Buyback Subsidies, the Time Consistency Problem, and the ITQ Alternative

Colin W. Clark, Gordon R. Munro, and Ussif Rashid Sumaila

ABSTRACT. *This paper deals with the time consistency problem associated with buyback schemes, arising from the fact that the schemes may be anticipated by vessel owners. After reviewing and elaborating upon the key results of our recently published article on buybacks and limited-entry programs, we discuss the consequences of combining buybacks with ITQ schemes, or the equivalent, instead of limited-entry programs. We conclude that substituting ITQ schemes for limited-entry programs cannot be relied upon to eliminate fully the time consistency problem. We suggest that what may be required is a management program that combines rights-based schemes with taxes.* (JEL Q22, Q28).

I. INTRODUCTION

While there is general agreement among fisheries economists concerning the impact upon resource management of most fisheries subsidies, this general agreement does not apply to the impact of subsidies used for buyback purposes. Some economists argue that buyback subsidies, by leading to the removal of economically wasteful and resource-threatening, excess-fleet capacity, make a positive contribution to resource management and conservation. Matteo Milazzo, for example, in his thorough, and wide ranging World Bank study on world fisheries subsidies, argues that "many commentators have noted how difficult it is to induce the exit of capital from fishing, because these assets … have little other use. … disinvestment in fisheries has to be actively promoted with … subsidies" (Milazzo 1998, 65). Milazzo thus concludes that decommissioning or buyback subsidies do indeed have a positive impact. (Milazzo 1998, 64–72).

Numerous other economists have argued against the usefulness of buyback subsidies, doing so largely in terms of efficacy. That is to say, they have argued that the subsidies are basically ineffective. Fleet capacity, upon being removed through buybacks, tends to seep back into the fishery (see, e.g., Holland, Gudmundsson, and Gates 1999). There is another round of economic waste, as yet more investment in excess fleet capacity occurs, and the threat to resource conservation, posed by excess capacity, reemerges (Weninger and McConnell 2000). Cunningham and Gréboval (2001) warn in a study prepared for the FAO that, while buyback schemes appear to offer an ideal way to reduce fleet capacity, resource managers must be certain not to introduce such schemes until the conditions necessary for ensuring the scheme's long-term effectiveness are in place.

This counterargument implies that, if the post buyback seepage of capacity back into the fishery can be blocked, the buyback subsidies could have a positive impact on resource management. Indeed, a panel on buyback programs at the International Institute of Fisheries Economics and Trade (IIFET) 2004 Japan Conference, concluded that "buybacks provide a viable option for management of fisheries," given that they are "used … as a part of a transition from an ineffective management regime to one

The authors are, respectively, professor emeritus, Department of Mathematics, University of British Columbia, Vancouver; professor emeritus, Department of Economics and Fisheries Centre, University of British Columbia, Vancouver; and director, Fisheries Economics Research Unit, Fisheries Centre, University of British Columbia, Vancouver. The authors wish to express their thanks to the Sea Around Us Project, Fisheries Centre, University of British Columbia for support, which is, in turn, sponsored by the Pew Charitable Trust of Philadelphia.

Land Economics • February 2007 • 83 (1): 50–58
ISSN 0023-7639; E-ISSN 1543-8325

that is more effective," that is, ... free of seepage of excess fleet capital back into the fishery (IIFET 2004).

What this implied claim ignores, however, is that there is a potential time consistency problem with seepage-free buyback schemes, arising from the fact that the schemes may be anticipated by vessel owners. The authors of this paper have now written several papers on this theme, the latest one of which recently appeared in the *Journal of Ecological Economics and Management (JEEM)* (Clark and Munro 2003; Clark, Munro, and Sumaila 2005; Munro and Sumaila 2002).

In the recent *JEEM* article, the authors conclude that the solution to the excess capacity problem may lie with taxes, a rights-based fisheries management system, such as ITQs, or some combination of the two. This claim is no more than conjecture, however, and is not explored in any detail.

In this paper, we shall review the key results of the recent *JEEM* article, and then go on to inquire whether or not the solution to the excess capacity problem lies with rights-based management systems alone. We shall conclude that even a rights-based management scheme may prove to be vulnerable to time consistency problems.

Our review of the key results of the *JEEM* article will be more than a mere summary. Since that article was finalized, the authors have come to realize that some of these key results can be made much more transparent, which we do in this paper.

