LIMITS TO THE PRIVATIZATION OF FISHERY RESOURCES

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ABSTRACT

A debate is emerging over the extent to which privatization of fishery resources – private ownership and resource management without significant state oversight- is practical and socially desirable. What we term the "optimists" maintain that there are no effective limits to privatization and that the decades old fear that privatization could, in some cases, lead to resource extinction are baseless, and of theoretical interest only. This paper attempts to add to the debate by arguing that the fears are, regrettably, not at all baseless and that there are, in fact, definite limits to socially desirable privatization. The paper goes on to discuss means, by which such limits could be identified, on a fishery by fishery basis.

Keywords: Marginal stock effects, existence value, privatization, dedicated access privileges

Introduction

The increasingly widespread implementation of harvesting rights schemes (or Limited Access Privilege Programs (LAPPs) to use American terminology), such as ITQ schemes, territorial use rights fisheries (TURFS) and fisher cooperatives, has steadily increased the opportunity for private sector groups to influence fisheries management policy. This development, in turn, has given rise to a debate over the extent to which private sector influence over fisheries management should be encouraged, with some authors implying that private sector management of the resource should be allowed to expand to the point that public sector oversight ceases to be significant (see, for example, Arnason, 2007). The private "individual," or entity, would then be the owner of the resource, de facto, if not de jure.

It is the purpose of this paper to contribute to the debate. In order to give focus to our contribution, we turn to the well known 1973 Colin Clark result that, under certain circumstances, a private owner of a fishery resource could opt to drive the resource to the brink of biological extinction, even in the absence of a positive minimum viable population (MVP) (Clark, 1973). The Clark result is of particular interest, because a recent stimulating, and provocative, Science article, by Grafton, Kompass and Hilborn, does, on the basis of empirical investigation, declare that Colin Clark's 1973 result is really no more than a theoretical curiosity, devoid of practical significance. If fishery resources are under private ownership, the private owners can be relied upon to be conservationist, and indeed to stabilize fishery resources under their control at levels above that associated with MSY (Grafton, Kompass and Hilborn, 2007). We shall argue that the 1973 Clark result cannot, in fact, be safely dismissed, but rather continues to have substantial practical relevance.

If the 1973 Clark result does have practical relevance, there follows what we might call a "so what?" question. If a private owner of a resource concludes that it is economically optimal to "deplete fully" (Grafton et al., 2007) a fishery resource, what is there to say that a public owner would not come to exactly the same conclusion? Hence, there is really nothing to be lost by placing the resource under private ownership. This "so what?" question is to be investigated.

Public and Private Portfolio Managers

"Green" national income accounting, and the related concept of a capital approach to sustainable growth, both of which are being applied to fisheries (FAO, forthcoming), rest upon the Hicksian view of the social manager, as manager of a portfolio, consisting of produced, "natural," and human capital assets (Hicks, 1946; FAO forthcoming, para. 24). Capture fishery resources are to be seen as a sub-component of the "natural" capital assets in the social manager's portfolio.

Portfolio management requires that the concept of asset market equilibrium be invoked, which, simply stated, is that asset markets will be in equilibrium, only when all assets of a common risk class are seen to earn the same rate of return (Solow, 1974). If a particular asset in the portfolio is found to be yielding more, or less, than the rate of return for the common risk class, then portfolio rebalancing is called for, until asset market equilibrium has been achieved (Gaudet, 2007). One can, and indeed should, think of the social rate of discount applied to capture fishery resources as reflecting the common rate of return relevant to such resources.[i]

If fishery resources should be privately owned, one should also think of the private owner as a portfolio manager, in that the private owner has alternative investment opportunities, real and financial. Thus the "private" rate of discount is to be seen as the private resource owner's perception of the common rate of return on assets of a comparable risk class.

Having said all of this, let us note that this simple version of the asset market equilibrium rule is applicable, only in the absence of non-convexities. If non-convexities are encountered, then the rule becomes somewhat more complex. At a later point in the discussion, a non-convexity issue will, in fact, come before us.

