Marine Resource Economics, Volume 18, pp. 329–344
Printed in the U.S.A.
0738-1360/00 $3.00 + .00

Multilateral Governance of Fisheries: Management and Cooperation in the Western and Central Pacific Tuna Fisheries

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Abstract *The tuna resources of the Western and Central Pacific are the world's largest and most valuable fisheries of their type and are of significant economic importance to the Pacific island countries through whose waters they migrate. Two major concerns exist with the current governance of this fishery. First, Pacific island countries receive only a small share of the resource rents from the tuna fisheries. Second, the current management structure of the fisheries will not ensure the long-term sustainability of the resources. This paper derives a model to show that the sustainability of the resource can be improved when a single policymaker acts as Stackelberg leader and sets a tax, or an equivalent quantity instrument, to maximize rents from the resource. A practical institutional mechanism is presented that mimics the model's rent maximization outcome and that offers substantial benefits to both Pacific island countries and distant water fishing nations.*

Key words Fisheries, governance, rents, tuna.

JEL Classification Codes Q01, Q22, Q28.

Introduction

The Pacific Ocean spans more than a third of the earth's surface and half of the earth's sea surface, an expanse of 180 million square kilometers. Scattered in the Western and Central part of the Pacific Ocean are the 200 high islands and 2,500 low islands and atolls that comprise the 22 countries and territories of the Pacific islands (figure 1). The Pacific islands' exclusive economic zones (EEZs)[1] exceed landmass by an average factor of 3,000 to 1 (World Bank 2000). Not surprisingly, the Pacific Ocean has had significant influence in the shaping of culture and economies of these nations.

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The authors wish to thank three anonymous reviewers for their helpful comments. Authorship is alphabetical.

[1] Ocean area of national jurisdiction within 200 miles of a state's coastline as delineated in the United Nations Convention on the Law of the Sea (United Nations 1994).

