8-5

The Economic Benefits of Fisheries Management: The Case of Western Channel Sole

By:

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Executive Summary

Sole (*Solea Solea*) is a valuable flatfish species that lives partly buried in sandy bottoms in the western part of the English Channel. Because of fairly high catch levels, stock size has fallen substantially since the late 1970s. Between 1979 and 2007, the spawning stock biomass (SSB) fell by about 40 percent, from 5,400 tonnes to 2,300 tonnes. This decline represents a substantial disinvestment in the stock. There are also indications that the stock is being harvested unsustainably. A dynamic bioeconomic analysis showing optimal net returns or rents from the fishery points to the need for a substantial investment in the stock, with the exact magnitude depending on the discount rate. For a discount rate of 3.5 percent, as recommended by the UK Treasury for public investments, the optimal stock level is 5,114 tonnes. Essentially, then, this recommendation involves rebuilding the stock to its level before the start of the depletion process at the end of the 1970s. How quickly the optimal stock level is reached depends on how much is harvested during the rebuilding period and how productive the stock is.

This case study considers four policy options for the sole fishery. One option is to allow the situation prior to the implementation of the European Commission's management plan to continue. In this case, the stock may be driven to near extinction over the next few years. Three alternatives for stock recovery are also considered. One alternative is based on the European Commission's recently adopted management plan for sole. The next alternative involves an annual total allowable catch of 500 tonnes until the optimal stock level is reached. Finally, the fastest approach involves a moratorium on the harvest until the optimal stock level is achieved. Depending on which alternative is chosen, the optimal stock level will be reached between 2011 and 2020, when higher annual catches will be possible on a sustainable basis. The sole stock is harvested by fishers from the United Kingdom, Belgium, and France, with the United Kingdom having a 59 percent share. The most important fleet segment consists of beam trawlers. As part of a rebuilding program for the stock, this fleet will need to be restructured.

Given the different options for a management plan, which one would you choose, taking into account both the different values of the resource rent and the social costs of reducing fishing effort in the implementation phase?

Imagine now that the fishery was in a least-developed country, that the data on the fish stock were highly incomplete, and that the government would have great difficulty in actually reducing the fishing effort. How would this influence your policy choice? What alternative or complementary measures would you suggest?

Background

The economic health of global marine fisheries has been in alarming decline owing to a combination of depleted fish stocks, increased fishing effort, stagnant or decreasing catches, and overcapacity of fleets (World Bank 2008). One result of the excessive levels of fishing effort is the dissipation of resource rent associated with the fish stock, where rent is defined as the surplus of revenue over cost of production. In addition, where resource rent is not considered explicitly and not quantified, the incentive for each fisher to attempt to catch fish before others ensures that such rent is eventually fully dissipated. Hence, understanding the nature and degree of rents in fisheries is crucial for designing management instruments that achieve sustainable exploitation patterns (DFID 2004).

Although rent dissipation is a major concern in marine fisheries, studies show that in many fisheries worldwide, there is great potential for generating substantial rents. The degree to which and the rate at which rents are dissipated may lead to varying policy incentives. As a result, identifying the level of potential economic rents is important for policy direction.

This case study is on the sole fishery in the western English Channel, also known under the International Council for the Exploration of the Sea (ICES) as Area VIIe. Owing to fairly high catch levels, stock size has declined substantially. The spawning stock biomass (SSB) fell by about 40 percent in the period 1979–2007, and there are indications that the stock is being harvested unsustainably.

Sole (*Solea Solea*) is a valuable flatfish species that lives partly buried in sandy bottoms in the western part of the English Channel. Sole spawns in spring and early summer in shallow coastal waters. The fish become sexually mature at three to five years, when they are 25–35 centimeters long, with the males being somewhat smaller than the females. Sole can live for more than 40 years, but as a result of intense fishing, most sole in the western English Channel are less than six years old.

Sole is particularly exploited by beam trawlers and, to a lesser extent, inshore gill nets. The size of the stock fluctuates from year to year owing to some particularly productive, but irregularly occurring, years for the stock.

Bjørndal and Bezabih (2008) have used a bio-economic model to estimate rents and assess alternative management paths. The bioeconomic model underlying the analysis is based on certain simplifying assumptions. One assumption is that the fishery is managed by a single owner. In one sense this assumption is correct, because total allowable catch quotas (TACs) are set at the level of the European Union. On the other hand, TACs are divided among several countries, in particular the United Kingdom, Belgium, and France. This analysis does not consider the implications of multicountry harvesting for achieving an agreement for rebuilding stock and complying with quotas, for example.

