Income subsidies and incentives to overfish

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Abstract. Using a two-stage harvesting game, I model the political and economic incentives to overfish in a regulated, restricted access common property fishery with income supplements. As variable fishing effort is regulated and effort caps appear to be binding, I argue that social choice of political lobbying effort becomes the principal choice variable by which commercial fishermen continue to press for additional fishing opportunities relative to the regulator's desired catch target.

The model helps explain recent fish stock collapses. The analysis also questions the appropriateness of continuing the fishing category of Canadian employment insurance as the regulator embraces a precautionary, risk averse approach to fisheries management.

Keywords: Bioeconomic modelling, Common property, Rent-seeking, Fishery regulations, Bio-diversity, Canada.

INTRODUCTION

Many of the world's commercial fisheries are in decline, if they have not already collapsed[1]. The Canadian federal government closed the Newfoundland northern cod fishery between 1992 and 1999 and has all but shutdown the commercial Pacific salmon fishery off the coast of British Columbia in the summers of 1998 and 1999. Altogether, these closures have cost the federal government billions of dollars in temporary assistance to unemployed fishermen. Although it is well recognized that public subsidies have exacerbated overfishing problems that characterize common property fisheries, the reforms to Canada's unemployment insurance implemented in 1997 failed to remove fishermen income subsidies and managed to make them only less generous. Curiously, the Liberal government scaled back the generosity of the fishing category of unemployment insurance because of equity considerations (Gislason, et al., 1998), and not because of any efficiency or ecological considerations.

In this paper, I explore how the Canadian unemployment insurance programmes have contributed to private and social incentives to expand fishing effort. I argue that in the context of a regulated restricted access commons fishery, collective political action rather than individual fishing effort drives any overfishing and further exacerbates the rent dissipation outcomes that are commonly observed. My intent is to demonstrate how the synergy of separate public programmes can result in large private benefits if fishing effort can expand. To the extent that biodiversity and natural existence are valuable, how do public programmes, perhaps unwittingly, create incentives to overfish and risk stock collapses? I argue that effort caps in the form of tight time and area closures when set near or below the number of weeks necessary to qualify for Unemployment Insurance (UI), create large marginal political net benefits from expanded effort caps[2].

Institutional reform such as the creation of individual and transferable quotas (ITQs) or some variant will not necessarily solve the problems of some restricted access fisheries such as the British Columbia (BC) commercial Pacific salmon fishery (Copes, 1996). That is why it is important to study and understand the incentive structure under this institutional arrangement and try to do the best we can given the incentive problems caused by ambiguous property rights[3].

WHAT WE KNOW

A number of static and dynamic equilibrium fishing models have enjoyed considerable success in offering plausible explanations as to why open access fisheries are overfished or might even result in extinction[4]. Typically,

[1] See *inter alia* Safina (1995).

[2] Area closures will reduce or eliminate time spent fishing depending on the relative importance.

[3] The Canadian UI scheme may be unique. Readers should find the modelling framework sufficiently sparse and accessible so as to facilitate applications to other tax or subsidy programs, within a regulated, restricted access fishery.

[4] Munro (1982) and Hartwick and Olewiler (1998) provide excellent overviews. Clark (1990) provides a thorough treatment of dynamic or capital-theoretic

entry occurs in an open access fishery until all private rents are dissipated. This social waste may also be accompanied by biological overfishing or even commercial extinction in the context of depensatory stock effects. In contrast, a sole-owner fishery maximizes rent and under most sets of assumptions never exceeds the maximum sustainable yield (MSY) harvest in the context of a static equilibrium. In dynamic equilibrium models, relatively high discount rates can induce rational individuals to harvest to the point of commercial if not biological extinction (Clark, 1990).

An income subsidy such as seasonal unemployment insurance benefits will clearly provide incentives to expand fishing effort in an open access fishery[5]. In the beginning of the programme, fishermen will initially benefit from quasi-rents akin to a windfall; however, overtime we would expect positive net additions to fishing capacity to drive UI-origin rents to zero[6].

There are several potential shortcomings with these models. Analogous to commonly cited limitations of standard neo-classical economic theory, somewhere between perfect competition (open access fishery), and pure monopoly (sole-owner fishery), lies the messy real world. Real fisheries contain virtually no examples of pure open access or rent-maximizing conditions[7]. Most open access fisheries are regulated; the vast majority is subject to some kind of restricted access. Furthermore, practitioners generally restrict the traditional models to solve fishing effort or capacity within standard economic markets for output and inputs. As any veteran observer will testify, commercial fishermen can constitute a formidable political lobby with considerable ability to influence policy and extract rents from the state[8]. In this respect, this paper attempts to contribute to the understanding of regulated, restricted access commons fisheries by developing a simple, institutionally realistic model based on individual fishermen behaviour that explicitly takes into account the political dimension.