II. BUYBACKS, LIMITED ENTRY, SUBSIDIES, AND THE TIME CONSISTENCY PROBLEM: A REVIEW

In providing a framework to the discussion to follow, we turn to the seminal 1977 *Journal of Political Economy* article, by Nobel Laureates Finn Kydland and Edward Prescott, in which the time consistency problem was first discussed, and consider their introductory, and simple, two-period model (Kydland and Prescott 1977). While the model that we shall review is a continuous time one, the Kydland and Prescott two-period model does in fact provide us with the added degree of transparency, to which we referred. The Kydland and Prescott (1977) article, it will be recalled, is particularly concerned with the limitations of optimal control theory in analyzing dynamic policy issues.

A policy, in each time period, is deemed by Kydland and Prescott to be consistent (in an optimal control context), if it maximizes the social objective function, taking as given the decisions made by the economic agents in previous time periods, and given that future policy decisions are arrived at in the same manner (Kydland and Prescott 1977, 475). Thus, in the introductory two-period example ($t = 1; 2$), the *consistent* policy set in $t = 2$ ignores the impact of that policy upon economic decisions made by the economic agents in $t = 1$. The consistent policy in $t = 2$ is optimal, the authors conclude, only if the period 2 policy has a zero impact upon the decisions made by the economic agents in period 1 (or, if the direct and indirect effects upon the social objective function of changes in the economic agents' decisions in period 1, induced by the policy changes in period 2, are zero) (Kydland and Prescott 1977, 476). If expectations of the economic agents are rational, such that the economic agents in $t = 1$ anticipate the policy decisions made in $t = 2$, then we can look forward, with some confidence, to the period 2 time-consistent policy being decidedly sub-optimal. The essence of the time consistency problem is captured in the following quotes: "there is no mechanism to induce future policy makers to take into consideration the effect of their policy, via the expectations mechanism, upon current decisions of [economic] agents" (Kydland and Prescott 1977, 481), which does, in turn, lead to the general conclusion that the "time consistent policy rule is not [the] best" (Prescott 2004).

Turning now to the aforementioned recent *JEEM* article, we take, as our example, a hitherto unexploited fishery resource, which is now, for whatever reason, open to exploitation. Initially, the fishery is a pure open-access one, subject to no, or wholly ineffective, harvest regulations. Over-exploitation of the resource, as to be expected, occurs. After the pure open-access fishery has achieved an equilibrium, the resource managers intervene with a vigorous limited-entry management regime, designed to rebuild the resource to an optimal level, and to rid the fishery of any "excess" fleet capacity.

The claim made by Milazzo (1998) and others that a government sponsored buy-back program is necessary to get such a resource rebuilding program underway rests upon the argument that vessel (and human) capital in the fishery is less than perfectly malleable. Since the vessels have few, if any, other uses, vessel owners will have to be bribed to leave the fishery, if fleet harvests are to be reduced and unwanted vessel capital removed.

In light of the importance of non-malleable vessel capital to the issue at hand, we introduce the following model, based upon Clark, Clarke, and Munro (1979) and McKelvey (1985, 1987), which addresses the issue of non-malleable vessel capital head on.

The model equations are as follows:

$$\frac{dx}{dt} = F(x) - qEx \qquad [1]$$

$$0 \leq E(t) \leq K \qquad [2]$$

$$\frac{dK}{dt} = I - \gamma K \qquad [3]$$

$$\pi = (pqx - c)E - c_f(I), \qquad [4]$$

where x denotes the biomass, $F(x)$ the natural rate of growth of the biomass, E is the rate of fishing effort, q the catchability coefficient, and K denotes the stock of fleet capital measured in terms of "standardized" vessels. The variable I denotes the rate of investment in fleet capital and γ the rate of depreciation of such capital. The price of harvested fish is denoted by p, while c denotes unit operating costs, both of which are assumed to be constant.

Net revenue flow $\pi(t)$ consists of net operating revenue $(pqx - c)E(t)$ minus investment costs $c_f(I)$. It is assumed that

$$c_f(I) = \begin{cases} c_1 I & \text{if } I > 0 \\ c_s I & \text{if } I < 0 \end{cases} \qquad [5]$$

(and $c_f(0) = 0$). Here c_1 is the unit purchase cost of capital, that is, the cost of one vessel, and c_s is the scrap, or resale, value of one vessel.

