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Rents Drain in Fisheries: The Case of the Lake Victoria Nile Perch Fishery*

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Abstract

Many fisheries are potentially very valuable. According to a recent report by the World Bank and the FAO (2008), global fisheries rents could be as high as US$ 40-60 billion annually on a sustainable basis. However, according to the report, due to the "common property problem", most fisheries of the world are severely overexploited and generate no economic rents. The Lake Victoria Nile perch fishery could be among the most valuable fisheries in the world. Unfortunately, also this fishery has fallen prey to the common property problem with excessive fishing effort, dwindling stocks and declining profitability. As a result, there is a large and growing rents loss in this fishery (compared to the optimal) reducing economic welfare and economic growth opportunities in the countries sharing this fishery. As in other fisheries, the biological and economic recovery of this fishery can only come though improved fisheries management.

Key words: Fisheries rents, fisheries rents loss, Nile perch fishery, Lake Victoria, fisheries management, common property problem.

Introduction

The social purpose of fisheries is to utilize naturally occurring fish stocks to improve as much as possible the long run living standards of the population. To achieve this aim usually implies that the fish stock be modestly harvested and maintained at a relatively large size while causing minimal environmental damage. In other words, maximizing the contribution of fisheries to social well-being normally implies sustainable fisheries.

The net economic benefits from fisheries are often referred to as fisheries rents. In developed market economies, fisheries rents may be approximated by the profits accruing from the fishing operations. In less developed market economies, the net economic benefits tend to exceed the profits of fishing as the latter is usually measured.

Many fish stocks are potentially very valuable and on average they may be able to generate net economic benefits (rents) amounting to some 50% of the value of landings (FAO, 1992; Garcia and Newton, 1997; World Bank, 2008). To see this in context, this profit ratio is comparable to those obtainable from fairly typical oil reserves. An added bonus is that fish stocks are renewable, so profits from fisheries can be sustained indefinitely. Oil reserves, by contrast, must eventually run out.

The problem is that because of inappropriate institutional structure, the so-called common property arrangement, the potential net benefits from fisheries are generally not realized. Under the common property (or common pool) arrangement everyone, or at least everyone belonging to a well-defined group, can extract from the fish stocks. This, virtually inevitably, leads to a loss of all the potential profits from the fishery (Gordon, 1954; Hardin, 1968). As a result, although there are individual exceptions, the fisheries of the world are not generating much economic profits. If anything they are losing a good deal of money which is made good by subsidies (World Bank, 2008). The economic waste in global fisheries, i.e. the fisheries rents loss, has recently been estimated to be some US$50 billion per year (2006; World Bank, 2008). To put this amount in context, it is slightly less than the total amount of money given for development assistance in the world (Addison *et al*., 2005).

The Nile perch fishery in Lake Victoria is one of the world's more valuable commercial fisheries. It developed after Nile perch were introduced into the lake in the late 1950s and early 1960s and has been producing some 300,000 t annually in recent years; it employs tens of thousands of people and is a major export industry for the three countries involved. Clearly the Nile perch is a very valuable resource. The question is whether the current fisheries management and harvesting policies are maximizing the long run net economic benefits from this fishery.

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The fisheries problem

The fisheries problem is fundamentally caused by the common property problem, i.e., the absence of private property rights in the fishery. It is this lack of individual rights to stocks and harvests which basically forces fishers to engage in a wasteful competition with each other for shares in the obtainable catch. This waste appears as:

(1) excessive fishing fleets and effort;
(2) excessively reduced fish stocks;
(3) little or no profitability and unnecessarily low personal incomes;
(4) unnecessarily low contribution of the fishing industry to the GDP; and
(5) a threat to the sustainability of the fishery.

The essence of the fisheries problem is captured by the diagram in Figure 1. In this diagram the revenue, biomass and cost curves of a typical fishery are drawn as functions of fishing effort. All three curves are sustainable in the sense that they would apply in the long run, if fishing effort was kept constant at the corresponding level.