The second important assumption is that sole is treated as a single-species fishery. In reality, however, sole is part of a multispecies fishery where fishing vessels harvest not only sole, but also other species, such as monkfish and megrim. Although this fact has an impact on both the effectiveness of regulations and the cost of harvesting, this analysis disregards the multispecies aspects of the fishery.

Stock Development and Harvests

The spawning stock biomass increased from 2,800 tonnes in 1969 to a peak of 5,400 tonnes in 1979 (Figure 1). Subsequently there was a declining trend in stock size, albeit with periods of increasing stock. Stock size in 2007 was 2,270 tonnes, the lowest level ever recorded. Annual harvest increased from 350 tonnes in 1969 to a maximum of 1,500 tonnes in 1983. In the period 1999–2006 annual harvest has varied between 960 and 1,080 tonnes. There is reason to ask whether this harvest level is sustainable.

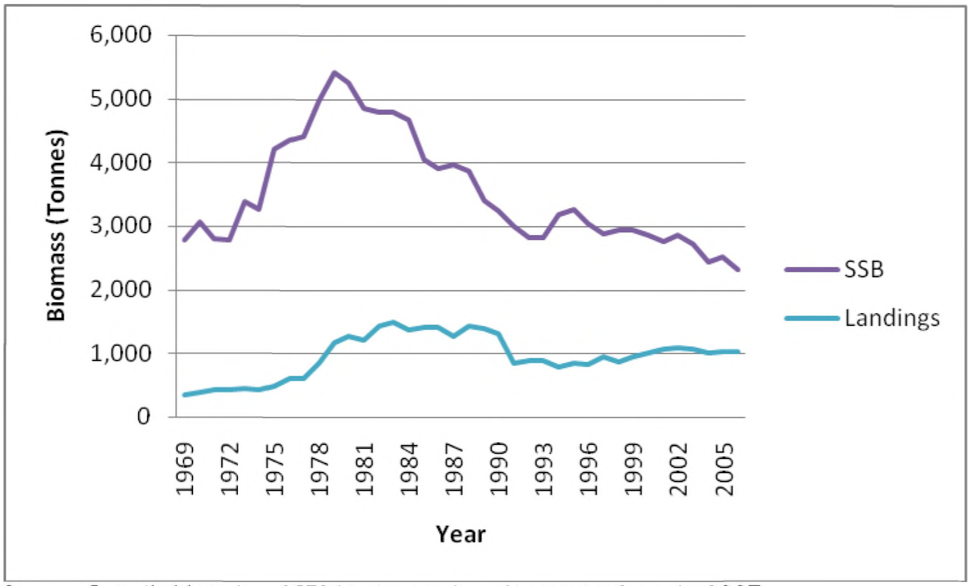
The reduction in stock level since 1979 represents a substantial disinvestment in the stock, and stock assessments indicate overexploitation. The sole fishery may not be at risk of collapse, but proper management is in order.

Regulations

In 2006 the agreed total allowable catch quota (TAC) for Area VIIe was set at 940 tonnes—a 10 percent decrease in fishing mortality compared with 2005 (fishing mortality is the rate at which the size of a fish stock is reduced due to harvesting). In 2007 the TAC was set at 900 tonnes, representing another 10 percent decrease in fishing mortality. The TAC is shared among a number of countries. The United Kingdom has the largest share, with 59 percent of the TAC.

In 2007 European Commission (EC) Council Regulation No. 509/2007 established a multiyear plan for the sustainable exploitation of sole in Area VIIe. This regulation specifies that a recovery plan will take place in the years 2007–09 and a management plan will be undertaken in subsequent years. For 2007–09, the TAC is set at 20 percent less than the mortality in 2007 or at a fishing mortality rate of 0.27 (whichever results in a greater TAC). The TAC for 2008 and 2009 is set at 765 tonnes and represents the first year of implementation of the long-term management plan for the stock. For 2010–12, the TAC would be set at 15 percent less than the average mortality during 2007–09 or at a mortality rate of 0.27 (whichever results in a greater TAC). For 2013–15, the TAC would be set at a mortality rate of 0.27 unless the stock has not recovered to a precautionary level of 2,800 tonnes, in which case the formula for 2010–12 would be applied. Complementary limitations to fishing effort would also be introduced.