Numerous economic fields and other social science disciplines have intensively studied common property regimes. Regulated, restricted access fisheries have, however, received modest attention by fishery economists, perhaps because of the idiosyncratic nature of jurisdiction-specific rules. Clarke (1980) and Wilen (1985) employ game-theoretic analyses with Nash equilibria similar to the approach that I use in this paper. Both papers predict the dissipation of all rents in the long

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models.

[5] I suspect many fishery experts and economists share Schrank's (1998, p. 80) view that

"By encouraging fishermen to remain in the industry, unemployment insurance, implemented as a fishermen's subsidy, and intended as the solution to a short term political problem, became the single greatest hindrance to the long term adjustment of Canada's Atlantic fishery into a commercially viable industry".

[6] Quasi-rents are rates of return above factor market rates (or opportunity costs) earned temporarily. Ferris and Plourde (1982) provide weak econometric evidence that UI resulted in an increase in the size of the Newfoundland inshore fleet and rent dissipation overtime.

[7] Some quota fisheries may come close to maximizing rent. One way quota owners could maximize rent would be to form a co-operative and harvest co-operatively to minimize transaction costs, fully exploit cost sub-additivities, etc.

[8] The strength and influence of commercial fishermen and their ability to intimidate federal bureaucrats was widely recognized. The Pearse Commission report states that:

"Working with insufficient knowledge of stock sizes and population dynamics, under heavy pressure from competing groups of fishermen, and with inadequate control over fishing activity, management has in many respects been reduced to a series of desperate attempts to meet the demands of vocal user groups without visibly destroying the resource. This is acknowedged by the Department:

'In the past, escapement targets have often been compromised on the basis of compelling social considerations… or because of run failure.' …." (Pearse, 1982, p. 37).

Socio-political considerations appear to have delayed necessary reductions in northern cod harvests off Newfoundland that might have prevented the need for the closure of the fishery in 1992, as well as render unnecessary the generous income maintenance programmes that followed. In his memoirs, former influential conservative cabinet minister John Crosbie from Newfoundland gives a fascinating account of the politics of fishery management and the pressures he endured to keep total allowable catches (TAC) as high as possible in spite of learned advice to the contrary (Crosbie, 1997). As minister of fisheries, Crosbie imposed a moratorium on collapsed northern cod stocks in July 1992 that would last until 1999.

run through fishing capacity increases on unregulated margins, although it is clear that quasi-rents can be earned in the short-term. Clarke (1980) shows that a limited-entry regime combined with total quota management would result in positive albeit sub-optimal rents approaching zero as the number of fishing vessels increases[9].

Several authors have reviewed work on regulated restricted access fisheries and discussed policy implications[10]. To my knowledge, none of this or other theoretical work has analyzed the synergy of income subsidies and binding time and area closures.

UNEMPLOYMENT INSURANCE

The Canadian government first implemented an unemployment insurance (UI) programme in 1941 that covered less than half of Canadian workers. Overtime more and more workers were added. In 1957, the government added fishermen to the programme, ostensibly in an attempt to secure support for weak Liberal Party candidates in Newfoundland during the 1957 federal election (Schrank, 1998, Lund, 1995). Fishermen are the only self-employed workers to qualify for UI benefits. Similar to the case of other workers, who seasonally cycle in and out of unemployment insurance on a regular basis, the UI programme is best characterized as a pure income supplement, augmentation or subsidy programme. Insurance is a misnomer to the extent that insurance premiums are usually paid to avoid a risky outcome[11]. In this case, fishermen anticipate seasonal unemployment UI benefits and qualifying hurdles with something close to absolute certainty.

Eligibility requirements as well as the generosity of payments have varied over the years[12]. Self-employed fishermen, partners and sharemen (crew that share the catch) or co-adventurers are eligible. Virtually all claims are seasonal and run for a maximum of 27 weeks, beginning on either May 1 or November 1. Typically under the UI system an individual needs 10 weeks of insurable earnings to qualify of which six must be from fishing.

Insurable earnings are based on the landed value of catch minus 25 per cent of that gross income. The minimum value of catch is 20 per cent of the maximum insurable earnings, which in 1994 were $156 and $780 per week respectively. The "employer" is usually the buyer of the catch. Fishing claimants may average gross returns over the total number of weeks as long as at least 15 hours a week was spent in fishing-related activities. Fishermen and fish buyers equally share the cost of premiums. Deck hands employed on fishing vessels owned by incorporated enterprises can claim regular category UI benefits.

UI significance in fisher total income

The importance of UI income to the total income of fishermen varies considerably among individuals, but fishing UI benefits constitute a significant portion of income. Once sufficient weeks are worked, a fisherman qualifies for a lump sum payment that amounted to on average roughly 25 per cent of total labour income (crew wages, vessel owner returns and UI payments) for BC commercial fishermen in the 1988-1994 period (Schwindt *et al.*, 2000)[13].

In the Canadian Atlantic provinces, self-employed fishing families who derived more than 50 per cent of their income from fishing in 1990 enjoyed an average income of $31,903 and UI benefits of $9,580 (May and Hollett, 1995). Dependency on UI fishing benefits in 1992 varied from close to 80 per cent of total family income for those earning between $10,000 and $15,000 per year to 17 per cent for those earning more than $80,000 per year.