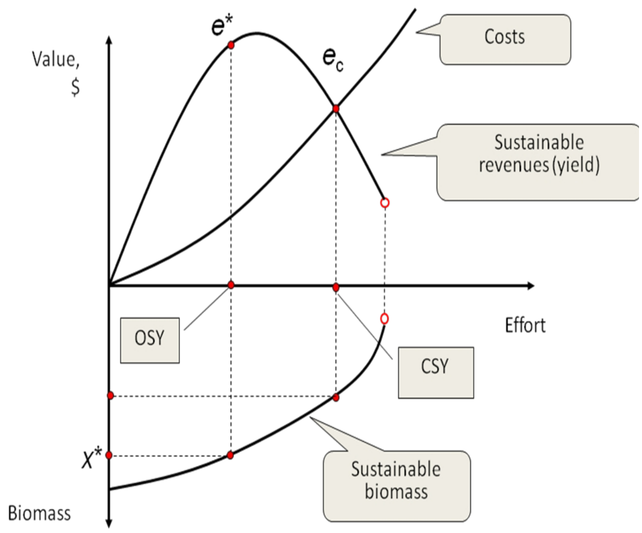

Figure 1. A graphic depiction of the sustainable fisheries model. OSY = optimal sustainable yield, CSY = Competitive Sustainable Yield, which is equivalent to the open access equilibrium.

The lower part of Figure 1 describes what happens to sustainable biomass as fishing effort is increased. Basically sustainable biomass is monotonically reduced as fishing effort is increased (note that the level of biomass is measured in a downward direction) If, as illustrated in the diagram, fishing effort exceeds a certain level, the stock size becomes insufficient for regeneration, the fishery is no longer sustainable at that effort level, and the stock collapses.

The upper part of Figure 1 is the well known sustainable fisheries model initially forwarded by Scott Gordon (1954). As illustrated, sustainable revenues initially increase with fishing effort but at a declining rate as the biomass is reduced. At a certain level of fishing effort, sustainable revenues are maximized. If fishing effort is increased beyond this point, sustainable revenues decline as the biomass level is reduced still further. Finally, at a certain level of fishing effort, the fishery is no longer sustainable. The stock collapses and there will be no sustainable revenues. As drawn in Figure 1, costs, on the other hand, increase monotonically with fishing effort.

Figure 1 reveals that the socially optimal level of the fishery occurs at fishing effort level e^*. At this level of fishing effort, profits and consequently the contribution of the fisheries to GDP is maximized. It should be noted that that the optimal fishing effort e^* is less than the one corresponding to the maximum sustainable yield. Consequently, the optimal sustainable stock level, x^*, is comparatively high as can be seen from the lower part of the figure. An optimal fisheries policy is therefore biologically conservative and the risk of a serious stock decline is generally very low.

Under the common property arrangement of the fishery, the fishing industry will find equilibrium at fishing effort level, e_c. At this level of fishing effort, costs equal revenues and there are no net profits or rents in the fishing industry. If, at the same time fishing labour is paid its reservation wage the net contribution of the fishery to the GDP is approximately zero. In other words, the fishery contributes virtually no net benefits to the economy. Notice that this is the equilibrium outcome in any common property fishery irrespective of the size and productivity of the underlying natural resource.

The reason for this unfortunate outcome is not difficult to understand. Assume for instance that fishing effort is below the equilibrium level, e_c. At this level of fishing effort there will be profits. This does two things. It encourages existing fishers to expand their operations in order to increase their profits. It attracts new participants wanting to partake in these profits into the fishery. Thus investment in fishing capital takes place and fishing effort rises. Obviously this process will continue as long as there are any profits to be had in the fishery. Equilibrium in the common property fishery will only be reached when there are no profits, i.e. at effort level e_c.

Compared to the net-benefits obtainable by the optimal fishery, the common property arrangement is highly wasteful. Not only does it generate little or no net economic benefits, it also implies a much smaller biomass level. Indeed, as can easily be verified from inspection of Figure 1, the common property fishery may easily imply the exhaustion of the biomass altogether.

It is important to realize that fishers subject to the common property arrangement can do nothing to avoid this wasteful outcome. When many fishers share ownership in a common fish stock, each one has every reason to grasp as large a share of the potential yield as possible. Prudent harvesting by one fisher in order to maintain the stocks will, for the most part, only benefit the other more aggressive fishers without preventing the ultimate decline of the stocks. Thus, each fisher, acting in isolation, is powerless to alter the course of the fishery. His best strategy is to try to grasp as large a share in the fishery as possible while the biomass is still large enough to yield some profits.