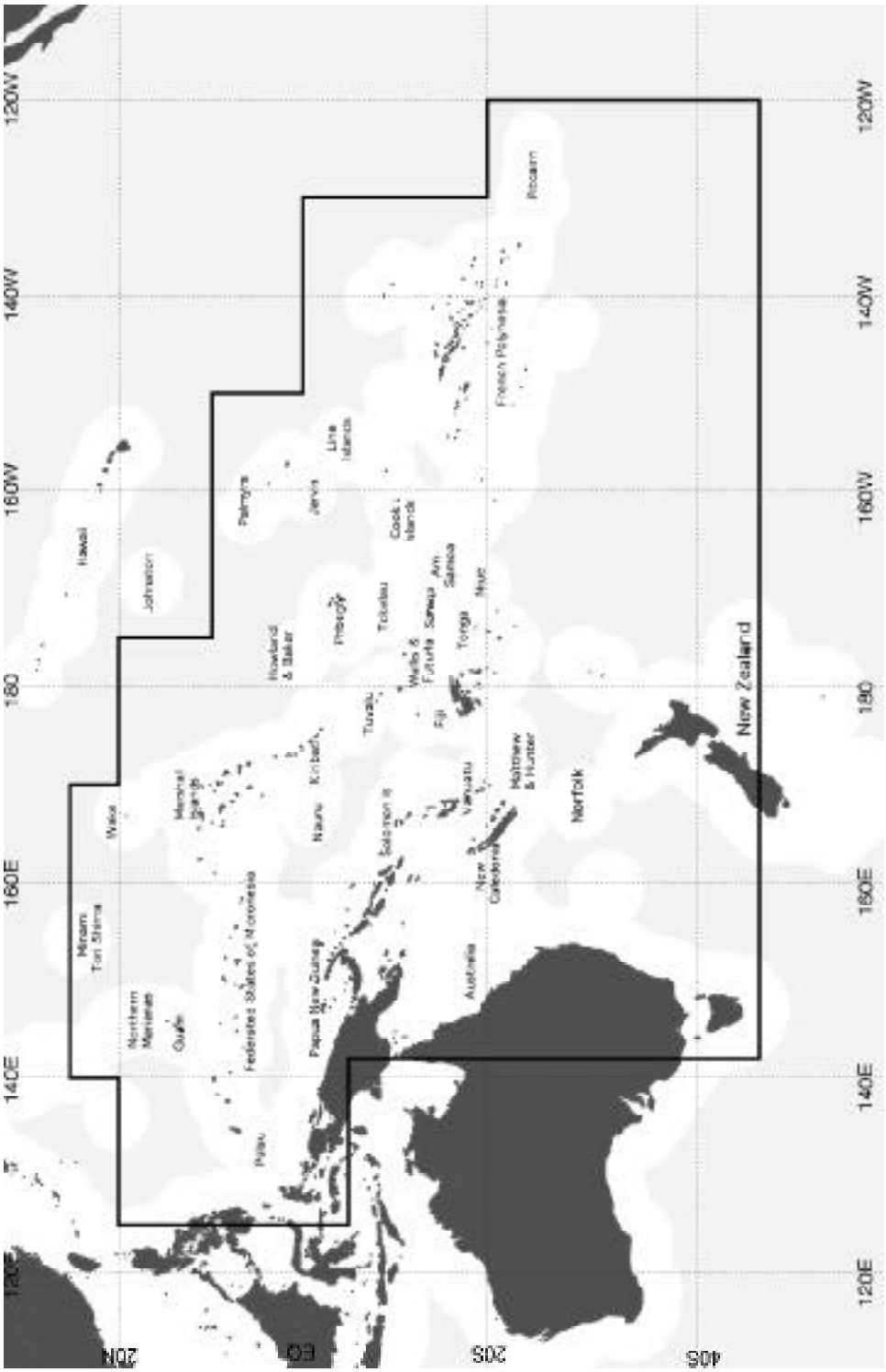

Figure 1. The Western and Central Pacific Region: Exclusive Economic Zones (Source: Secretariat of the Pacific Community 2000)

While coastal marine resources provide an important source of food, income, culture, and recreation, offshore marine resources in the region are frontiers of high economic and strategic potential. The Western and Central Pacific (WCP) Ocean is home to the world's largest and most valuable tuna fishery (table 1). The region supplies one third of the global tuna supply and 40 to 60% of tuna to canneries (Tarte 1999). Tuna is the only significant natural resource of the Polynesian and Micronesian communities.[2] The value of the fishery in 1998 was US$1.9 billion, equal to around 11% of the region's gross domestic product (GDP) (Gillett *et al.* 2001). Domestic fishing fleets in the region are poorly developed and access fees paid by distant water fishing nations (DWFNs), approximately US$60 million, dominate benefits from the fishery accruing to the Pacific island countries (PICs). Fishery revenue also constitutes a significant portion of government revenue, export earnings, and GDP for many of the PICs, as shown in table 2.

Two major concerns exist with the governance of the WCP tuna fisheries. The first is that the PICs are deriving only a small share of the benefits from exploitation of their tuna resources. Bertignac *et al.* (2000) estimate that the overall resource rent in the WCP tuna fisheries is around 13% of gross revenue at 1996 levels of effort. Such rents are comparable to the fees, based on cost recovery alone, charged by the Australian Fisheries Management Authority to fishers in the Australian bluefin tuna fishery of approximately 11% of gross revenue (Australian Fisheries Management Authority 2000). Bertignac *et al.* argue that if effort level and the fleet structure of the fishery were at lower levels, the rent could be as high as 40% of gross sales. At lower levels of exploitation, the maximum possible rents, as a proportion of gross returns, would be comparable to what the European Union pays African countries for access fees, which range from 18 and 45% of the value of their catch (Iheduru 1995). By contrast, PICs have negotiated access fees on the order of 3% of gross revenue for the right to fish in their EEZs (Gillett *et al.* 2001).[3] Thus, at the current access fees and level of exploitation, PICs could *potentially* double their fees and yet still receive less than half the total resource rents in the fisheries.

Table 1
Average Yearly Tuna Catch in the Major Tuna Fishing Areas, Late 1990s

Major Tuna Fishing Areas	Average Yearly Tuna Catch (metric tons)
Western and Central Pacific	1,000,000
Eastern Pacific	525,000
West Africa	385,000
Western Indian Ocean	450,000

Source: Gillett *et al.* (2001).

[2] The Pacific islands have three main cultural groups (although there is substantial blending of cultural traits). The Melanesians settled in the high islands of Fiji, New Caledonia, Papua New Guinea, the Solomon Islands, and Vanuatu. These islands are rich in natural resources such as minerals, petroleum, and forests. Melanesia contrasts with the resource-poor islands of Polynesia (Cook Islands, French Polynesia, Wallis and Futuna, Niue, Pitcairn, Tokelau, Tuvalu, American Samoa, Samoa, and Tonga) and Micronesia (Guam, Kiribati, Marshall Islands, Federated States of Micronesia, Nauru, Northern Mariana Islands, and Palau).