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[9] Although Clark (1980) casts his model in a dynamic setting; we should find the same results with a static model. This seems to fit the observed data well. The BC salmon fishery does appears to extinguish economic wealth in aggregate, yet BC fishermen generally earn private rents (Schwindt, 1995, Schwindt *et al*., 2000). See also Dupont (1990) who estimates large negative rents for the BC Salmon fishery but does not distinguish between public or private rents.

[10] See Dupont (1996), Fraser (1979), Townsend (1990) and Wilen (1988).

[11] Curiously, the government persists in presenting the fishing category programme as "insurance" suggesting that the two week waiting period prior to receiving benefits corresponds to the deductible of an insurance policy (Human Development and Resources Canada, Employment Insurance and fishing, 2000b).

[12] The following information on elegibility comes from May and Hollett (1995). See also Roy (1998) for detailed information.

[13] Gislason *et al.* (1998) report that UI payments represented a 70 per cent top up of fishing earnings or 21 per cent of all income sources for the average self-employed BC fisher in 1993. In the same year, net fishing revenues accounted for 36 per cent of income. The average income for all fishers from all sources was $26,150.

Average UI benefits per family increase steadily as total family income increases.

In BC, the benefit/contribution ratio varied between less than 7:1 to over 14:1 between 1977 and 1996 (see figure 1). Average benefit/contribution ratios for the fishing category Canada wide were slightly higher.

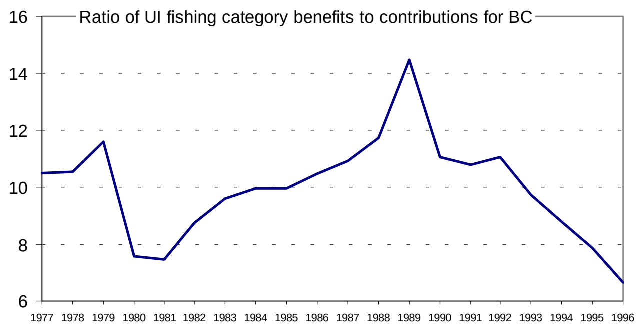

Figure 1

Source: Human Development and Resources Canada

The following graph shows net benefits and contributions over the same period (see figure 2).

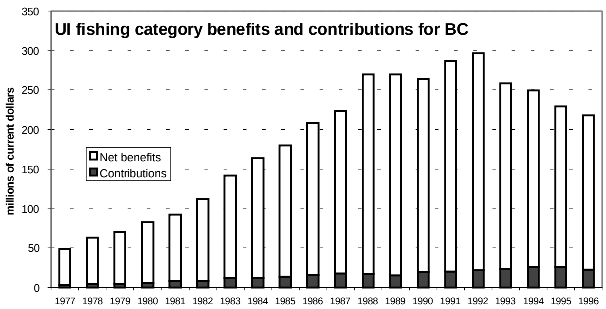

Figure 2

Source: Human Development and Resources Canada

There is no doubt that UI contributed substantially to additional entry and overcapacity in Canadian fisheries. The number of fishermen in Newfoundland increased to 22,615 in 1964 from 14,956 at the beginning of the programme and later increased to over 35,000 in 1980 (Lund, 1995).

Stamp fisheries

In the case of the BC salmon fishery, Fisheries and Oceans Canada (FOC) made use of increasingly tight time openings to offset increases in fleet catching power[14]. Often, this did not permit all fishermen to qualify for UI benefits and so in cooperation with fishermen, FOC officials would open "stamp fisheries", short opening fisheries usually in the autumn, so fishermen could work additional weeks to qualify for UI. Anecdotal evidence suggests that managers were quite pleased if they could accommodate the fishermen. Sometimes the fishermen set nets in areas with few, if any fish (Hilborn and Walters, 1992); other times they targeted low value chum salmon in a fishery that intercepted high value and relatively scarce steelhead as by-catch.

THE MODELS

I employ a micro-theoretic version of a simple Gordon-Schaeffer, static equilibrium, bioeconomic model as the base model to illustrate the story of significant marginal benefits to politically loosening fishing effort caps. The logistic-growth function traces a symmetric parabola with a global maximum and allows the possibility of harvesting to extinction as is or with minimal modifications.

A more complicated dynamic model is unnecessary because I do not wish to focus on the discount rate or issues of capital theory. I assume that the institutional arrangement and property rights regimes that lead to contracting problems can influence the subjective discount rate of commercial fishermen and otherwise directly impact incentives to collaborate (Swanson, 1994). I would, therefore, expect financially constrained and poorly diversified owner-operators—ill equipped to endure low-income seasons—to highly discount the future, hence the appropriateness of a static equilibrium model. I expect all self-employed fishermen who share in the value of the catch to behave essentially the same as owner-operators. Roughly 2/3 of fishermen on both Canadian coasts are self-employed[15].