This, in a nutshell, is what Hardin (1968) called 'the tragedy of commons'. The common property arrangement in fisheries basically forces the fishers to overexploit the fish resources, even against their own better judgment. As a result, the potential benefits of these resources, no matter how great, become wasted under the onslaught of a multitude of users.

Global fisheries rents loss

In 2006, the World Bank and the FAO organized a major research effort to assess the degree of economic inefficiency in ocean capture fisheries worldwide (World Bank, 2008). A two-pronged approach was adopted. On the one hand, the world's ocean fisheries were treated as one big fishery and the level of rents and rents loss in this fishery assessed. On the other hand, several case studies of individual fisheries around the world were undertaken with specific models for each particular fishery being constructed and the level of rents and rents loss in each one of them assessed.

According to the results of the World Bank/FAO study, the common property problem in fisheries has been even more devastating than previously thought. The study confirms what the FAO has been saying for years; that the great majority of the world's commercial fish stocks are seriously overexploited. The global commercial fish stocks are estimated to be less than a quarter of their initial (pre-exploitation) size and between 1/3 and 1/2 of what would be economically optimal. Similarly, global fishing fleets and fishing effort are hugely excessive. Fishing fleets in operation (a large number of fishing vessels are lying idle around the world) are estimated to be two to three times larger than what would be needed for optimal fishing. Perhaps most shockingly, the net economic benefits from the global utilization of the world's ocean fish stocks are very small. In fact, in terms of profits, it appears that the global fishery is actually operated at an overall loss of some US$ 5 billion annually, a loss made good by subsidies to fishing companies in the developed part of the world. This real operating loss should be compared to the attainable net profits from a well run global marine fishery which according to the World Bank/ FAO report is about US$ 46 billion annually. The key results of the World Bank/FAO study are summarized in Table 1.

Table 1. Rents and rents loss in the global fishery. The calculations in this table are based on two different biomass growth functions, the logistic (Clark, 1976) and that proposed by Fox (1970), both of which are theoretically and empirically possible, giving two sets of outcomes. From World Bank (2008).

		Current		Optimal		Difference	
	Units	Logistic	Fox	Logistic	Fox	Logistic	Fox
Biomass	t x 10^6	148.4	92.3	314.2	262.9	165.8	170.6
Harvest	t x 10^6	85.7	85.7	80.8	81.6	-4.9	-4.1
Fleet/Effort	Index	1.00	1.00	0.56	0.46	-0.44	-0.54
Profits	USD x 10^9	-5.0	-5.0	39.5	54.0	44.5	59.0
Rents	USD x 10^9	-5.0	-5.	39.5	54.0	44.5	59.0

The World Bank/FAO aggregate study employed two different biomass growth functions, the logistic one (Clark 1976) and the one proposed by the biologist Fox (1970), neither of which was preferred by the available empirical data nor basic theory. As a result there are two sets of results, one for the logistic and one for the Fox biomass growth function.

As indicated in Table 1, the global fishery could yield net economic benefits between US$ 39.5 billion and 54.0 billion annually. In the base year, 2004, however, the global fishery was run at a loss (before subsidies) of US$ 5 billion. Thus, the annual rents loss in the global fishery is between US$ 44.5 billion and 59 billion depending on which biomass growth function applies. This rents loss amounts to about 60% of the total revenues of the global ocean fishery in the base year.

Of course these results are subject to considerable uncertainty which is extensively discussed in the report. This uncertainty stems from various sources but most important is the lack of precision in the estimates of parameters of the global fisheries model underlying the results. The uncertainty of the rents loss estimate is illustrated in Figure 2 and the corresponding confidence intervals are reported in Table 2.

Table 2. Estimates of global rents loss according to confidence intervals (from World Bank, 2008).