The 1973 Clark Result and Threat of Extinction: Actual or Fanciful

The 1973 Clark result can be expressed as follows. Denote the growth of the biomass, x, by F(x), and assume that the growth function is characterized by pure compensation. Denote the private owner's discount rate by δ_p. Then it will be optimal for the private owner to drive the resource to extinction, if:

$$\delta_p > F'(0) = r \tag{1}$$

given that $p > c(0)$, where r denotes the intrinsic growth rate of the resource,[ii] p denotes the price of harvested fish (assumed to be constant), and where $c(0)$ denotes the average cost of harvesting the last unit of fish.[iii] The result is, in effect, stating that asset market equilibrium leads to a corner solution, in that the rational private portfolio holder must divest him/herself of the entire stock.

The proviso, namely that $p > c(0)$, leads to a consideration of the non-trivial issue of the sensitivity of harvesting costs to the size of the biomass, characterized by Clark and Munro as the Marginal Stock Effect (MSE) (Clark and Munro, 1975). Let us consider the MSE in the context of the now standard issue basic dynamic economic model of the fishery applied to the private sector owner.

In this standard issue dynamic economic model of the fishery, the underlying biological model is the much loved (by economists) Schaefer model. Let p and b, both constants, denote the price of harvested fish and unit cost of fishing effort respectively, and assume that fleet and human capital are perfectly malleable. The objective of the private owner of the resource is assumed to be that of maximizing the present value of the stream of resource rents from the fishery through time. Thus the private owner's objective functional is given by:

$$\max\ PV = \int_0^{\infty} e^{-\delta_p t}(p - c(x))h(t)\,dt \qquad (2)$$

where c(x) is the unit cost of harvesting, $c(x) = \frac{b}{qx}$, where q, a constant, is, in turn, the catchability coefficient. This leads to the well known result that the optimal biomass, x^*, is given by the following Modified Golden Rule equation:

$$F'(x^*) - \frac{c'(x^*)F(x^*)}{p - c(x^*)} = \delta_p \qquad (3)$$

where the L.H.S. of (3) is the "own rate of interest," or yield, on the marginal investment in x, while the second term on the L.H.S. is the MSE, arising from the sensitivity of harvesting to the size of the biomass.

To be reminded of just how sensitive harvesting costs are to biomass size in this model, recall that $c(x) = \frac{b}{qx}$, where qx is the CPUE, to use the biologist's terminology. Note that there is a strict linear relationship between CPUE and x, with the consequence (also well known) that: $\lim_{x \to 0} c(x) = \infty$.

Consider exactly what this implies. Suppose that we commence with: $F'(x) - \frac{c'(x)F(x)}{p - c(x)} < \delta_p$. Asset market equilibrium considerations demand disinvestment in x at the margin. As x decreases the "own rate of interest" of the resource steadily increases until equality is achieved with δ_p, at a positive stock level, even if δ_p is in some sense "large."

We can, in fact, go much further than this. Even if the fishery is characterized by Pure Open Access (which is the equivalent of $\delta_p = \infty$), rather than management by a private "sole owner," the resource is safe from extinction. If $\lim_{x \to 0} c(x) = \infty$, then we are assured that the expansion of the fishery will be brought to a halt at a positive stock level, simply because a point is reached at which the profits from fishing become negative. Indeed, this result provides us with a simple test of the applicability of the standard issue, Schaefer based, dynamic economic model of the fishery to a given fishery. Pose the following question: would the fishery resource be secure against being driven to the verge of extinction under Pure Open Access?

This is not a trifling matter. Ragnar Arnason, in his eloquent plea for private resource management, explicitly incorporates a positive MSE in his analytical model, and does not consider cases in which the MSE is weak, let alone non-existent (Arnason, 2007).[iv] Grafton, Kompass and Hilborn state that "… in *all* cases … fishery profits become negative *long before* biomass is fully depleted" (Grafton, et al., 2007, p. 1601). While it is not entirely clear whether this statement applies to the four fishery resources reported upon in the article, or whether it is meant to apply to all fishery resources, the reader can easily gain the impression that a strong MSE is the norm, and that the answer to our test question about the resource being safe from extinction (or anything close to it) under Pure Open Access is generally a firm yes.

The question now before us is whether the answer to our test question is, or is not, generally yes, as implied by Grafton et al. (2007). If it is, and if the cases of a negligible, or at least weak, MSE are rare exceptions, then it is true that the 1973 Clark Result, and all that it implies, can be safely confined to the classroom.