Vessel capital is deemed to be perfectly malleable if $c_1 = c_s$, perfectly non-malleable if $c_s = 0 = \gamma$; and quasi-malleable if $\gamma > 0$, or $0 < c_s < c_1$. For ease of exposition, the authors assume that vessel capital is perfectly non-malleable. Given this assumption, they are able to assume further that: $0 < I(t) \leq +\infty$. The case $I(t) = +\infty$ allows for a possible instantaneous jump in K.

Next, we assume that all other inputs, for example, labor, are perfectly malleable. Finally, we assume as well, that vessels in the fleet are identical with respect to cost and crews.

Denote the initial, virgin, biomass, $x(0)$, as x_0. Once exploitation commences, x will fall below x_0. We show that the biomass cannot fall below the biomass level, denoted as x_a^0, at which net operating revenue is zero. For reference purposes, we point to a second biomass level, x_b^0, which would be the pure open access level, if vessel capital were perfectly malleable. The biomass level, x^e, is simply the Bionomic Equilibrium, familiar from the standard economic literature (see Gordon 1954).

The authors assume that $x_0 > x_b^0$ (otherwise there would not be a viable fishery), and that p, c, c_1 are such that the pure open access equilibrium biomass level, x^e, lies between x_a^0 and x_b^0.

Investment in K, at $t = 0$, occurs instantaneously. Since $c_s = \gamma = 0$, the only costs relevant to vessel owners, once investment in vessel capacity takes place, are operating costs. The vessels will be fully utilized, $E(t) = K(t)$, so long as net operating revenues are positive. It will be recalled that we introduce assumptions, which ensure that x_a^0 will never be achieved.

What will be the extent of investment in vessel capital at $t = 0$, $K(0) = K^0$? This will depend critically upon vessel owner expectations. Since vessel capital is perfectly non-malleable, would-be investors in vessels have no choice but to attempt to forecast future profits from the fishery. Berck and Perloff (1984), were the first to introduce the concept of rational expectations into fisheries economics. We adopt the Berck and Perloff definition of rational expectations—perfect foresight—and the Berck and Perloff definition of the polar opposite, myopic (adaptive) expectations, which depend only upon past and current events. It is assumed that investors' expectations about fish population dynamics, and about the total number of vessels entering the fishery, are rational in the Berck and Perloff sense.

The next question is how investors' expectations regarding resource managers' policy are formed. It does seem contradictory to suppose that vessel owners' expectations pertaining to resource managers' policy could possibly be myopic. It may be, however, that the resource managers are so successful in concealing their intentions about future policy that the vessel owners then have nothing to go on, other than past and current policy.

In any event, we first assume that vessel owners' expectations, with respect to the resource managers' policy, are indeed myopic. Once investment in vessel capital is made at $t = 0$, $K(0) = K^0$, the resource will decline to a pure open access equilibrium level, $x_a^0 < x^e <_b^0$ and the fleet will be used to capacity, $E(t) = K(t)$, for all $t > 0$. Since there has been no intervention by resource managers in the past, the total present value of these operating profits will be perceived by vessel owners as being

$$PV(x_0, K^0) = \int_0^\infty e^{-\delta t}\{pqx(t) - c\}E(t)dt, \qquad [6]$$

where $x(t)$ and $E(t)$ are as specified above, for all $t > 0$.

Since it is assumed that the vessels and crews are identical in all respects, an owner of a single vessel will anticipate receiving an average share of the present value, equation [6], that is, the total present value of operating profits divided by the number of vessels, K^0. Thus, we can argue that investment in fleet capital will proceed up to the point that

$$c_1 K^0 = PV(x_0, K^0). \qquad [7]$$

It is now supposed that at $t = \theta > 0$ a point in time well after x^e is achieved, the fisheries authorities intervene with a vigorous limited-entry management program. Since the vessel owners' expectations regarding resource managers' policy have been myopic, the vessel owners are completely taken by surprise. The resource managers deem the present situation to be undesirable, and set a new target stock level $x_{opt} > x^e$, and a corresponding optimal fleet capital stock K_{opt} that would allow harvesting at x_{opt} to be undertaken on a sustainable basis, with no idle capacity. Harvesting has to be reduced temporarily, and the amount of vessel capital devoted to harvesting has to be reduced permanently. Vessel owners, however, who are just breaking even under current conditions, and who have no alternative fishing opportunities, put up intense, and politically effective, resistance. Unless the resistance can be overcome, the resource management program will be stymied.

