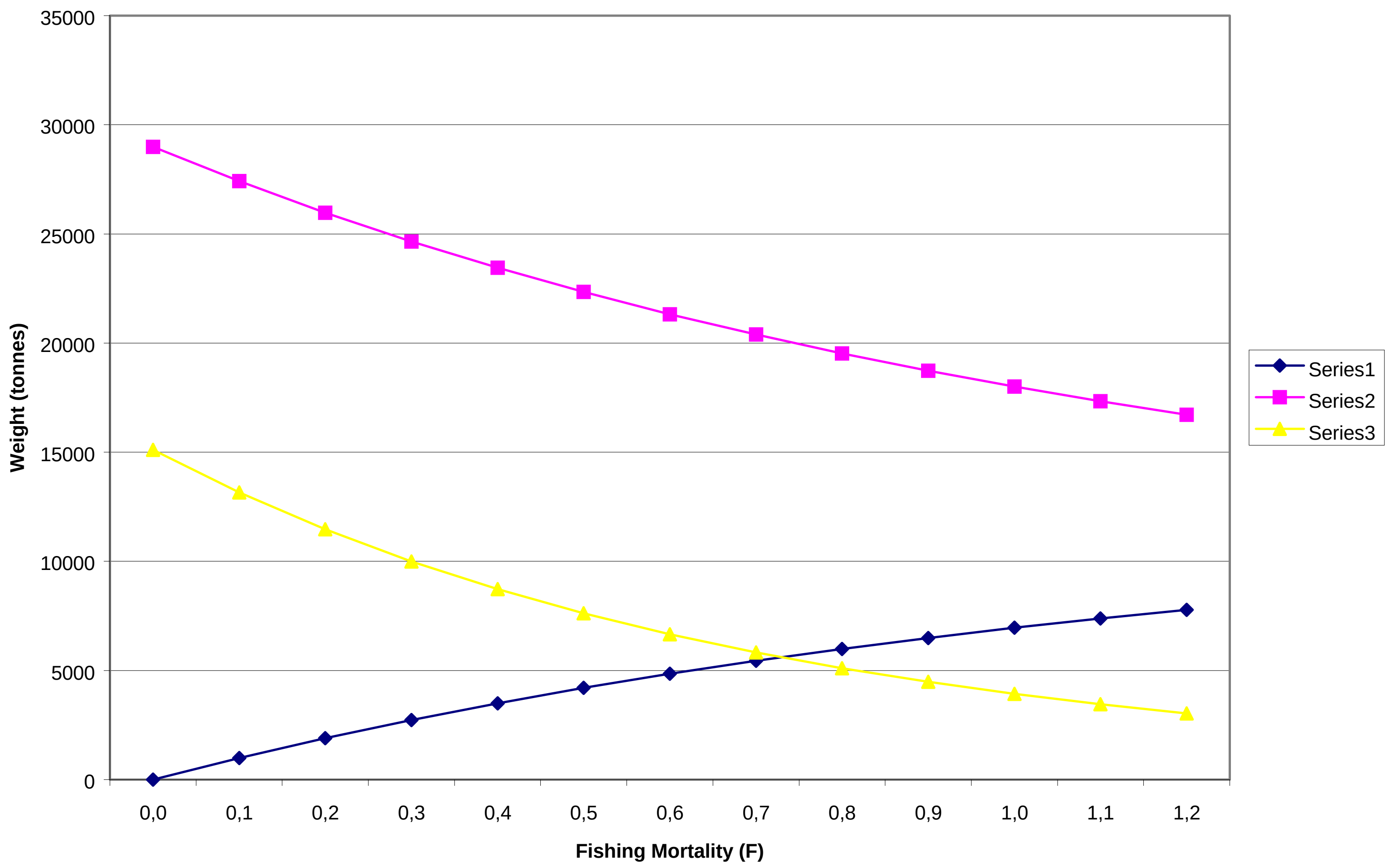

Figure 2. Changes in annual catch weight, revenue and profit with F = 0.5/F(initial)