Figure 1: Annual Spawning Stock Biomass (SSB) and Landings for Sole, 1969–2006 (tonnes)



Source: Compiled based on ICES biomass and catch statistics for sole, 2007.

These TACs are considerably higher than those recommended by the ICES, which recommended a TAC of 230 tonnes for 2006 and 350 tonnes for 2007. The ICES recommended these substantial reductions in order to reach the biomass consistent with the precautionary approach (B_{pa}) in one year. B_{pa} is estimated to be 2,800 tonnes. Stock sizes below this level are believed to endanger the future sustainability of the stock.

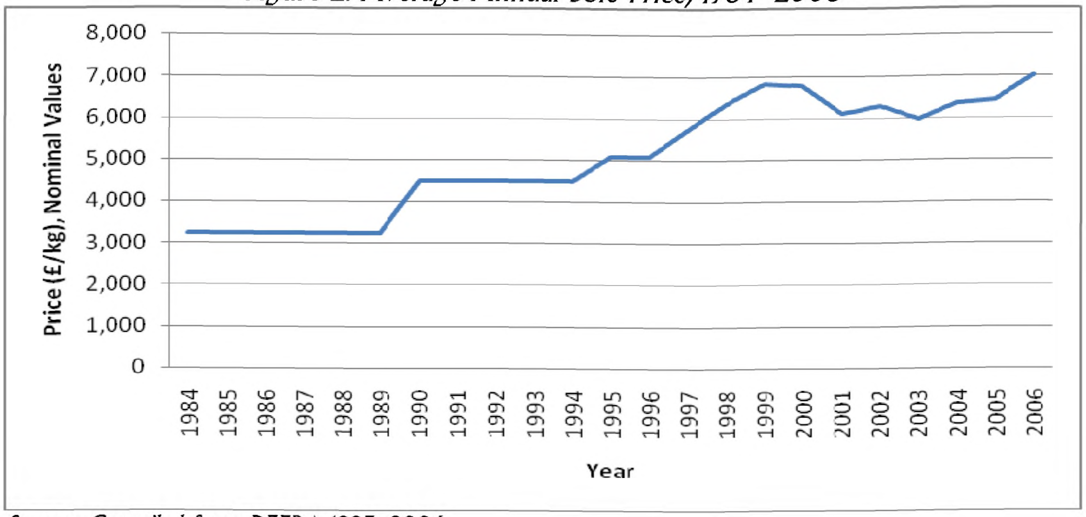
Current technical measures include a minimum landing size of 24 centimeters and a minimum mesh size of 80 millimeters for beam trawlers. The number of days at sea is restricted to 216 for beam trawlers of mesh size equal to or greater than 80 millimeters and for static demersal nets including gill nets, trammel nets, and tangle nets.

Prices and Costs

On the basis of cost data in reports from the UK Seafish Authority for 2001, 2004, and 2005, Bjørndal and Bezabih (2008) estimated that for beam trawlers the cost of harvesting sole is £3 per kilogram (kg). This cost per kilogram includes variable and fixed costs, including depreciation and a normal return on capital.

Average annual prices of sole in the United Kingdom for 1984–2006 were obtained from the UK Sea Fisheries Statistics. The nominal price was stable at about £3.50/kg in the period 1984–89 (Figure 2). Since then the price trend has been positive, although prices have declined in some years. In recent years the upward trend has been particularly strong, with the price rising from about £7.00/kg in 2005 to about £8.00/kg in 2006.