We have noted that the "strong" MSE associated with the standard issue dynamic economic model of the fishery rests upon a strict linear relationship between CPUE and the size of the biomass (Clark, 2006). There is, in fact, no biological evidence that this is commonplace among fishery resources. J. Cooke and J. Beddington,[v] in an article on the relationship between CPUE and fish stock abundance, state that "… a linear relationship, CPUE and abundance have rarely been demonstrated" (Cooke and Beddington, 1985).

One significant class of fishery resources, for which a complete absence of linearity has been clearly established, is that of small schooling pelagics, such as herring, sardine, anchovy and menhaden. Mackinson, Sumaila and Pitcher report that studies have shown that CPUEs in such fisheries remain constant as the stocks decline (Mackinson, Sumaila and Pitcher, 1997). As is generally known, the answer to our test question in these cases, about the security of a resource under Pure Open Access is a definite no. The authors refer to the lengthy catalogue of examples of pelagic stock collapses (Mackinson, et al., 1997, p. 11). All readers are, or should be, well aware of the near death experience of the famous Norwegian Spring Spawning Herring resource.

While it has been well recognized that the MSE, in the case of small pelagics, can be expected to be weak, we now have reason to worry about, or at least be suspicious about, the strength of the MSE in the case of demersals as well. We consider two specific examples, namely Northern Cod, off Newfoundland and Labrador, and an orange roughy resource off Australia.

In the case of Northern Cod, there is clear evidence that, in the late 1970s, marine biologists believed that there was a strong, although by no means perfectly linear, relationship between CPUE and stock abundance (Munro, 1980, Table 3-6; Chapter 3, n. 62). While the stock could be, and had been, excessively depleted under conditions of ineffective control, it seemed entirely reasonable to believe that the resource was in no danger of ever being driven to the brink of commercial, let alone biological, extinction.

Then, in the last half of the 1980s, something went horribly wrong. The government of Canada was compelled in 1992 to introduce a "temporary" harvest moratorium, which remains in place 16 years later. While there is much speculation about the causes of Canada's worst fisheries management disaster, adequate explanations have yet to be forthcoming.

The orange roughy case allows us to ask what would happen if a fishery based upon such a resource was characterized by something close to Pure Open Access. The answer has been provided to us through an experiment performed by History, in the form of the South Tasman Rise orange roughy stock.

It is now well established that, if a shared fishery resource is managed non-cooperatively, the result can be akin to Pure Open Access – the Prisoner's Dilemma syndrome (Clark, 1980; Munro, Van Houtte and Willmann, 2004). The South Tasman orange roughy resource straddles the Australian Fishing Zone and the adjacent high seas. When the resource was discovered by the Australians in 1997, it was believed that the only other state that might attempt to exploit the high seas segment of the resource would be New Zealand. The Australians entered into a cooperative management arrangement with the New Zealanders at the end of 1997. The cooperative resource management arrangement did, however, prove to be flawed.

The consequence was that cooperative management degenerated into non-cooperative management. The economist's theory of non-cooperative management of shared stocks proved to have strong predictive power in this case. The resource was subject to extensive overexploitation (Munro, et al., 2004).

Just how severe the overexploitation was has recently been revealed. After the initial non-cooperative management debacle, the two states reconvened to establish a new, and sounder, cooperative resource management arrangement in early 2000 (Munro, et al., *ibid*.). Initial harvests under the new cooperative resource management agreement were less than 10 per cent of the TAC set under the first cooperative resource management arrangement in late 1997 (Munro, et al., *ibid*.). The government of Australia has recently informed the FAO that, in the spring of 2007, the two cooperating states agreed that the appropriate annual TAC for the fishery was 0 tonnes, and that this annual TAC of 0 tonnes should remain in place for an indefinite period of time (Rolf Willmann, FAO, personal communication). The authors would suggest that the South Tasman rise orange roughy resource would fall well within the reasonable person's definition of "depleted fully."

The authors would further suggest that there are many demersal stock fisheries for which the strength of the MSE is in doubt. Indeed, Harley, Myers and Dunn, in their 2001 article, report that they found strong evidence of non-linear relationship between CPUE and biomass in an analysis of over 200 demersal species (Harley, Myers and Dunn, 2001).