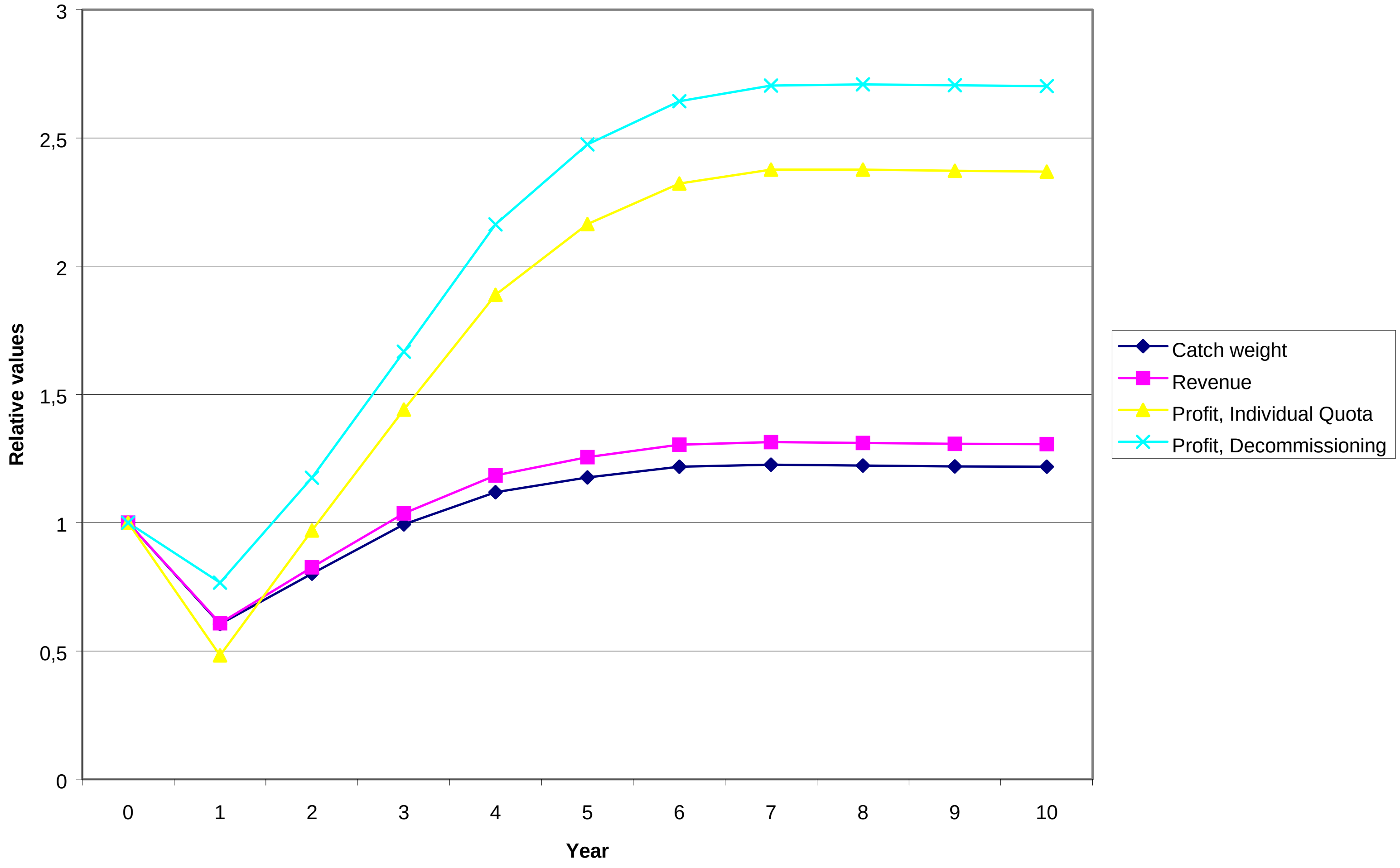

Figure 3. Changes in annual catch revenue with range of reductions in F.