Basic bioeconomic model of harvesting

Fishermen exploit a fish stock that grows according to a logistic form

$$X(t) = \frac{K}{1 + ke^{-\gamma t}} \tag{1}$$

where γ is the intrinsic growth rate, K is the

[14] Fraser (1979) documents how fleet catching power increased over the 1970s.

[15] Human Resources and Development Canada, (2000a).

environmental carrying capacity and $k \equiv (K - X(0))/X(0)$. The growth rate of the stock is

$$g(X) = \frac{dX(t)}{dt} = \gamma\left[1 - \frac{X}{K}\right]X . \tag{2}$$

The growth rate function is symmetric and yields a maximum sustainable yield (MSY) at $X = K/2$.

A limited access fishery requires that the total number of license and boat combinations be determined exogenously by the regulatory agency. Without loss of generality, I assume the presence of $1,\dots,n$ identical operator-owners or skippers that furnish equal amounts of fishing effort e_i and having equal access to productive technology and capital θ usually referred to as the catchability coefficient. An individual fisherman's catch is a multiplicative combination of fishing effort e_i, the catchability coefficient θ and current fish stock X

$$c_i(e_i, X) = \theta e_i X , \tag{3}$$

so the total catch is

$$C(E, X) = \sum_{i=1}^{n} c_i = \theta E X , \tag{4}$$

where $E = \sum_{i=1}^{n} e_i$.

Stock growth with fishing mortalities then becomes

$$\dot{X} = g(X) - C(E, X) . \tag{5}$$

Biometric equilibrium occurs when $\dot{X} = 0$, so the equilibrium stock is

$$X^e = \left(1 - \frac{\theta E}{\gamma}\right)K , \tag{6}$$

which yields the sustainable yield or aggregate harvest function

$$C(E;\theta, K, \gamma) = \theta E\left(1 - \frac{\theta E}{\gamma}\right)K , \tag{7}$$

as long as $E < \gamma/\theta$, and the individual harvest function of

$$c_i(E;\theta, K) = \theta e_i\left(1 - \frac{\theta E}{\gamma}\right)K . \tag{8}$$

In a simple open access fishery, each operator-owner fisherman maximizes rent by choosing effort taking as given the effort levels of other vessel owners. The result is a classic negative production externality cast in a non-co-operative prisoners' dilemma. Specifically, let the aggregate harvest function be

$$C(E;\theta, K, \gamma) = \theta\left[e_i + (n-1)\overline{e}_j\right]\left[1 - \frac{\theta e_i + \theta(n-1)\overline{e}_j}{\gamma}\right]K \tag{9}$$

where $e_j = \{e_1,\dots,e_j \neq e_i,\dots e_n\}$ and the bar over $e_j, \overline{e}_j$ reinforces the notion that the effort choices of all other vessel owners are exogenous to individual choice.

For simplicity and without loss of generality, operator-owners produce identical catches that are shared at the dock according to the individual share of effort $e_i/\left(e_i + (n-1)\overline{e}_j\right)$. This rule introduces another negative externality in the model that is often cited in the fishing literature, and can be characterized as a race to acquire shares of fish. For example, an alternative-sharing rule might be pre-determined shares that are not affected by effort levels. In this simple model, such a share would be $(1/n)$. The competitive sharing rule is the same one applied to lotteries that are ex ante actuarially fair and is used in rent-seeking models (see Rowley, Tollison, Tullock, 1988.)

In a survey of restrictions in fisheries, Townsend (1990) points out the importance of congestion or crowding externalities, suggesting they have been ignored by economists. I leave explicit congestion externalities out of the cost function for tractability; competitive sharing and negative production externalities in the current model capture the spirit of short-run cost congestion, which should occur in static sustained yield equilibrium as well[16].

The regulator fixes the number of vessels n before vessel owners choose fishing effort simultaneously. Assuming a constant output price of q and some well-behaved simple, linear cost function $w \cdot e_i$, each of n fishermen maximizes net benefits by solving

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[16] Expanding the harvest function results in negative crossed terms, i.e., $e_i \cdot \overline{e}_j$, which adequately captures congestion effects.

$$\max_{\{0 \le e_i \le e_X\}} \pi_i\left(e_i, \overline{e}_j\right) = q\theta e_i\left[1 - \frac{\theta e_i + \theta(n-1)\overline{e}_j}{\gamma}\right]K - w \cdot e_i \quad (10)$$

Effort is chosen from a closed set $\{0 \le e_i \le e_X\}$ for $i = 1,\ldots,n$ fishermen, where e_X denotes effort such that $n \cdot e_X$ causes stock collapse. The resulting Nash equilibrium is unique and socially inferior to a full cooperation or single-owner outcome[17].

Private rents are never exhausted. In the face of insufficient barriers to entry or insufficient regulation of capital-embodied technology, the number of vessels or the effective fish catching capacity increases over time, and rents will further dissipate, but not entirely disappear under usual parameter values. As mentioned earlier, I believe this fits well with observed private positive rents in some fisheries, although the bulk of those may be infra-marginal[18].