The resource managers respond by introducing a subsidized buyback program to remove $K^0 - K_{opt}$ from the fleet, an action that is also unanticipated by the vessel owners. Subsequently, with $E = K_{opt}$, the resource rebuilds gradually to x_{opt}. Finally, the fisheries authorities respond to the Cunningham and Gréboval (2001) admonitions with great seriousness. There is no seepage whatsoever of vessel capital back into the fishery, so that the stock of fleet capital remains at $K = K_{opt}$ forever.

The buyback subsidies are indeed conservationist in nature. They have had the effect of removing a critical barrier to resource stock recovery. The fishery will, once x_{opt} is achieved, enjoy unending prosperity. There is no time consistency problem, since the buyback policy has no impact upon the decisions of vessel owners in periods preceding the buyback. It can indeed be said that the buybacks have provided a viable option for management, in being employed as a part of a transition from an ineffective management regime to one that is more effective.

We then introduce a second, alternative, scenario, in which the expectations of the vessel owners, with respect to resource managers' policies, are rational. The vessel owners anticipate fully the resource managers' intervention and buyback program. For ongoing ease of exposition, the authors assume that, at the time of the buyback program, only vessel owners who entered the fishery no later than $t = 0$, will be eligible for the program. They also assume, as in the first scenario, that the program is introduced, at $t = \theta > 0$, a time far enough in the future to ensure that the program is introduced, after the original open access equilibrium has been achieved.

What then will be the investment in fleet capacity at $t = 0$? To answer this question, we first note that the present value of the post buyback fleet operating profits, discounted back to $t = \theta$, can be expressed as

$$PV_1(K_{opt}) = \int_{\theta}^{\infty} e^{-\delta(t-\theta)}(pqx(t) - c)E(t)dt, \quad [8]$$

where $E(t) = K_{opt}$.

Since no vessel owner, who can do better by remaining in the fleet, will sell out, it is assumed that, at $t = 0$, a buyback price of not less than $PV_1(K_{opt})/K_{opt}$ must be offered. It is assumed that this price, $c_2 = PV_1(K_{opt})/K_{opt}$, is in fact sufficient to achieve the desired result. Observe that those who sell out at $t = 0$, and those who remain in the fleet, will receive the same reward.

Under this second scenario, investment in K at $t = 0$ is denoted as K_1^0, which will be determined by

$$c_1K_1^0 = \int_0^{\theta} e^{-\delta t}(pqx(t) - c)E(t)dt + e^{-\delta\theta}c_2K_1^0, \quad [9]$$

(where $E = K_1^0$ for $0 \le t \le \theta$) provided this equation has a solution K_1^0.

Note that equation [9] can be rewritten as

$$c_3 = \frac{\int_0^{\theta} e^{-\delta t}(pqx(t) - c)E(t)dt}{K_1^0}, \quad [10]$$

where

$$c_3 = c_1 - e^{-\delta\theta}c_2. \quad [11]$$

Thus, under rational expectations pertaining to resource managers' policy, the anticipated buybacks constitute a subsidy to vessel owners at $t = 0$. For our purposes in this paper, we shall assume $c_3 > 0$. In the recent *JEEM* article, however, we were at some pains to point out that there is no guarantee that c_3 will be positive.

Investment in K, at $t = 0$, and the initial depletion of the resource, will be greater than they would be under myopic expectations. Surely, however, this does not really matter, since after the buyback, the resource will be restored to x_{opt} and the fishery will be prosperous forevermore.

In fact, the investment in vessel capital stimulated by rational expectations does indeed matter, in economic terms. The *post* $t = \theta$, ever prosperous, fishery is something of a snare and a delusion.

Consider the following. The Net Present Value (Net PV) of revenue flows from the fishery, $t = 0$ to $t = \infty$, is just the PV of operating profits, minus the cost of vessel capital incurred at $t = 0$. If the fishery had remained a pure open access one from $t = 0$ onwards, with no buyback program, the Net PV of the fishery would be given by equation [6]—that is, zero, just as the received theory would predict.

Note that, from the previous discussion, the present value of the net operating profits from the ever prosperous post buyback fishery, discounted back to $t = 0$, can be expressed simply as $e^{-\delta\theta}c_2K_{opt}$ (see equations [8] and [9]).