In these many cases of doubt, the precautionary approach (common sense) is to assume that the MSE is weak. The negative consequences of assuming that the MSE is weak, when it is in fact strong, are minor, if not trivial, in comparison with the reverse, as the example of Northern Cod reminds us painfully.

In any event, the conclusion that is forced upon us is straightforward enough. There is no justification whatsoever for assuming that existence of weak to negligible MSEs is a rare occurrence. Indeed, there is reason to worry that the reverse may be the case. This leads to a second conclusion, namely that the 1973 Clark Result cannot be summarily dismissed out of hand.

There remain, however, two objections to the 1973 Clark result, working in opposite directions that we must consider. The first is that the result rests upon an autonomous model, which carries with it the assumption that the relevant parameters are constant through time. Of course, they are not. Surely a private owner of a fishery resource, for which the 1973 Clark result, holds might be concerned that the resource asset could be worth holding at some point in the future. After all, extinction is forever.

Clark and Munro did, as it happens, address this very question thirty years ago (Clark and Munro, 1978). Placing the issue of extinction in the context of a non-autonomous model makes the conditions for extinction somewhat more stringent, but provides no guarantee whatsoever against the threat of extinction. The authors talk in terms of constantly "riding the back of a tiger" (Clark and Munro, 1978, p. 201).

The second, and much more important, objection arises from the fact, noted earlier, that Clark's model rests upon a pure compensation biological model, which in turn implies that there does not exist a positive minimum viable population (MVP). There is, in fact, increasing evidence that positive MVPs, in the sense that there exist populations below which the resources cannot recover their original levels of abundance, are commonplace (Hutchings, 2000; Lierman and Hilborn, 2001). This second objection leads directly to the implication that the 1973 Clark result *understates*, perhaps by a wide margin, the risk of resources being driven to extinction, and does so for the following reasons.

Let x_1 denote the MVP in the strict sense that $F(x) < 0$ for $0 < x < x_1$. The resource stock then heads for inevitable extinction, if $x(t)$ is ever reduced below x_1. Clearly, therefore, open-access fishing will result in extinction if $x_{BE} < x_1$, where x_{BE} is the bionomic equilibrium biomass, given by $x_{BE} = c/pq$ in the Schaefer model. The article of Dulvy, Sadovy and Reynolds (2003) indicates that this eventuality has in fact occurred in well over 100 marine fisheries.

The question then arises whether, under certain circumstances, a private resource owner would deliberately reduce $x(t)$ below x_1. We make the unrealistic assumption that x_1 is fully known to the resource owner (otherwise overfishing to the point of extinction could be attributed to simple ignorance). The promised non-convexity issues now arise. The Modified Golden Rule equation, Eq. (3), is no longer relevant, since validity of this equation requires a convexity assumption, which ceases to be valid under depensation. Thus, even if there exists a unique, positive solution x^* to this equation, x^* is not necessarily optimal.

A simple example (Clark, 1971) explains why this is so. Let the MSE be zero (i.e. $c'(x) \equiv 0$), and consider a fishery initially at $x = x^*$. The present value of a sustained harvest strategy with $x(t) = x^*$ is

$$PV_{sust} = pF(x^*)/\delta_p \quad \text{where} \quad F'(x^*) = \delta_p$$

On the other hand, the present value of a rapid extinction strategy is

$$PV_{ext} = px^*$$

In the event that $F(x)$ is convex we have

$$F'(x) < F(x)/x \text{ for all } x \tag{3a}$$

and this immediately implies that

$$PV_{sust} > PV_{ext} \tag{3b}$$

in this case.[vi] If $F(x)$ is not convex, for example, if there exists an MVP, x_1, then the inequality (3a) is no longer valid. It is easy to construct examples for which

$$F'(x^*) > F(x^*)/x^*$$

and therefore deliberate extinction is more profitable than any sustained-yield strategy (unless $\delta_p = 0$).

The above example can be extended to the case where MSE $\neq 0$. The general conclusion is that, in the event that a positive MVP exists, deliberate extermination of a fish population may be the private owner's optimal strategy, even at quite low discount rates, and even if the cost of actually catching the last fish would be infinite.