Figure 2: Average Annual Sole Price, 1984–2006

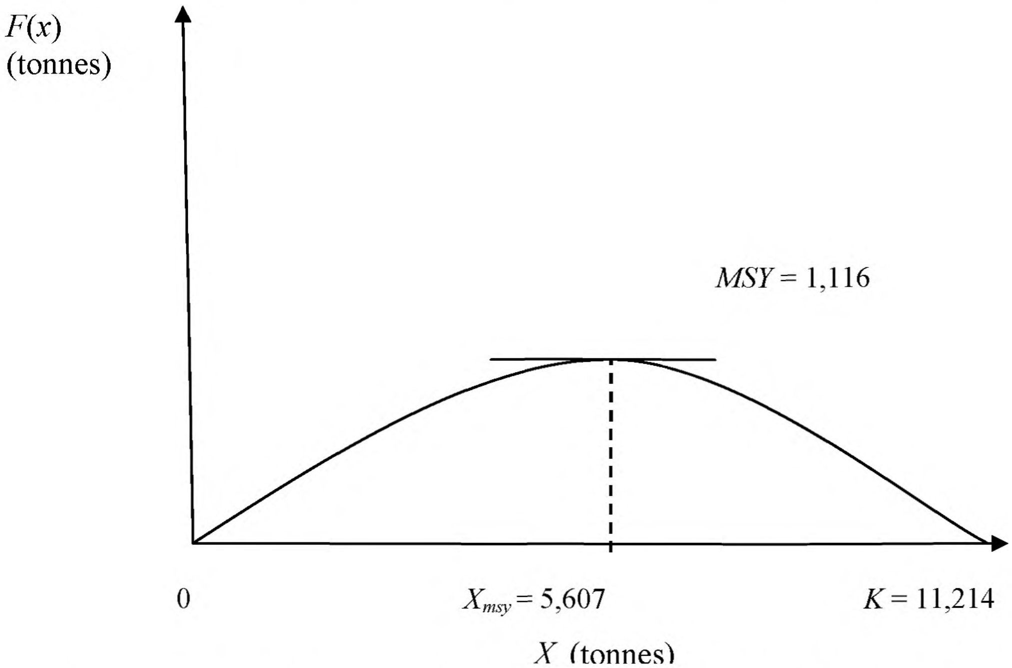


Source: Compiled from DEFRA 1995–2006.

Stock Dynamics

The natural growth function for sole is illustrated in Figure 3. The carrying capacity of the stock is estimated at 11,214 tonnes (*K*). This level is the maximum size of the stock and the level it would approach under natural conditions—that is, in the absence of harvesting. The stock level that gives rise to the maximum sustainable yield (MSY) is 5,607 tonnes, with the MSY equal to 1,116 tonnes. The growth curve is fairly "flat" over a range of stock values around X_{msy}.

Figure 3: Natural Growth Function F(x) for the Spawning Stock Biomass



Note: The natural growth function is a mathematical function describing the relationship between the natural growth of a fish stock and the size of the fish stock, measured either in biomass weight (tonnes) or numbers of fish.
Source: Author.

Table 1: Estimates of Optimal SSB and Harvest for Different Discount Rates

Discount rate (%)	Biomass (tonnes)	Harvest (tonnes)
0	5,607	1,116
3.5	5,114	1,107
5.0	4,903	1,098
10.0	4,198	1,045
20.0	2,790	834

Source: Author's calculations.

Table 1 presents estimates of the optimal biomass and corresponding harvest for discount rates between 0 and 20 percent. It is here assumed that the fishery is managed by a single owner whose objective is to maximize the net economic returns (or rents) from the fishery.

Optimal SSB varies between about 5,600 tonnes (discount rate = 0) and about 2,800 tonnes (discount rate = 20 percent), with the corresponding annual harvest varying between about 1,100 and 800 tonnes. The optimal harvest does not change much for discount rates between 0 and 10 percent because of the curvature of the estimated growth function, as already noted.

Recent decades have seen a substantial disinvestment in the spawning stock biomass, from 5,400 tonnes in 1979 to 2,300 tonnes in 2007. The bioeconomic analysis presented here calls for a substantial investment in the stock. The exact magnitude of the investment depends on the discount rate. For a discount rate of 3.5 percent, as recommended by the UK Treasury for public investments, the optimal stock level is 5,114 tonnes. Essentially, this recommendation calls for the stock to be rebuilt to its level before the start of the depletion process at the end of the 1970s and early 1980s.

Investing in the stock means that harvests must be reduced below natural growth for a period of time to permit the stock to grow. Once the stock has increased to its optimal level of 5,114 tonnes, annual harvest can be increased to a sustainable level of 1,107 tonnes.

Policy Issues

The bioeconomic analysis has some important policy implications. First and foremost, there should be substantial investment in the stock to allow it to grow to an optimal level. Essentially, the stock depletion that has been taking place since 1979 should be reversed, by reducing harvests, and the stock rebuilt to its level before the start of the depletion process. Policy makers must determine how much should be invested and how fast—that is, over what time period—the investment should take place.