Confidence	Estimated rents loss (billion US$)
95%	26-73
90%	31-70
80%	37-67

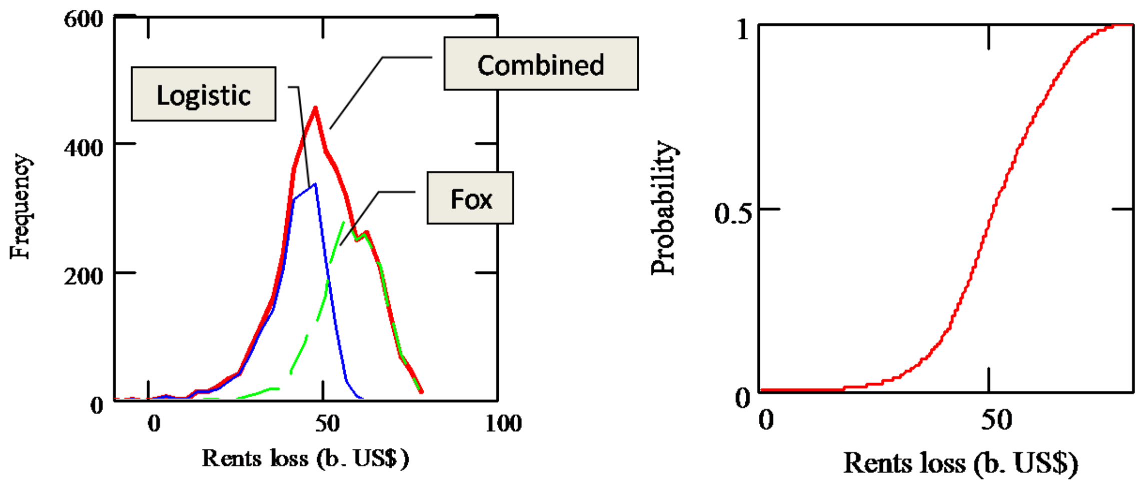

Figure 2. Uncertainty of the global rents loss estimate: density and distribution functions (from World Bank, 2008)

The results from the aggregate global ocean fishery were supported by the individual case studies. About 20 such studies of different fisheries were carried out and a considerable range in the rents loss in individual fisheries was observed but, taken together, the results were similar to the ones from the aggregate global study.

The inescapable conclusion is that, far from benefiting the people of the world, the global ocean fishery is actually an economic burden. Having decimated most of the fish stocks by excessive harvesting, the world's global fishing fleets are contributing next to nothing the world's economy and a significant part of the fishing fleets are being kept afloat by subsidies in various forms.

The global marine fishery provides a striking example of how much economic damage can be caused by the common property problem. The common property problem not only affects the global fishery but operates in any fishery which doesn't have enforceable property rights. Neither is it restricted to ocean fisheries, or even large scale fisheries, because small scale inland fisheries fall just as easily prey to the common property problem as large scale ocean ones.

Rents loss in the Lake Victoria Nile perch fishery

Nile perch were introduced into Lake Victoria in the early 1950's. By 1980, the Nile perch fishery had attained major commercial significance. Helped by successful international marketing campaigns, foreign and domestic investors installed fish processing plants specializing in Nile perch products. As a result, demand for Nile perch landings expanded greatly attracting a dramatically increased number of fishers to the fishery. In 2006, the Nile perch fishery contributed over 24 % of the total volume of fish harvest and 66 % of income generated from fisheries in the three East African countries of Kenya, Uganda and Tanzania (LVFO, 2007).

In terms of commercial value the Nile perch fishery dominates the Lake Victoria basin fisheries; in Kenya alone, which has a 6% share of the lake's area, the income derived from Nile perch fishery in 2006 was estimated to be US$134 million (landed value). Nile perch fish products processed by fish processing plants based in Kenya earned a further US $43.0 million in international trade. Thus, it may be estimated that the Nile perch fishery generated income of over US$ 177.0 million in Kenya alone.

Unfortunately, there are strong indications that the Nile perch catches have for some time exceeded the biological productivity of the resource. As a result, the stock is now severely overexploited and incapable of sustaining catch level unless a stock rebuilding program is initiated. At the same time, the number of fishers in Lake Victoria has continued to increase, further increasing the pressure on Nile perch and other fish species in the lake. The data are not readily available but it seems inevitable that this decline will be accompanied by substantially diminished profits to the fish processors and severely reduced incomes to individual fishers and their households.