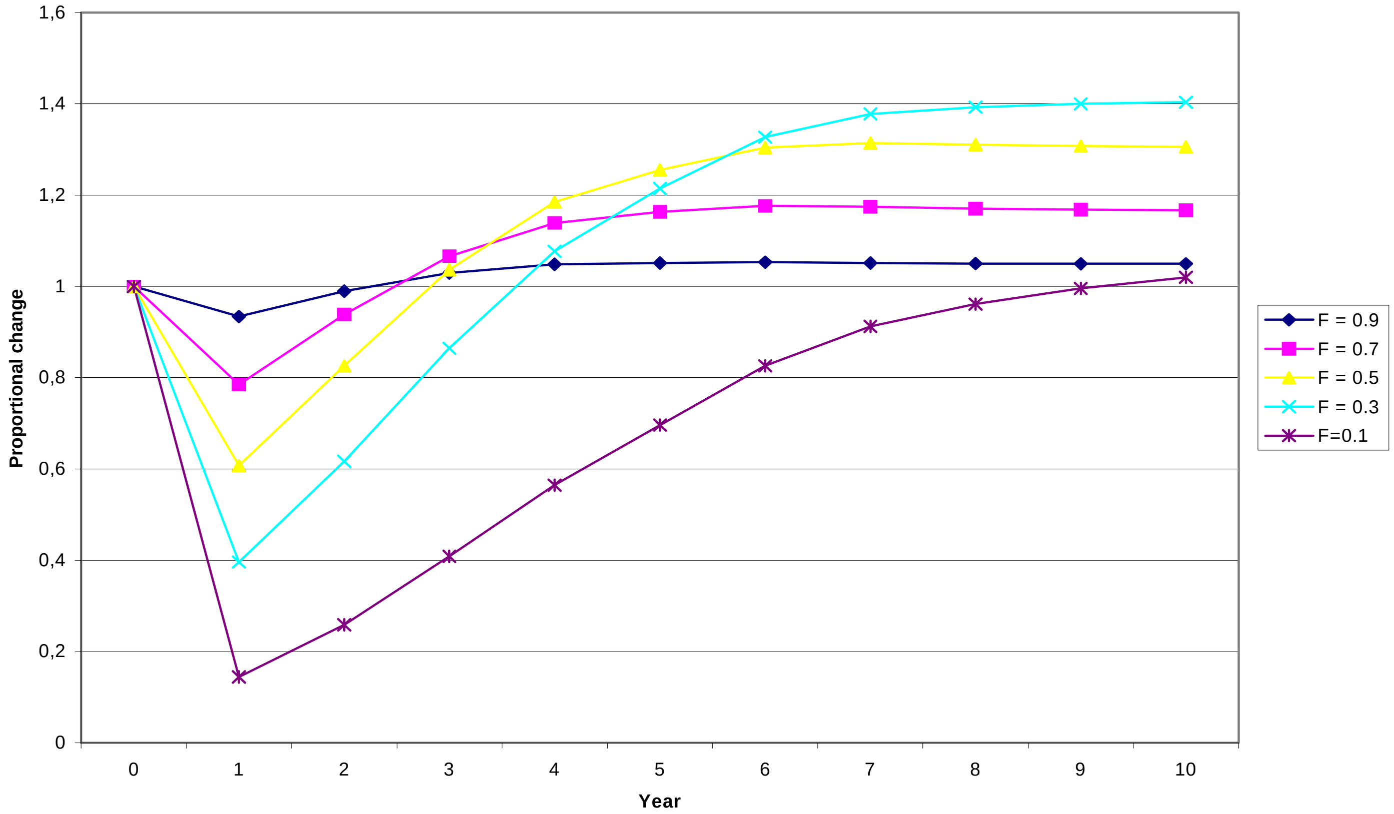

Figure 4. Changes in relative accumulated revenue from reduction in fishing mortality (F) to 0.5 of initial value, immediately and by five decrements of 0.1 of initial value, discounted at 0% and 25%