In the short run, investing in the stock will necessarily mean reducing harvests and lead to lower revenues for fishing fleets. In the long run, when the stock has been rebuilt, harvests can increase to a higher level. This approach involves short-run sacrifices for long-run benefits. The "short run" may amount to several years, however, and it may be difficult for fleets to sustain reductions in income, even if they are temporary. Yet the sole fishery has the potential to yield a fairly substantial resource rent. With proper stock management, after a rebuilding period the fishery could be reopened, allowing for higher catches and revenues on a sustainable basis.

To achieve the optimal level of rent, not only would the stock need to be allowed to grow to the optimal level, but the fleet would also need to be restructured to reduce excessive fishing effort and harvesting costs. A more thorough analysis of this issue would require more detailed effort and cost data.

Sole represents the most important output of the UK beam trawler fleet. Although sole represents only a little less than 10 percent of catch quantity, it accounts for close to 30 percent of catch value. Yet according to Bjørndal and Bezabih (2008), this fleet currently earn no rents, but rather is incurring losses. The reason this situation continues must be that the capital in the vessels can be considered a "sunk cost" with little, if any, alternative value. Thus, vessels can keep fishing as long as revenues cover variable costs, including maintenance of gear and vessel. This situation is not uncommon in fisheries.

In the long run, however, the situation is not sustainable. Sooner or later vessels will need to be replaced, but fleets can replace their vessels only if their economic situation changes considerably. Presumably this change can take place only after a substantial restructuring of the fleet, including a substantial reduction in fleet capacity.

Some of the simplifications made in this analysis also have policy implications. Sole is part of a multispecies fishery. Fishing vessels harvest sole at the same time as they harvest other species like monkfish and megrim. This fact has an impact on both the effectiveness of regulations and the cost of harvesting. This analysis assumes that sole is a single-species fishery, and although impacts on other fisheries are difficult to quantify, they need to be considered.

Another assumption is that the fishery is managed by a single owner. This analysis does not consider the implications of multicountry harvesting for achieving an agreement for rebuilding the stock and complying with quotas, for example. As noted, the major countries participating in this fishery are the United Kingdom, Belgium, and France. For all countries participating in the fishery, improved management brings with it the promise of increased harvests, revenues, and rents.

Because fish cannot be easily observed, assessing stock size is a challenging task for fisheries scientists. Over the years, they have developed sophisticated statistical methods and combined results from these models with analyses based on acoustic surveys. Although there is uncertainty about the precise stock size, stock data for sole are good.

The situation in developing countries may be very different. In many of these countries, expertise in fisheries science is limited, data collection is inexistent or inconsistent, and the national fisheries administration is frequently understaffed and underfunded. In addition, access to fisheries is often unregulated, with limited government control over the actual fishing effort and few incentives for fishers to limit their catches to what would be sustainable in the long term. Moreover, fisheries are typically mixed, so that fishers at any time may harvest fish from many different stocks, in some cases 20–40 different stocks. In a situation like this, assessing stock is infinitely more difficult, and as a consequence fisheries management in many developing countries is at best very limited and at worst nonexistent.

Stakeholders

A number of stakeholders can be identified.

The European Commission

The European Commission sets TACs and other regulations, after consultation with the national governments involved and based on advice from the ICES. Thus, the European Commission has a central role in the overall management of the fishery.

UK and Other National Governments

National governments also play an important role in the case of sole—particularly the United Kingdom, Belgium, and France. Ultimately, they need to agree on TACs and regulations to be implemented by the European Commission. Monitoring and enforcement of the regulations is the responsibility of the United Kingdom and other governments. Thus, the effectiveness of regulations is largely determined by the countries involved.

The UK Beam Trawler Fleet and UK Inshore Fleet

As already noted, the UK beam trawler fleet is the most important fleet segment in this fishery, not only in the United Kingdom, but overall. Sole represents the most valuable output for this fleet. Moreover, beam trawlers currently earn no rents; if anything, they are incurring losses. Thus, a restructuring of the fleet is called for, with some of the current operators in all likelihood having to leave the fleet over the next few years. The UK quota is shared between the beam trawler fleet and the inshore fleet. Thus, if one fleet gets more of a given quota, it will happen at the expense of the other fleet.

Belgian and French National Fleets

No information is available regarding other fleet segments in the sole fishery, but there is no reason to believe that the Belgian and French fleets currently earn positive rents.

Policy Options

The 2007 SSB level was 2,300 tonnes. An optimal policy will involve an investment in the stock. This analysis assumes that the discount rate is 3.5 percent, which will imply more than a doubling of the stock to 5,114 tonnes.