[3] Note that some countries exchange bilateral aid (mainly from Japan) in exchange for cheap access, which means that these figures are underestimates of effective access fees. The size of this underestimation is not known.

Table 2
Economic Statistics Showing the Importance of the Fishing Industry for Selected Pacific Island Countries

	Government Revenue (percent)	Exports (percent of total value)	GDP (percent)
Cook Is.	…	41 (1999)	…
Fiji	…	7 (1997)	1.4 (1998)
FSM	29 (1998)	92 (1997)	15.5 (1990)
Kiribati	61 (1998)	53 (1993)	9.5 (1993)
Marshall Is.	25 (1993)	94 (1997)	…
New Caledonia	…	27 (1996)	…
Palau	5 (1993)	-	…
Papua New Guinea	2 (1999)	0.6 (1999)	…
Samoa	…	-	6.2 (1999)
Solomon Is.	[a] 5 (1993)	20.1(1993)	9 (1993)
Tonga	…	18 (1998)	…
Tuvalu	[a] 35 (1993)	-	5 (1993)
Vanuatu	-	<1 (1993)	…

Notes: … = not available
- = negligible or zero
[a] = approximately
< = less than
Source: Petersen (2002).

The second major issue for the WCP tuna fisheries is that the current structure of governance is not ensuring the long-term sustainability of the resource. Evidence exists of economic overexploitation (Bertignac *et al.* 2000) and concern has been raised that bigeye tuna, the most lucrative of the four tuna species in the fishery, is being biologically overexploited (Secretariat of the Pacific Community 2002). Similar worries have also been voiced about the exploitation levels for yellowfin tuna (Secretariat of the Pacific Community 2002).

To address these issues, this paper describes the existing institutions for multilateral fisheries governance. We then describe current governance for tuna in the WCP and highlight its institutional weaknesses. We follow with an innovative model, where a single policymaker maximizes steady-state rents and ensures sustainability of the resource through the use of an *ad-valorem* tax or an equivalent quantity instrument. The proposed multilateral governance structure for the WCP tuna fisheries that will encourage cooperation amongst PICs and DWFNs to achieve the desired outcomes of the model is detailed in the fifth section. The paper concludes with a review of the potential benefits and difficulties with implementing the multilateral governance structure.

Existing Institutions for Multilateral Fisheries Governance

The third United Nations Convention on the Law of the Sea (UNCLOS III) defined property rights for the conservation and use of marine resources within 200 miles of a state's coastline, a region termed the Exclusive Economic Zone (EEZ). UNCLOS III was signed in 1982 and ratified in 1994 (United Nations 1994). The establish-

ment of these state-property rights was expected to significantly ease overexploitation problems, as 90% of ocean's fish harvests takes place within the coastal regions. Moreover, the coastal states believed that DWFNs would not be able to commercially harvest on the high seas unless they were granted access to national waters by coastal states (Brasao, Costa-Duarte, and Cunha-e-Sa 2000). For many high-seas fisheries, this belief has proven to be false, and important stocks in international waters continue to be subject to overexploitation.

In order to encourage cooperation in the management of straddling and highly migratory fish stocks, the Draft Agreement for the implementation of the provisions of the UN Convention on the Law of the Seas of 10 December 1982, relating to the conservation and management of straddling and highly migratory fish stocks, known simply as the UN Fish Stocks Agreement, entered into force in 2001 (United Nations 2001). The most important aspect of the UN Fish Stocks Agreement is that both coastal states and DWFNs are required to cooperate in managing the fish stocks either bilaterally, multilaterally, or through the establishment of Regional Fisheries Management Organisations (RFMOs), as appropriate. Thus, while clearly defined property rights have not been established for the high seas, indistinct property rights have been allocated to all users of marine resources that straddle the EEZs and high seas (coastal states and DWFNs) for management and conservation.

A number of RFMOs for tuna have been established both prior to, and in response to, the establishment of the UN Fish Stocks Agreement. In 1950, the Inter-American Tropical Tuna Commission (IATTC) was established to maintain the populations of tuna, and other fish stocks taken by tuna vessels, in the Eastern Pacific Ocean (IATTC 1949). While its principal duties are to coordinate research and development activities and recommend appropriate conservation measures, the IATTC has also played a minor role in tuna management. The Indian Ocean Tuna Commission (IOTC), established in 1993 and adopted in 1996, contributes to improving knowledge of tuna resources in the region, coordinating research and development activities, and reviewing the economic and social aspects of fish stocks (IOTC 1993). Like the IATTC, the IOTC has played a limited role in conservation and management measures. However, it is envisaged that such measures are likely to be adopted in time by both these RFMOs (Hedley 2002).