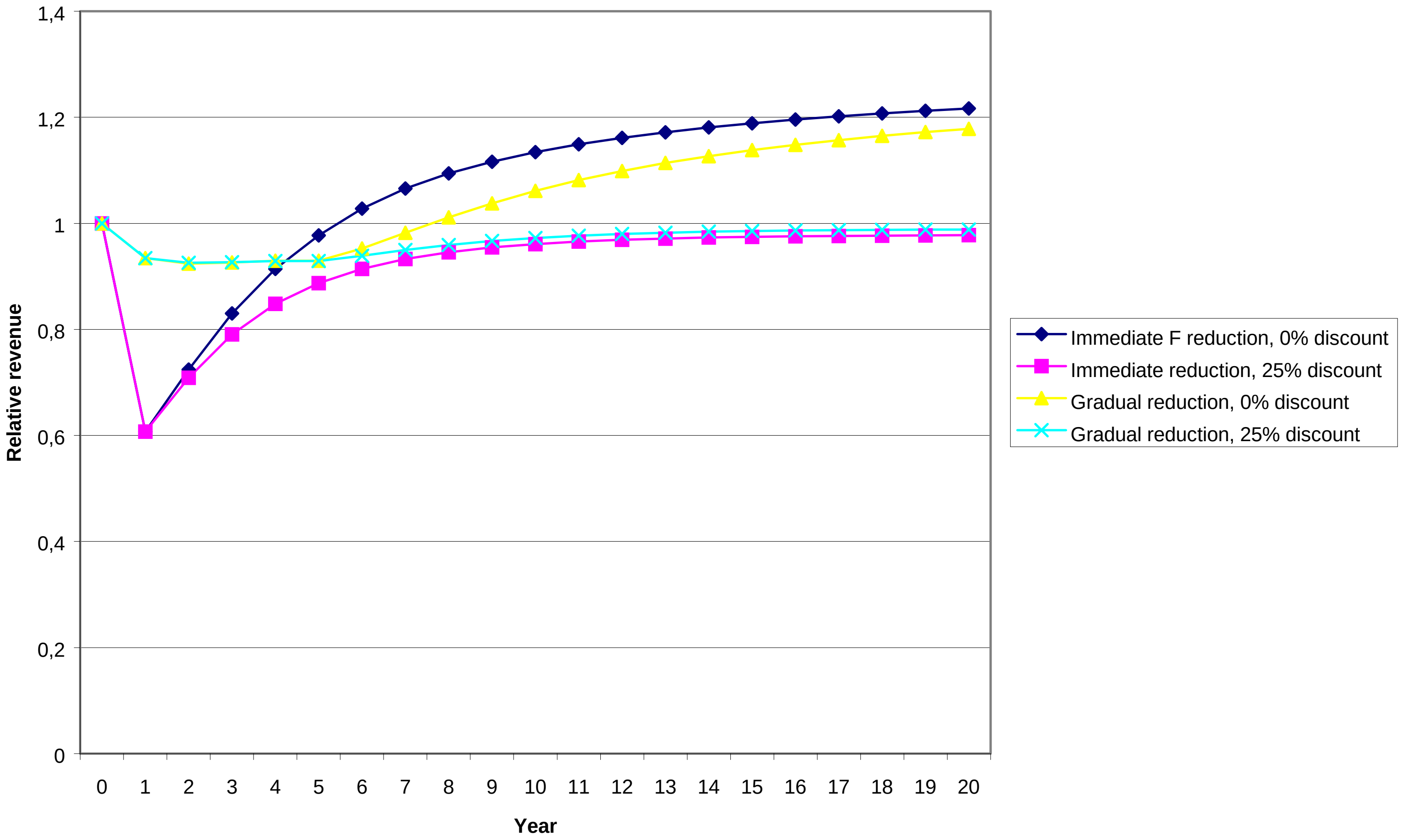

Figure 5. Changes in relative accumulated profit from reduction of fishing mortality (F) to 0.5 of initial value, immediately and by 5 decrements of 0.1 of initial value, discounted at 0% and 25%.