Optimality conditions arising from individual rent maximization problem determine the rent per unit of effort

$$\begin{aligned}\frac{vc(E) - w/\theta}{vc(E)} &= s_i \frac{1}{\varepsilon_{E,vc}} \\ &= \frac{e_i}{E} \frac{-1}{\dfrac{dE}{dvc(E)} \dfrac{vc(E)}{E}},\end{aligned} \quad (11)$$

where $vc(E) = q\left(1 - \theta E/\gamma\right)K$ represents value of catch per unit effort, w/θ is cost per unit effort measured in productivity units, $s_i = e_i/E$ is the share of total fishing effort of the i^{th} fisherman and $\varepsilon_{E,vc}$ is the elasticity of aggregate effort with respect to catch value per unit effort[19].

Rent per unit effort increases as share of effort increases or the relationship between aggregate effort and value of catch becomes more inelastic. Conversely, as the effort/catch relationship becomes more elastic, rents tend to zero. A common property fishery with close to full rent dissipation imples a high degree of aggregate effort responsiveness to any increase in catch value per unit effort[20].

The fishing effort reaction function is linear

$$e_i^R = \frac{\gamma}{2\theta}\left[1 - \frac{w}{q\theta K}\right] - \frac{(n-1)}{2}\overline{e}_j, \quad (12)$$

and has a negative slope $de_i^R / d\overline{e}_j = -(n-1)/2$ that becomes steeper as the number of fishermen n increases meaning effective cooperation decreases as numbers of strategic competitors rise. The above equations readily illustrate the negative externality that occurs where any increase in equilibrium fishing effort of others is met by a reduction of own fishing effort of only half the amount increased. Note also that fisherman i's marginal revenue will not rise with other rival fishermen's effort

$$\frac{\partial^2 \pi\left(e_i, \overline{e}_j\right)}{\partial e_i \, \partial e_j} = \frac{-q\theta^2 K}{\gamma} < 0. \quad (13)$$

Symmetrical fishermen choose the same level of fishing effort

$$e_i^N = \frac{\gamma}{\theta(n+1)}\left[1 - \frac{w}{q\theta K}\right]. \quad (14)$$

Equilibrium individual fishing rent is

$$\pi_i^N = \frac{\gamma(w - p\theta K)^2}{(n+1)^2 q\theta^2 K}. \quad (15)$$

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[17] The model is technically identical to a Cournot output oligopoly model. See Shapiro (1989) for a thorough critique of the properties of various oligopoly models.

[18] On the other hand, if I assume fishermen gain from non-pecuniary life-style benefits, then in a world of fishermen with heterogeneous abilities, the least productive fishermen could still earn positive total private rents while earning negative private pecuniary rents.

[19] Fishermen solve $\max_{e_i} \pi_i = \theta e_i vc(E) - we_i$. First order conditions are

$$d\pi_i / e_i = \theta vc(E) + \theta e_i \, dvc(E)/dE - w = 0,$$

which I re-arrange to find the mark-up formula.

[20] Note the rewards to concentration. Larger shares of the fishery translate into higher per unit effort rents as the negative production and competitive-sharing externalities are attenuated through partial internalization of the externalities. Here is one possible reason why Canadian fishery managers appear to favour "corporate concentration", in lieu of effective capacity reduction measures.

Per capita collusive (or sole-owner) fishing rent is

$$\frac{\pi_m^*}{n} = \frac{1}{4n}\frac{\gamma(w - p\theta K)^2}{q\theta^2 K}. \tag{16}$$

Fishing rents per capita diminish more rapidly in the open-access fishery relative to the sole-owner fishery as the number of participants n increases.

Clearly, individual fishermen would be better off coordinating fishing effort and minimizing resources expended to catch fish. In a restricted access fishery (where n is fixed) but with no effective time and area closures, individual fishermen would be better off by restricting effort below levels prescribed by the Nash equilibrium effort levels. Yet, should aggregate effort find itself below the non-cooperative equilibrium, individual fishermen always have a private incentive to increase own fishing effort.

Income transfer

In an open access situation, adding a pure income supplement will encourage additional entry until all quasi-rents are dissipated. If the income subsidy is a multiple of fishing income, then the marginal revenue of fishing will increase and induce equilibrium effort to increase. If the subsidy is essentially a lump-sum income transfer with an attainable qualifying threshold measured in weeks fished, then marginal returns to fishing will not be affected outside the discontinuity and may even decrease as higher earnings are clawed back. The UI programme exhibits all features. Simply qualifying initially entitles one to a lump-sum transfer; the amount of benefits are a positive function of average weekly earnings and are clawed back for higher income earners. As I argue below, it is the imposition of effort caps below the minimum required weeks that radically alters incentive structures.

Effort caps under regulated fisheries

Under a regulated, restricted access fishery (RAF), the regulatory agency announces some cap on aggregate fishing effort so $\sum \theta e_i \leq \theta E_0$, attempting to implement some maximum sustainable yield (MSY) or similar objective. I assume that managers are well aware of the available productive capital and technology as captured by the parameter θ and that θ changes sufficiently slowly so that for all practical purposes it is fixed within a fishing season planning horizon.