The Social Portfolio Manager

We turn now to our – "so what?" – question. If the private owner of a fishery resource were to find it optimal to liquidate the resource and invest the resultant proceeds elsewhere, then surely it would be likely that a social manager would come to exactly the same conclusion. We commence by assuming that all convexity assumptions hold.

Obviously, we could have a situation in which $\delta_s << \delta_p$. Put this to one side and assume for the time being that $\delta_s = \delta_p$. Assume that there are no differences between social and private fishing effort costs that the demand for harvested fish is perfectly elastic, and that p, the price of harvested fish, accurately reflects the marginal social economic benefit (gross) from harvested fish.

The answer to our question is possibly yes, so long as there are no "externalities" that are external to a private owner, but internal to a social manager. We exemplify such "externalities" by taking the case of "existence value"[vii] , a quintessential public good.[viii] "Existence value," with respect to living natural resources is not trivial, being embedded in national legislation, such as the Endangered Species Act in the United States, and the Species at Risk Act in Canada, and has found its way into international law, through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which at last count has 172 member countries.[ix]

One can, without difficulty, incorporate existence value into the standard issue dynamic economic model of the fishery. Guidance is provided by a thirty-five year old article on non-renewable resources, by Neil Vousden (Vousden, 1973).[x] Let existence value be denoted by E(x), with $E'(x) > 0$, and $E''(x) < 0$. We shall suppose that E(x) is measured in monetary terms through the application of contingent valuation or some comparable technique. We shall assume, again as is reasonable, that:

$$\lim_{x \to 0} E'(x) = \infty \quad \text{(or at least some very large number)}$$

In continuing with the previous assumptions about price of harvested fish and unit cost of fishing effort, we can express the social manager's objective functional as:

$$\max PV = \int_0^\infty e^{-\delta_s t}\{(p - c(x))h(t) + E(x)\}dt \qquad (4)$$

where δ_s is the social rate of discount. Through a routine application of the Maximum Principle, we find the optimal biomass level, as perceived by the social manager, x_s^*, to be given by the following equation:

$$F'(x_s^*) + \frac{E'(x_s^*) - c'(x_s^*)F(x_s^*)}{p - c(x_s^*)} = \delta_s \qquad (5)$$

.

Since E(x) is a quintessential public good, we can assume that to a private owner of the resource $E(x) = 0$.[xi] Continuing with our assumptions pertaining to fishing effort costs and price of harvested fish and the equality of δ_s and δ_p, we can say that, if the same resource were under the control of a private owner, the private owner's perception of the optimal biomass, x_p^*, would be given by:

$$F'(x_p^*) - \frac{c'(x_p^*)F(x_p^*)}{p - c(x_p^*)} = \delta_p \qquad (6)$$

Existence value results in a second component in the MSE, as perceived by the social manager; a second component is absent in the MSE as perceived by the private owner.

Now suppose that harvesting costs are, in fact, completely insensitive to biomass size. Equations (5) and (6) would then reduce to:

$$F'(x_s^*) + \frac{E'(x_s^*)}{p - c} = \delta_s \qquad (7)$$

$$F'(x_p^*) = \delta_p \tag{8}$$

respectively.

Next suppose that: $\delta_s = \delta_p > r$. Asset market equilibrium considerations would cause a private owner to "cash out," to liquidate the resource. For a social manager such liquidation would be in violation of the same asset market equilibrium considerations. There is certain to be a positive resource level x, at which the "own rate of interest" on the resource, as perceived by the social manager, is equal to δ_s. In summary, we would have: $x_s^* > 0; \quad x_p^* = 0$. We can go farther. Relax the assumption that $\delta_p = \delta_s$, and consider the unlikely case in which $\delta_p << \delta_s$, we could still easily have an outcome, in which: $x_p^* = 0; \quad x_s^* > 0$.

Some supporters of close to unlimited private resource management control concede that Existence Value might matter, but argue that the social manager could, if necessary, deal with this, without having to resort to direct management controls, through the use of taxes, positive or negative. As Clark and Munro demonstrated, in a somewhat different context, some twenty-eight years ago, such indirect controls work effectively, if harvesting costs are sensitive to the size of x, but are essentially infeasible, if this sensitivity does not exist (Clark and Munro, 1980). The implications, with respect to the problem at hand, are obvious.