The present value of net operating profits from the fishery, from $t = 0$ to $t = \infty$, discounted back to t = 0, PV', is thus given by the following equation:

$$PV' = \int_0^{\theta} e^{-\delta t}(pqx(t) - c)E(t)dt + e^{-\delta\theta}c_2K_{opt}, \quad [12]$$

where $E = K_1^0$ for $0 \leq t \leq \theta$.

Investment in K_1^0, at $t = 0$, is given by equation [9]. A comparison of equation [9] and equation [12] makes it obvious that

$$PV' - c_1K_1^0 < 0. \quad [13]$$

The Net PV of revenue flows from the fishery ($t = 0$ to $t = \infty$) is *negative*. The net operating profits from the fishery, ever prosperous after $t = \theta$, are more than offset by wasted investment in fleet capacity at $t = 0$. The problem is, of course, that rational investors in vessel capital at $t = 0$ are taking into account, not just the pre- and post-buyback operating profits from the fishery, but also the buyback subsidies themselves. A policy of non-intervention in the fishery, bad as it is, is superior to the interventionist policy, when rational expectations exist.

We now note the following point, which was ignored in the our *JEEM* article. While the model reviewed is a continuous time one, there are, given the assumptions adopted, two, and only two, critical points in time, namely $t = 0$ and $t = \theta$. Consequently, results described are all but indentical to the key result of the Kydland and Prescott (1977) introductory two-period model. In that two-period model, the fundamental question is whether policy measures introduced in period $t = 2$ do, or do not, have an impact on the decisions made by economic agents in period $t = 1$.

In the model just discussed, the fundamental question is whether the introduction of the buyback scheme at $t = \theta$ does, or does not, have an impact upon the investment decisions of vessel owners at $t = 0$. If the answer is that, yes it does, then we are confronted with an unambiguous time consistency problem.

As a further comment, we now acknowledge that, when we argued in the *JEEM* article that the buyback scheme introduced at $t = \theta$ could result in the Net PV of revenue flows from the fishery being negative, we *understated* the inferiority of the interventionist policy described. We ignored the additional administrative costs imposed upon society by the intervenionist policy, implicitly assuming that these additional costs would be zero. We now readily admit that this implicit assumption is too strong.

III. THE ITQ ALTERNATIVE

Let us now consider the alternative of a rights-based mechanism, as exemplified by an ITQ scheme. We return to our example of a hitherto virgin fishery resource opened for exploitation. It will be assumed that, when the vigorous management program is implemented, an ITQ, as opposed to a limited-entry scheme, is put in place. It may be that the resource managers are more certain of seepage being blocked under an ITQ scheme, than they are of it being blocked under a limited-entry scheme.

We shall assume that, when put in place, the ITQ scheme works flawlessly. The ITQs are permanent in duration, and are expressed as percentages of the TAC. The ITQ holders, we shall further suppose, coalesce and act like a corporation. Finally, assume that the discount rate employed by the ITQ "corporation" is the same as the social discount rate. If the ITQ scheme is fully implemented the moment that the fishery resource is opened to exploitation, then all should be well. There is no good reason why excess capacity should emerge, in the first place.

Suppose on the other hand, that the ITQ scheme is put in place only after a delay. Suppose that, as in Part 2, the fishery is initially a pure open-access one, and then becomes subject to a vigorous management regime. Then the outcome is much less clear.

If the vessel owners are myopic, with respect to the resource managers' policy, then the ITQ scheme should be successful, regardless of whether the resource managers do, or do not, accompany the ITQ scheme with a buyback program. But then, a buyback/limited entry program, free of seepage would also be successful when confronted with myopic vessel owners.

Next, suppose that the vessel owners' expectations regarding resource managers' policies are rational, and consider the following two cases. For both cases, we shall assume that the resource managers make no attempt, through taxes, or other means, to force ITQ holders to cover resource management costs, let alone to capture some part of the resource rent. We shall also assume that, similar to the previous buyback/limited-entry programs, the ITQ scheme is implemented at $t = \theta$.

ITQ Scheme Accompanied by a Buyback Program

In this first case, we shall suppose that the resource managers introduce a buyback program at $t = \theta$ designed to reduce K to K_{opt}, in order to put the ITQ scheme on a "proper footing." We encounter exactly the same time consistency problem that we did with the buyback/limited entry program, in the face of vessel owner rational expectations. Investment in vessel capital will be given by equation [9] with all that that implies. In economic terms, society would be better off, if the resource managers had not intervened, and had simply allowed the pure open-access fishery to run its course.