In theory, fishery management could solve the biological overfishing problem, although not necessarily the economic problem as any temporary rents created by the restrictions of variable fishing effort will increase effort directed to other input margins. Evidence suggests that the input *time* is difficult to substitute for other inputs. Dupont (1991), in a study of the BC salmon fishery, finds that restrictions on fishing days are difficult to substitute and suggests they make a better management tool than restrictions on some inputs such as tonnage limits. This result suggests that effort caps, as implemented by time and area closures, are possible to enforce and reasonably effective. The only opportunity fishermen have for expanding fishing effort beyond the allotted time and area opening is to influence its determination before it is announced.

Homens and Wilen (1997) model a regulated open access fishery by assuming managers consistently set safe quotas through seasonal length restrictions. I make the same assumption except I allow political effort to expand season lengths.

Biological overfishing appears to plague even RAFs for a number of possible reasons. In this analysis, I choose to focus on the explanation that overfishing is exacerbated because the process of determining the TAC is subject to political influence by the fishermen in the fishery. Fishermen form associations and deck-hands form unions that appear to wield substantial political influence over government appointed managers.

The key to understanding manager behaviour lies in the climate of unavoidable uncertainty in which managers are required to make decisions. Subjective decision-making inevitably plays a role where science offers little explicit guidance. Managers personally face little prospect of immediate gain other than possible promotion. Moreover, short-term socio-economic objectives such as job creation play an important role; vote-sensitive politicians provide relevant guidance to careful but ambitious civil servants. Abundant anecdotal evidence of “extended” openings and the political driven relaxation of TACs suggests that lobbying has been successful. Mistakes may result in costly moratoriums and more public support; however, the short-term benefits accrue to tightly focussed groups of workers and political representatives whereas costs are diffused over large numbers of taxpayers[21].

I postulate that implemented effort caps are a positive function of collective political lobbying or rent-seeking

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[21] Wilen and Homans (1998) provide empirical evidence that regulators of the relatively successful North Pacific Halibut fishery attempt to smooth fishermen income and thus harvests, suggesting that stock safety was not the only goal.

effort P exerted by fishermen such that $E \leq E_{00}$, where $E_{00} \leq E_0 + E(P)$. The regulator posts E_0 and political effort is exerted to increase effort cap to E_{00}. The rent-seeking function is subject to diminishing returns so $E'(P) > 0$ and $E''(P) < 0$. Individuals face the constraint $e_i \leq e_{00}$, where $e_{00} = e_0 + e(np)$, $e'(np) > 0$, $e''(np) < 0$, and $P = n \cdot p$. Inherent in this formulation is the notion that fishermen's political strength is a positive function of total numbers[22].

The assumption of diminishing returns captures the notion that although managers might accommodate political pressure to increase openings beyond the initial level E_0, they are professionally and morally encouraged, if not bound, to avoid excessive overharvesting[23].

Assuming away free rider and other agency/moral hazard problems, the fishermen cooperatively choose political effort and thus maximize "political rents"[24]. Fishermen play a two-stage game. In the first stage, the regulator exogenously establishes a safe aggregate effort cap and fishermen optimally and socially choose political effort to relax the effort cap prior to fishing and in the second stage, choose individual fishing effort. Rational foresight allows using backward induction to solve the model by first choosing fishing effort given political effort and then to solve for optimal political effort.

$$\max_{\left\{\begin{smallmatrix}1.\, p \geq 0 \\ 2.\, e_i \geq 0\end{smallmatrix}\right\}} NB_i\left(p, e_i, \overline{e}_j\right) = \begin{cases} \pi_i\left(e_i, \overline{e}_j\right) + 0 - c(p) & \text{for } e_i < Q \\ \pi_i\left(e_i, \overline{e}_j\right) + UI - c(p) & \text{for } e_i \geq Q \end{cases} \quad (17)$$

subject to: $0 \leq e_i \leq e_{00} < e_i^N$,

where $e_{00} = \left[e_0 + e(np)\right]$, UI represents the income subsidy, and Q represents the amount of effort (time measured in weeks) necessary to qualify for UI. The cost of political effort is captured by $c(p)$. The constraint allows the possibility that the fishery can be shutdown, allowing effort to vary between zero and the politically augmented effort cap. Effort caps greater than Nash equilibrium values are ruled out as Nash behaviour would render effort caps unnecessary.

If initially proposed fishing effort caps consistently qualify fishermen for income transfers, $e_0 \geq Q$, then impacts on marginal incentives to fish are likely minimal. At higher income levels, if benefits are clawed back as in the case of the Canadian UI regime, then incentives to fish may decrease relative to a regime with no UI as marginal fishing net benefits would decline faster than without UI. If fishing effort fails to qualify fishermen for income transfers $e_0 < Q$, then fishermen potentially experience a proportionately large marginal incentive to increase political effort in order to allow sufficient openings so that fishermen qualify for UI. The direct marginal benefit to political effort is approximately $UI/(Q - e_0)$. Marginal returns to relaxed openings increase exponentially as the initial effort cap e_0 approaches the minimum required period Q.