Different approach paths can be pursued to reach this stock level. How quickly the optimal stock level will be reached depends on how much is harvested during the rebuilding period and how productive the stock is. The first option is a continuation of the situation prior to the implementation of the European Commission's recently adopted management plan. The second option is based on the European Commission's management plan for sole. The third option involves an annual TAC of 500 tonnes until the optimal stock level is reached. The fourth option, known as bang-bang, is most extreme approach path and involves a moratorium on the harvest until the optimal stock level is achieved.

Option 1: Continuation of the Pre-Management Plan Policy

If regulations prior to the implementation of the European Commission's management plan were not changed, the stock would be subjected to a constant yearly harvesting of 958 tonnes, which is the actual harvest recorded in 2006. Consideration of the impact of this management approach commences at the end of 2007. The results show that the stock would have been driven to extinction by the year 2011—that is, after four years (Figure 4). This outcome may be a bit of an exaggeration, given that catch per unit of effort may have declined as stock size was reduced, making stock depletion less severe. Nevertheless, this result clearly shows that if nothing had been done, the stock would have been driven to near extinction.

Option 2: The EC Sole Management Plan

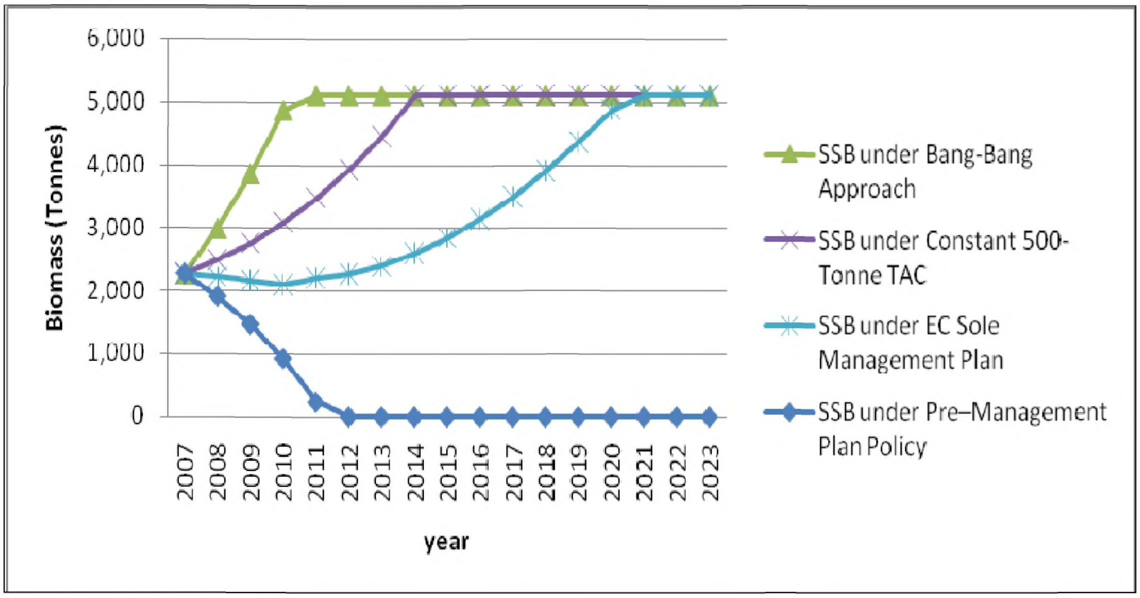
The second approach is based on the management plan introduced by the European Commission for Western Channel sole. In the first two years of the recovery period, 2008 and 2009, the TAC was set at 765 tonnes. The TAC is then reduced to 600 tonnes per year until 2012. In 2013 the TAC is further reduced to 550 tonnes and maintained at this level until the steady-state stock level has been achieved (Figure 4). In 2020, the last year before a steady state is reached, the TAC is set at 868 tonnes.

Option 3: Constant 500-Tonne TAC

The next case assumes an annual TAC of 500 tonnes until the steady state is reached. This value is chosen arbitrarily—it is less than the TACs of recent years, but more than what the ICES has recommended. The reason for considering this approach path is that the closure of the fishery would be a draconian measure that might impose substantial social costs on the fishers affected.