ITQ Scheme Unaccompanied by a Buyback Program

In this second case, the resource managers do away with the government-supported buyback program entirely. The ITQ holders (the industry) must deal with the problem of excess capacity on their own. We shall suppose that the perfect ITQ "corporation" ensures that from $t = \theta$, onwards only K_{opt} is employed in the fishery. The "corporation" "mothballs," or in some fashion disposes of the excess vessel capital—without cost, we shall suppose.

Denote the investment in vessel capital at $t = 0$ as K_2^0. The present value of operating profits from the fishery (ignoring post ITQ management costs), discounted back to $t = 0$, PV'', can be expressed simply as follows

$$PV'' = \int_0^\infty e^{-\delta t}(pqx(t) - c)E(t)dt, \qquad [14]$$

where $E = K_2^0$ for $0 \leq t \leq \theta$; and $E = K_{opt}$ for $\theta \leq t \leq \infty$.

Investment in vessel capital at $t = 0$ will be given by

$$c_1 K_2^0 = \int_0^\infty e^{-\delta t}(pqx(t) - c)E(t)dt \qquad [15]$$

$$\left(E = K_2^0 \text{ for } 0 \leq t \leq \theta;\ E = K_{opt} \text{ for } \theta \leq t \leq \infty\right).$$

The Net PV from the fishery will thus equal zero. The resource rents forthcoming from the perfect ITQ scheme will be dissipated by excess investment in vessel capital at $t = 0$. This is a better outcome than Case A, but no better than a non-interventionist, pure open-access fishery.

The discussion of Case B, up to this point, has ignored management costs under the ITQ regime. If the management costs are positive (how could they be otherwise?), the Net PV from the fishery (discounted back to $t = 0$) will in fact be negative, unless the resource managers diverge from their no tax policy to the extent of recovering the management costs from the industry.

In any event, the introduction of ITQ schemes provides no assurance of escape from the time consistency problem. On the contrary, the problem can arise, even if the resource managers decree that industry must deal with any excess vessel capacity present in the fishery.

What then is to be done? At this point, we have no definitive answer. One possible solution that we put forth for consideration and future research is to accompany the ITQ scheme with a resource rent extracting tax, or the equivalent. The case for accompanying ITQ schemes with resource rent extracting taxes has often been made on equity grounds (see Macinko and Bromley 2002; Clark 2006). Here we are suggesting that a case can be made on management grounds, as well.

With respect to resource management, there has, in recent years, been considerable debate on taxes as an alternative to ITQs (see, e.g., Hannesson and Kennedy 2004; Weitzman 2002). We have no wish to enter this debate, other than to state that it should not be cast in either or terms. In instances where, for whatever reason, taxes alone are deemed not to constitute an adequate management tool, then one should, for management purposes, consider ITQs (or some other rights-based mechanism) in combination with taxes (or the equivalent).

In any event, in putting forward our suggested solution for further discussion, we would note that, while the idea of combining taxes and ITQs for management purposes may be new to fisheries (at least to the best of our knowledge), the idea is far from new in the environmental economics literature, where quotas take the form of pollution permits. The idea dates back some 30 years (see, for example: Roberts and Spence 1976).

IV. CONCLUSION

Rational expectations on the part of investors in vessel capital, can lead to a time consistency problem in both buyback/limited entry schemes, and buyback/ITQ (or other rights based) schemes. Indeed, such expectations can result in a time consistency problems emerging, even in ITQ schemes, in which the resource managers eschew any form of government buyback subsidies.

We concede that we have made some apparently extreme assumptions, in that we allow for perfect foresight and perfectly non-malleable vessel capital. We would assert, however, that the points remain in a world of quasi-malleable capital, and uncertainty.

One quick test of our assertion is to ask, whether there is any empirical evidence from the real world, of uncertainty and quasi-malleable vessel capital, of the type of time consistency problem that we have described. The answer is yes, at least with respect to buybacks and limitations on entry. In a 1999 empirical study, the Danish economists, Jörgensen and Jensen conclude that buyback subsidies in EU fisheries do indeed stimulate investment in fleet capacity. The anticipation of future subsidies, not only has the effect of encouraging directly vessel owners to invest, but also causes the vessel owners' bankers to look more kindly upon requests for loans for vessel construction purposes (Jörgensen and Jensen 1999).

As a final comment, we would say that, if some of our assumptions appear to be extreme, the counter-assumption, namely that vessel owners' expectations regarding resource management policies are myopic, strains one's credulity to the breaking point.