However, any increase in effort beyond the initial effort cap e_0 may result in a small decline in equilibrium fishing income that is relatively unimportant compared to the net gain received from qualifying for the income transfer UI. See figure 4, where the initial effort cap e_0 is arbitrarily placed near the maximum sustainable yield (MSY) level of effort.

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[22] The effort relaxation function $E(P)$ could very well exhibit at first increasing returns to numbers, and then show diminishing returns.

[23] Another way to motivate the diminishing returns hypothesis to political effort is to evoke the Becker (1983) model where pressure group competition limits effectiveness and mounting deadweight costs can spur taxpayers into activism. Environmental groups, various professional and academic experts and others often oppose policies proposed by fishermen associations.

[24] Even if fishermen choose individual political lobbying effort ignoring the positive externalities of own effort, the general direction of the results is the same: political effort to expand TACs will increase in the face of lump sum income transfers when expanded effort is necessary to qualify for the stipulated criteria.

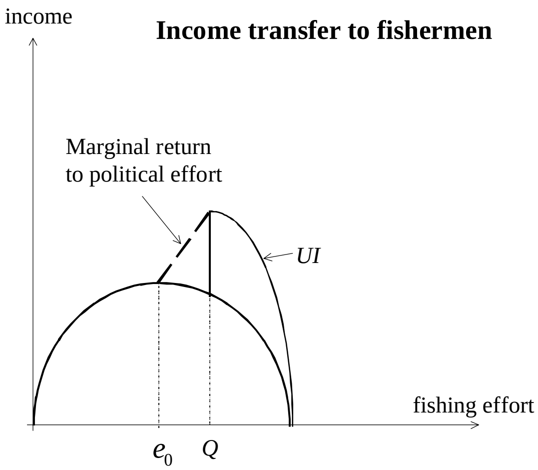

Figure 3: If the initial effort cap prevents fishermen from exerting sufficient effort to qualify for benefits, fishermen will confront a significant marginal return to political effort targetted at relaxing the effort cap $e_0 < Q$ to e_{00} such that $e_{00} \geq Q$.

In order to qualify for UI, the final season length must exceed the minimum required weeks for UI $e_{00} \geq Q$, which implies political effort must be chosen so $e(np^*) \geq Q - e_0$. Unless aggregate effort is somehow constrained below the cooperative level e_i^C , any increase in effort will result in a reduction in fishing rents $\pi_i(e_{00}) - \pi_i(e_0) < 0$. So fishermen will choose $p^* > 0$ so $e(np^*) \geq Q - e_0$ if and only if the marginal net gain from political effort is positive $\pi_i(e_{00}) + UI - \pi_i(e_0) - c(p^*) > 0$. Similarly, fishermen will choose no political effort if the optimal amount is insufficient to push the fishing season beyond the minimum requirements for UI, $p = 0$ if $e(np^*) < Q - e_0$.

Thus, even with a decrease in fishing rents, fishermen will gain from expanded effort caps by qualifying for UI income transfers. However, if e_0 is set so $Q < e_0$, then clearly there is some potential to reduce fishing effort. This suggests that rather than eliminating UI income transfers to fishermen, regulators could instead make minimum requirements so low that incentives to overfish decrease.

Employment insurance (EI) reforms implemented in 1997 replaced the minimum weeks worked with a minimum income requirement[25]. I would expect incentives to overfish to remain roughly the same. Now the value of net output qualifies fishermen for benefits as opposed to quantity of fishing input as measured by time. In some instances, EI could conceivably increase incentives to overfish, as now valuable fish must be caught in order to qualify. Likely, it will increase incentives to switch effort to more commercially valuable fish.

The general results of this modelling exercise should hold for a number of models including harvest functions lacking negative competive sharing and production externalities. One could also extend the analysis by incorporating the model in a labour-leisure model. The results should not significantly change. However, in such a framework, UI decreases the time opportunity cost of political effort and further excacerbates incentives to overfish.

I would also expect that salaried deck-hands elegible for regular category season UI/EI benefits as well as corporate fleet owners seeking to minimize labour costs would face the same political incentives to relax effort caps where UI/EI benefit streams are threatened. In the face of generous benefits, equilibrium fishing effort of employees will depend on the outcome of income and substitution effects, and is a priori ambiguous. In the face of a lump-sum transfer with a claw-back provision, employees may choose to decrease fishing effort. However, some outside workers will be induced to enter the fishery labour market and work sufficient weeks to qualify.

Heterogeneity

It is well recognized that a small proportion of fishermen catches most of the fish and earns most of the private pecuniary rents. In a situation, where the income subsidies of these high productivity fishermen would be completely clawed-back, then these high productivity fishermen may have little incentive to see effort caps expanded[26].