Thus it seems that the Nile perch fishery has now fallen victim to the same common property problem that has devastated so many fisheries around the world. This outcome is no surprise. The fact that this fishery has, by and large, been operated as a common pool fishery without an appropriate rights-based fisheries management regime made this outcome virtually inevitable. The longer the current inefficient fisheries management regime persists, the greater will be the devastation of the Nile perch and other fish stocks in the lake and the more difficult it will be to return to a healthy sustainable fishery.

During the winter of 2006/7, Mr. Simon Warui of the Ministry of Livestock and Fisheries Development in Kenya investigated of the Lake Victoria Nile perch fishery as a part of his studies at the United Nations University Fisheries Training Programme in Iceland (Warui, 2007). This study, of course, is not the final word on the matter. It was and remains a student dissertation based on three months of research work. Nevertheless, at this point of time, it is the most complete study of the rents and rents loss in this fishery. Moreover, it tells a story that fits both with theory and the experience from a multitude of similar common property fisheries around the world.

In his work, Warui adopted the World Bank/FAO methodology (World Bank, 2008) His model of the Nile perch fishery may be summarized in three equations as follows:

(1) $\dot{x} = G(x) - y$ (Biomass growth function)

(2) $y = Y(e,x)$ (Harvesting function)

(3) $\pi = p \cdot Y(e,x) - C(e)$ (Profit function)

The five variables of this model, i.e. *x*, *y*, *e*, *π* and *p* represent biomass, harvest, fishing effort, profits and landings price, respectively. The first four are endogenous, i.e. determined within the fishery, while the fifth (price) is exogenous, i.e. determined by market conditions outside the fishery. The derivative, $\dot{x} \equiv \partial x / \partial t$ measures the change in biomass at a point of time.

The model comprises three elementary functions basic to any bio-economic fisheries model; (i) the natural growth function, *G*(*x*), (ii) the harvesting function *Y*(*e*,*x*), and (iii) the cost function, *C*(*e*). The form adopted for these functions is specified below. As in the World Bank/ FAO global study there are two options for the biomass growth function.

(4) $$G(x) = \begin{cases} \alpha \cdot x - \beta \cdot x^2 & \text{(logistic)} \\ a \cdot x - b \cdot ln(x) \cdot x & \text{(Fox)} \end{cases}.$$

The harvesting function is specified as:

(5) $$Y(e,x) = q \cdot e \cdot x^d,$$

This is an extended version of the Schaefer (1954) harvesting function with *q* as the catchability coefficient and *d* as the schooling parameter. Normally $d \in [0,1]$. A value of *d* close to one would indicate little schooling and a lower *d* suggests increasing tendency toward schooling. For species such as Nile perch, *b* is thought to be between 0.75 and 0.95.

Finally, the cost function is specified as

(6) $$C(e) = c \cdot e + fk,$$

where *c* is a parameter and *fk* represents fixed costs.

The parameters of the model represented by equations (4)-(6) were estimated partly on the basis of the available data and partly by using the data-poor estimation techniques explained in the World Bank/FAO (2008) study. The key data used in the estimation are summarized in Table 3.

On the basis of the fisheries model expressed by equations (4)-(6) and the estimates of its parameters it is possible to derive a the traditional sustainable fisheries model for the Nile perch fishery corresponding to the upper panel of Figure 1.

The results of the rents and rents loss drain according to both the logistic and Fox biomass growth functions are summarized in Table 3.

Table 3. Key data used in the estimation of the Nile perch fisheries model

Variable	Assumed value
Maximum sustainable yield (t x 10^3)	300.0
Virgin stock biomass (t x 10^3)	1427.0
Landings in base year 2006 (t x 10^3)	255.0
Landings price in base year 2006 (US$ kg^{-1})	1.50
Net biomass growth in base year 2006 (t x 10^3)	0.00
Profits in base year 2006 (US$ x 10^6)	53.0

As illustrated in Figure 3, the model, employing the logistic biomass growth function, indicates that the current fishing effort (measured in non-motorized boat units) is well above the one corresponding to the maximum sustainable yield and way beyond the optimal level. As a result, the sustainable yield with the current effort is only about 250,000 t compared to the assumed maximum sustainable yield of 300,000 t. Even more worrying is that effort is currently just below that where the biomass ceases to be sustainable, i.e. where the sustainable revenue curve becomes vertical. The fishery appears to be in serious danger of a collapse if the present level of fishing effort is maintained.