References

Berck, P., and J. M. Perloff. 1984. "An Open Access Fishery with Rational Expectations." *Econometrica* 52 (2): 489–506.

Clark, C. W. 2006. *The Worldwide Crises in Fisheries: Economic Models and Homan Behavior*. New York: Cambridge University Press.

Clark, C. W., and G. R. Munro. 2003. "Fishing Capacity and Resource Management Objectives." In *Measuring Capacity in Fisheries*, ed. S. Pascoe and D. Gréboval, 13–34. FAO Fisheries Technical Paper 445. Rome: Food and Agriculture Organization of the United Nations.

Clark, C. W., F. H. Clarke, and G. R. Munro. 1979. "The Optimal Management of Renewable Resource Stocks: Problems of Irreversible Investment." *Econometrica* 47 (1): 25–47.

Clark, C. W., G. R. Munro, and U. R. Sumaila. 2005. "Subsidies, Buybacks and Sustainable Fisheries." *Journal of Enviromental Economics and. Management* 50 (1): 47–58.

Cunningham, S., and D. Gréboval. 2001. "Managing Fishing Capacity: A Review of Policy and Technical Issues." FAO Fisheries Technical Paper 409. Rome: Food and Agriculture Organization of the United Nations.

Gordon, H. S. 1954. "The Economic Theory of a Common Property Resource: The Fishery." *Journal of Political Economy* 62 (2): 124–42.

Hannesson, R., and J. Kennedy. 2004. "Landing Fees versus Fish Quotas." In *IIFET, Proceedings of the Twelfth Biennial Conference of IIFET: What Are Responsible Fisheries?* Corvallis, Ore: IIFET.

Holland, D., E. Gudmundsson, and J. Gates. 1999. "Do Fishing Vessel Buyback Programs Work:

A Survey of the Evidence." *Marine Policy* 23 (1): 47–69.

International Institute of Fisheries Economics and Trade (IIFET). 2004. "Special Session 3: Capacity Reduction Through 'Buyback' Programs with Special Reference to Experiences Throughout the World: Past Present and Future." In *Proceedings of the Twelfth Biennial Conference of IIFET: What are Responsible Fisheries?* Corvallis, Ore: IIFET.

Jörgensen, H., and C. Jensen. 1999. "Overcapacity, Subsidies and Local Stability." In *Overcapacity, Overcapitalisation in European Fisheries*, ed. A. Hatcher and K. Robinson. Portsmouth, U.K.: Centre for the Economics and Management of Aquatic Resources, University of Portsmouth.

Kydland, F. E., and E. C. Prescott. 1977. "Rules Rather than Discretion: The Inconsistency of Optimal Plans." *Journal of Political Economy* 85 (3): 473–91.

Macinko, S., and D. W. Bromley. 2002. *Who Owns America's Fisheries?* Washington, D.C.: Island Press.

McKelvey, R. 1985. "Decentralized Regulation of a Common Property Resource Industry with Irreversible Investment." *Journal of Environmental Economics and Management* 12 (4): 287–307.

———. 1987. "Fur Seal and the Blue Whale: The Economics of Extinction." In *Applications of Control Theory in Ecology*, 57–82. ed. Y. Cohen. Berlin: Springer-Verlag.

M. J. Milazzo. 1998. "Subsidies in World Fisheries: A Re-examination." World Bank Technical Paper No. 406, Fisheries Series. Washington, D.C.: World Bank.

Munro, G. R., and U. R. Sumaila. 2002. "The Impact of Subsidies upon Fisheries Management and Sustainability: The Case of the North Atlantic." *Fish and Fisheries* 3 (4): 233–50.

Prescott, E. C. 2004. "The Transformation of Macroeconomic Policy and Research: 2004 Nobel Address in Economics." http://nobelprize.org/economics/laureates/2004/prescott-lecture.html.

Roberts, M. J., and M. Spence. 1976. "Effluent Charges and Licenses under Uncertainty." *Journal of Public Economics* 5 (3–4): 193–208.

Weitzman, M. L. 2002. "Landing Fees vs. Harvest Quotas with Uncertain Fish Stocks." *Journal of Environmental Economics and Management* 43 (2): 325–38.

Weninger, Q., and K. E. McConnell. 2000. "Buyback Programs in Commercial Fisheries: Efficiency versus Transfers." *Canadian Journal of Economics* 33 (2): 394–412.