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[25] From $2,500 of earnings, for areas with more than 13.1 per cent unemployment, to $4,200 of earnings, for areas with 6 per cent or less unemployment, are required in order to qualify for benefits . For repeat users with annual fishing incomes under $23,250, benefits represent 59 to 93 per cent increases over fishing source income, once again depending on the regional unemployment rate.

[26] Johnson and Libecap (1982) show how heterogeneity of fishermen in terms of skills and productivity make "contracting" on regulations that would increase aggregate rent difficult to implement because "high rollers" would not necessarily benefit.

Numerically, I would expect this group to be very small[27].

CONCLUSION

I have attempted to sketch a model of individual fishing behaviour in a regulated, restricted access common property fishery. Regulators use a restrictive effort cap to prevent overfishing. An income supplement programme, that requires a minimum of fishing effort to qualify, provides strong incentives to lobby regulators to ease up the effort cap. Somewhere between chronic overcapacity, the exclusive reliance in most non-quota fisheries on time and area closures, and a generous income transfer programme that requires so many weeks fished in order to qualify, a system has evolved that creates incentives to overfish and ultimately threatens commercial viability if not ecological integrity.

The model sketched in this paper applies to UI supported fisheries on both Canadian coasts and inland. Although subsidizing farmers and fishermen as well as others appears to enjoy continuing broad political support in many countries including Canada, many believe that industrial activities should not risk catastrophic or permanent damage to the environment and biodiversity. In fact, in this era of governments openly embracing a precautionary, risk averse approach to renewable natural resource management, it is surprising that such a programme survives[28].

If enough people share that view, then maybe in Canada the fishing category of the current Employment Insurance (EI) regime will eventually be gracefully laid to rest. Over the years, fishing category UI has made up only 1 to 2 per cent of total UI benefit payments, so relative dollar amounts are not that significant (Hales, 1998). On the other hand, the potential immediate social costs and costs for future generations of UI induced overfishing are enormous as billion dollar rescue packages on Canadian Atlantic coast testify. The direct and indirect public subsidy multiplier of UI fishing benefits is likely very high.

Although I have restricted the analysis entirely to controlled common property fisheries, there are indications that the lure of EI benefits are complicating efforts to institute and manage private quota fisheries on the Canadian Atlantic coast. I also suspect that income supplements have hindered decentralized community efforts to self-regulate. Clearly, given the numerous references to dysfunctional politics in the literature on fishery management, more work needs to be done on the political behaviour of fishermen and regulator decision-making.

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[27] I have deliberately avoided integrating risk into the model. Where UI eligibility is a function of input measured by weeks spent fishing, risk is relatively unimportant. However, in the face of an output qualification as is the case with the current Employment Insurance fishing category income requirement, risk could play a greater role as the fishermen must catch fish to qualify. To the extent that fish stocks are subject to difficult to assess risk and much pure uncertainty, it is likely that fishermen will aim for longer seasons or higher quotas in order to assure themselves UI benefits.

[28] See Doubleday and Powles (1997) for a description of how Fisheries and Oceans Canada has embraced the precautionary approach. Note that although the Auditor General's Report *Pacific Salmon: Sustainability of the Fisheries* released in November 1999 has embraced the language and objectives of sustainable development as per its mandate, no reference was made to the role income subsidies play in influencing fleet configuration and management.

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NOTATION AND SOME ACRONYMS

UI	Unemployment insurance fishing category
EI	Employment insurance fishing category (as of 1997)
$X(t)$	fish stock at time t
γ	intrinsic stock growth rate
K	environmental carrying capacity
$g(X)$	fish stock growth rate
MSY	maximum sustainable yield
θ	capital-embodied productive technology (catchability coefficient)
e_i	individual variable fishing effort
E	aggregate variable fishing effort
$c_i(\bullet)$	individual fisherman's catch
$C(\bullet)$	total catch
$\dot{X}$	aggregate stock growth with fishing mortalities
X^e	equilibrium fish stock
$\overline{e}_j$	other fishermen's variable effort (exogenous)
q	output price
π_i	fisherman profit or rent
n	number of owner-operator fishemen
$n \cdot e_X$	aggregate variable effort which causes stock collapse
w	parametric cost of individual variable fishing effort
$vc(E)$	value of catch per unit effort
s_i	the share of total fishing effort of the i^{th} fisherman
$\varepsilon_{E,vc}$	elasticity of aggregate effort with respect to catch value per unit effort.
e_i^R	fishing effort reaction function
^{N}	superscript N denotes Nash equilibrium outcome
RAF	Regulated, restricted access fishery
E_0	initial aggregate variable effort cap
P	aggregate political effort

$E(P)$ aggregate effort cap relaxation function

E_{00} final aggregate variable effort cap

e_0 initial effort cap faced by individual fishermen

p individual political effort

$e(np)$ individual effort cap relaxation function

e_{00} final effort cap

UI income subsidy per fishermen

Q variable effort (measured in weeks) necessary to qualify for UI