Now allow for non-convexities and the possibility that a positive MVP, x_1, exists. We could then argue that, in the limit, we would have $E'(x) = \infty$, not when $x \to 0$, but rather when $x \to x_1$. In essence, it can be said that, from the public perspective, extinction is intolerable.

More on Intrinsic Growth Rates

Given the fact that the 1973 Clark result cannot be safely dispensed with, intrinsic growth rates do matter, after all. In the case of fishery resources in which the intrinsic growth rate is high, we might safely go a long distance towards allowing extensive private resource management and control. In cases in which the intrinsic growth rate is low, much greater caution would be in order.

Due to FishBase, we now have available to us estimates of intrinsic growth rates of a wide variety of species. Consider the following selected examples.

Table 1. Intrinsic Growth Rate Estimates for Selected Fish Species.

Species	Estimated Intrinsic Growth Rate
Demersals	
Alaska pollock	0.10
Pacific cod	0.10
Pacific halibut	0.10
Pacific ocean perch	0.025
Orange roughy	0.025
Sablefish	0.025

Yellowtail flounder	0.23
Yellowtail sole	0.23
Pelagics	
Bigeye scad	0.75
Pacific bluefin tuna	0.10
Pacific herring	0.23
Sockeye salmon	0.23
Swordfish	0.10

Source: Froese and Pauly (2008).

On the basis of these estimates, one could be prepared to consider granting extensive private resource management and control to a resource such as bigeye scad. On the other hand, to allow unlimited private resource management and control to resources such as orange roughy and sablefish could be seen as acts of supreme folly.

Some Conclusions

We conclude first that the 1973 Clark result cannot be safely dismissed. There are a non-trivial number of resources that cannot be safely entrusted to complete private control and management. There are indeed limits to private resource ownership.

None of this, however, is meant to diminish the importance of, and benefits arising from, LAPPs. In cases in which the intrinsic growth rate of the fishery resource is low and in which there is not convincing evidence that the MSE perceived by the private sector is significant, LAPPs can be implemented, and some management power granted to the private sector. The ultimate management powers, however, must rest with the public sector.

A useful model is provided by another renewable resource close to the authors' home base, namely the commercially exploitable forest resources of British Columbia, 95 per cent of which are publicly owned. The government of British Columbia grants long term harvesting rights to tracts of forest lands to private companies. The companies are actually required by government to carry out extensive forest management functions. The ultimate forest management authority and control, however, rests with the government of British Columbia.

In applying this model to a fishery resource, also close to the authors' home base, we think of the British Columbia sablefish fishery. The fishery is managed under an ITQ scheme, which to date has produced excellent results. Furthermore, the ITQ holders have made significant contributions to resource management (Clark, Munro and Associates, forthcoming). We would argue that the ITQ scheme should be maintained and refined, but would also argue that the ultimate management control must rest with the public sector.

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[i] In other words, the social rate of discount is to be seen as reflecting the opportunity cost of investing in the resoruces. See also, Hannesson, 2008, n.1.
[ii] In the Clark model F(x) takes the following familiar functional form:

$$F(x) = rx\left[1 - \frac{x}{K}\right]$$

where r, a constant, is the intrinsic growth rate of the resource and K, a constant, is the carrying capacity of the resource. We thus have

$$\lim_{x \to 0} F'(x) = r .$$

[iii] A slightly stronger condition is that: $p \geq c(0)$; $\delta_p > 2F'(0)$.
[iv] Arnason's underlying model is an application of what we are referring to as the standard issue dynamic economic model of the fishery.
[v] Who is currently the Chief Scientist for the United Kingdom.
[vi] Proof: $PV_{sust} = pF(x^*)/\delta_p = pF(x^*)/F'(x^*) > px^* = PV_{ext}$.
[vii] There are many "externalities that one could bring into the discussion, such as biodiversity considerations, and the fact that no effective produced capital substitutes for the fishery natural capital may exist.
[viii] Except, if the relevant private sector group is a conservationist organization.
[ix] Convention on International Trade in Endangered Species of Wild Fauna and Flora (2008) http://www.cites.org
[x] See, as well: Clark, 1990, p. 65 and Shultz and Skonhoft (1996).
[xi] See n. 7.