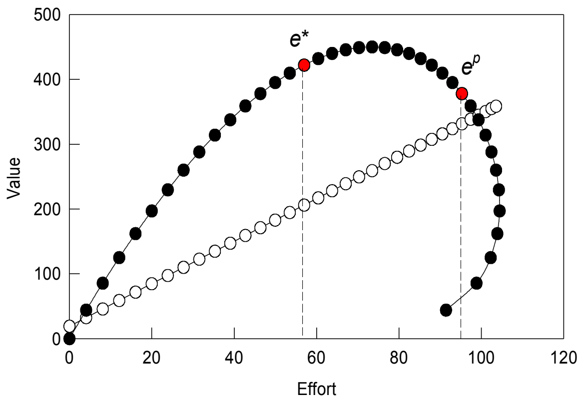

Figure 3. A sustainable fisheries model for Nile perch derived from the logistic biomass growth model.● = yield, ○ = costs, *e** = optimal level of fishing effort, e^p = present level of fishing effort.

According to Figure 3 the fishery in 2006 was operated at slight profits, some US$50 million. This should be compared to the potential profits of more than US$200 million which could be attained on a sustainable basis if a more appropriate fisheries policy was adopted. This more appropriate fisheries policy reduces fishing effort by some 40 and would be attained at a biomass level about double the current one and sustainable harvests of some 280,000 t annually. The results of the rents and rents loss drain according to both the logistic and Fox biomass growth functions are summarized in Table 4.

Table 4. A summary of the main results, using the logistic and Fox model to compare the current situation in the Nile perch fishery with predicted optimal values.

	Current		Optimal		Difference	
	Logistic	Fox	Logistic	Fox	Logistic	Fox
Biomass (t x 10^3)	436.3	264.3	892.9	717.0	456.6	452.7
Harvest (t x 10^3)	254.7	254.7	281.1	282.1	26.4	27.4
Effort (boats x 10^3)	94.7	94.7	56.9	44.9	-37.8	-49.8
Profits (US$ x 10^6)	52.9	52.9	216.4	257.0	163.5	204.1
Rents (US$ x 10^6)	72.0	72.0	235.5	276.1	163.5	204.1

Notable information in Table 4, in addition to what has already been discussed, is that it doesn´t make any material difference to the optimal policy whether the logistic biomass growth function or the Fox one applies. In both cases fishing effort should be reduced by some 40-50%. However, if the Fox biomass growth function applies, the actual rents loss of the current policy and the maximum attainable rents are substantially (some US$ 40 million) greater than if the logistic biomass growth function applies. The reason is that the Fox biomass growth function is more resilient (generates more biomass growth) at low stock sizes than the logistic. So, if it actually applies the calculated base year Nile perch biomass level in Lake Victoria is substantially less and the gains from a stock rebuilding policy correspondingly greater than if the Fox biomass growth function applies.

As in any study of this kind, there is a substantial uncertainty regarding the model and its parameters. Stochastic analysis based on Monte Carlo simulations indicates that with 90% confidence the current fishing effort should be reduced by some 25-60% to achieve the optimal sustainable yield. With the same 90% probability this would yield net economic gains of between US$90 million and 260 million annually.

It is one thing to identify the optimal sustainable yield and quite another to describe the best way to get there. Simple dynamic analysis suggests that to maximize the present value of the net profits from the fishery it would be necessary to close it immediately for one year, followed by a small amount of fishing in the following year and increase fishing effort in the third and fourth years until it reaches its long-term sustainable level. This would be characterized by a fishing effort of roughly 2/3 of the current level and a catch of around 280,000 t per year.

This optimal path of fishing effort is illustrated in Figure 4. The first year in the diagram represents the base year fishing effort; subsequent years represent the approximately optimal dynamic policy. The stock rebuilding policy depicted in Figure 4 is qualitatively the same as predicted by optimal dynamic theory and the actual ones that have been much more carefully worked out for other overexploited fisheries. One can therefore be reasonably confident in the broad structure of this policy.