The approach to a steady state is illustrated in Figure 4. The 500-tonne quota remains in effect for the period 2007–12, each year giving rise to some revenues. In 2013 the quota is reduced to 407 tonnes so that the steady state can be achieved starting in 2014 with an annual harvest of 1,107 tonnes. Thus, this approach reaches a steady-state stock level three years later than the fastest approach.

Figure 4: Alternative Future Paths for SSB, 2007–23



Source: Author's calculations.

Option 4: The Bang-Bang Approach

Under the fastest approach to the steady state—the "bang-bang" approach—the fishery is closed as of 2008 and remains closed through 2010. At the end of 2011, 853 tonnes will be harvested to get the stock to its steady-state level of 5,114 tonnes. Thereafter, this approach allows for a steady-state TAC of 1,107 tonnes (Figure 4). Thus, if the fishery is properly managed, the fishery can yield a rent (or surplus) on a sustainable basis. The short recovery period under this approach is a consequence of the good growth rate for sole.

Comparison

It is obvious that the size of the TAC during the rebuilding period has a great influence on how soon the steady-state stock level is reached. Under the fastest approach, the fishery is closed through 2010, and the steady state is reached in 2011. With a 500-tonne TAC during the rebuilding period, the steady-state harvest is allowed from 2014. In the case of an approach path based on the current management plan, the steady state is reached in 2021—10 years later than under the fastest approach.

Estimation of Rent

For estimates of the present value of rents, it has been assumed that the price of sole is £8/kg and that the cost of harvesting is £3/kg. This cost per kilogram includes variable and fixed costs, including depreciation and a normal return on capital. The difference between the price and the cost of production is called resource rent. Rent can be considered a return on the stock of fish as a factor of production. Thus, the sole fishery produces a rent of £5/kg. Rents have been discounted to 2007.[1] Here is how the present value of rents over time is calculated.

The present value of rents from the sole fishery has been estimated for all four alternatives (Table 2). The starting point for these calculations is assumed to be the 2007 situation, with an SSB of 2,300 tonnes. The calculations are based on a discount rate of 3.5 percent, involving an optimal stock level of 5,114 tonnes and a steady-state annual harvest of 1,107 tonnes.

[1] Thus, rents in 2008 are discounted one year; rents in 2009, two years; and so on.

Table 2: Present Value of Rents (with a 3.5 percent discount rate)

Approach	Present value (million £)
Option 1: Continuation of pre–management plan policy	20.0
Option 2: The EC sole management plan	65.0
Option 3: Constant 500-tonne TAC	137.0
Option 4: Bang-bang	140.0

Source: Author's calculations.

Continuation of the pre–management plan policy gives rise to a present value of rents of £20 million. Fairly high rents are achieved in the first few years of the period, while the stock is being driven to extinction.

The approach path based on the current EC management plan for sole gives a present value of £65 million. The "advantage" of this scenario is that it generates fairly high harvests and rents also while rebuilding the stock, but this result comes at the expense of delayed attainment of the steady state. The net result is a much lower present value than for the faster approach paths.

The case of a 500-tonne TAC in the rebuilding period allows for rents to be earned during rebuilding. It does, however, take longer than the bang-bang approach to reach the steady state, when annual rents will rise. This approach therefore represents a trade-off. The present value of rents for this alternative is £137 million, slightly less than for the bang-bang approach.

In the case of the bang-bang approach, as illustrated in Figure 4, no harvests will take place in the two-year period 2008–09. Thus, in these years the fishery will produce no revenue and generate no rent. The situation changes in 2010, when 853 tonnes are harvested. With a rent of £5/kg, the total rent will be £4,265 million. If the fishery is managed on a sustainable basis, as of 2011 the annual harvest level will be 1,107 tonnes and the associated rent of £5,535 million will be obtained annually ad infinitum. The present value of this stream of rents, measured as of 2007, is £140 million.

This estimation of rents leaves out several relevant matters. With a continuation of current policy, the stock could be driven to extinction. A fish stock, like any other biological resource, has an existence value, which the present analysis does not consider.

Under the fastest approach, the fishery is closed for three years. Fishers may be unemployed for parts of that period, a situation that would involve social costs. Moreover, without revenues from the sole fishery, some fishers may be driven to bankruptcy while waiting for the stock to recover.

Price is assumed to be constant regardless of quantity. Scenarios with a lower annual TAC, such as 500 tonnes per year, could involve a higher unit price than what is obtained when the fishery is in its steady state, because the price is likely to depend on quantity supplied.

Additional Readings

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