The rent maximizing dynamic policy involves somewhat dramatic reduction in fishing effort and harvests at the outset. This may be socially difficult to endure. Therefore, a more moderate stock rebuilding policy may be more appropriate. This will lead to a longer adjustment period until the optimal sustainable equilibrium is attained. Given the current depressed state of the Nile perch stock, any sensible policy would nevertheless imply a substantial reduction in fishing effort right away.

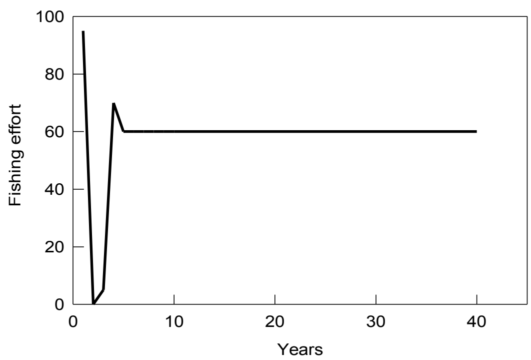

Figure 4. The evolution of fishing effort following the establishment of an optimum fishing effort policy. The first year in the diagram represents the base year fishing effort; subsequent years represent the approximately optimal dynamic policy.

There are some indications that the natural productivity of the Lake Victoria basin may be declining, possibly reflecting the impact of pollution or long term environmental cycles (Awange and Ong'an'ga, 2007). If this is the case, the total benefits of the stock rebuilding policies outlined above might be too optimistic. It is important to realize, however, that even in this case the gains from these policies would still outweigh the losses that will occur if the current policies are allowed to continue. Moreover, the best fishing effort policy in an environment where productivity is declining would still be roughly the same. It would still be optimal to reduce fishing effort drastically.

Discussion

Common property fisheries virtually without exception lead to overexploitation and loss of economic fisheries rents. In the global fishery, the resulting loss in economic rents is huge (World Bank 2008). It is by now well established (see e.g. Shotton, 2000; Arnason, 2007) that the best way to overcome the common property problem s problem is introduce a fisheries management regime based on property rights. For this purpose ITQs (individual transferable quotas), TURFs (territorial user rights) and community fishing rights have been introduced in many fisheries around the world (Shotton, 2000). The first two systems have clearly demonstrated their ability for recovering economic rents in fisheries and, in addition, introducing various kinds of new efficiencies in fisheries. The performance of ITQs, which are applicable to a much wider range of fisheries than TURFS, has been particularly impressive. Encouraged by the observed benefits of ITQs in other nations, over 15 major fishing nations have now adopted the ITQ-system in their fisheries management regimes and well over 20% of the global ocean fish catch is now taken under this form of fisheries management. In all these cases, increases in economic efficiency and profitability have been dramatic. In most cases previously declining fish stocks stabilized and in some cases recovered (Costello *et al*., 2008).

The Lake Victoria Nile perch fisheries management regime has essentially been a common property fishery. This is the fundamental cause of the inexorable decline in the biological foundation and the economic return of this fishery. To halt this trend and embark on a socially responsible fisheries policy as outlined in section 4 above, it is necessary to develop and implement a new fisheries management regime. Theory and experience of other fishing nations shows that this management regime has to be based on high quality property rights. Apart from this, not much can be asserted without a careful study of the social situation.

An ITQ-system seems attractive but may be difficult to enforce on an individual fisher basis. Organizing fishers into communities holding community ITQs and with some TURF rights may be a practical as well as an efficient way to go. The ITQs would be enforced on the community level and, provided that enforcement is effectively conducted, the communities would be induced to control their own members. This system of community ITQs has been tried for instance in England and Holland with encouraging results (MRAG *et al*., 2008). It goes without saying that under this system, each of the nations involved would have their own national Nile perch quota for which they are responsible and could allocate to their community units. These national quotas could be transferable and any overages by individual nations would be subject to the appropriate payment to the other nations plus the appropriate penalty. It is clear that for these national constraints to hold, each of the nations would have to exhibit a high degree of national responsibility.

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