The overexploitation of bigeye tuna and the negotiation of the UN Fish Stocks Agreement have alerted PICs and DWFNs to the need for cooperation in managing the WCP tuna stocks. This led to the September 2000 signing of the Multilateral High Level Convention (MHLC) on the Conservation and Management of Highly Migratory Fish Stocks in the WCP Ocean (MHLC 2000). All coastal and DWFNs (except Japan) signed the Convention, which requires the establishment of a WCP Tuna Commission that will be responsible for promoting cooperation and coordination between members to ensure the conservation of fish stocks. The Commission does not have an organisational structure as yet and, due to the time needed for ratification, it is not expected to come into force until at least 2004. Thus, it is timely at this formative stage to discuss how to strengthen the organization and encourage cooperation amongst PICs and DWFNs in the WCP.[4]

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[4] Note that the WCP tuna fishery is termed a 'straddling' stock, as resources move between the EEZs and adjacent high seas. Kaitala and Munro (1993) observe that the economics of 'shared' resources (which refers to resources that are shared between one or more coastal states), which are reasonably well developed, take us only part way in explaining the economics of straddling stocks, a field of research that is relatively undeveloped to date.

Current Institutional Structure of the Western and Central Pacific Tuna Fishery

Ten DWFNs that fish in the WCP region account for 86% of the total tuna harvest. The four largest countries in terms of catches are Japan, Taiwan, South Korea, and the United States (Secretariat of the Pacific Community 2000). Most coastal states are subject to almost continual bilateral approaches for access by the mobile distant water fishing fleets (Cartwright and Willock 1999), and PICs allocate fishing entitlements to DWFNs mainly through international treaties. These treaties are negotiated because DWFNs have a cost advantage in harvesting and marketing tuna over PICs. Thus, by allowing DWFNs to harvest their tuna resources, both parties can potentially be better off.

An illustration of the potential cost differences between DWFNs and PICs is given in figure 2. In this example, we assume density-dependent growth for tuna resources, a competitive market for tuna, and linear harvesting costs for both DWFNs and PICs. In the absence of cooperation or a bilateral treaty, the biomass that maximizes the rent to the PICs is X^*_{PIC}. This biomass exceeds the open-access or bionomic equilibrium (X'_{PIC}) under sole coastal state exploitation where the fishery generates no rents for the PICs. By assumption, the DWFN has lower harvesting costs than the PICs, and the biomass that maximizes its rents is X^*_{DWFN}, where $X^*_{DWFN} < X^*_{PIC}$. Thus, the lower cost DWFN will be less conservative in its harvesting and exploit at a *lower* level of the biomass than the higher cost PICs.[5] It follows, therefore, that successful joint exploitation of the tuna resources requires agreement on *both* the division of rents and the appropriate level of exploitation. Moreover, given that tuna migrate across jurisdictions and on the high seas, overall rent maximizing harvest and biomass levels requires cooperation from *all* parties, DWFNs and PICs.

With the exception of a multilateral treaty negotiated between the United States and the 16 PICs, all treaties between DWFNs and PICs are bilateral. PICs have been reluctant to enter into multilateral agreements for several reasons. First, there exists a perception by PICs that such agreements may compromise their sovereign rights. Second, the lack of supporting institutions that could compel or impose an agreement among PICs hinders their development. Third, the benefits and costs of implementing new institutions are likely to be unevenly distributed between PICs. Fourth, some PICs fear that multilateral agreements may jeopardize bilateral aid (Petersen 2002).

Petersen (2002) argues that existing bilateral treaties do not reflect the true value of the resource rent, are not transparent, give incentives to underreport, and do not ensure that the least-cost harvesters are allocated the access right. The politically independent PICs cooperate closely on establishing these treaties with the Forum Fisheries Agency. However, decisions about defining protocols for fishing rights, the negotiation of the rights (including the appropriate access fee level or equivalent level of total harvesting rights), and the means by which the rights are enforced are the responsibility of the individual PICs. While all vessels fishing in the region must be licensed, few restrictions are placed on the number of vessels; hence licensing acts predominantly as a mechanism for monitoring fishing activity.

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[5] Munro (1979) analyzed the case where two countries exploit a common transboundary fishery. If they both have the same discount rates, and if the lower cost country exploited the resource unilaterally, it would harvest at a lower biomass level than if its neighbor were the sole harvester.

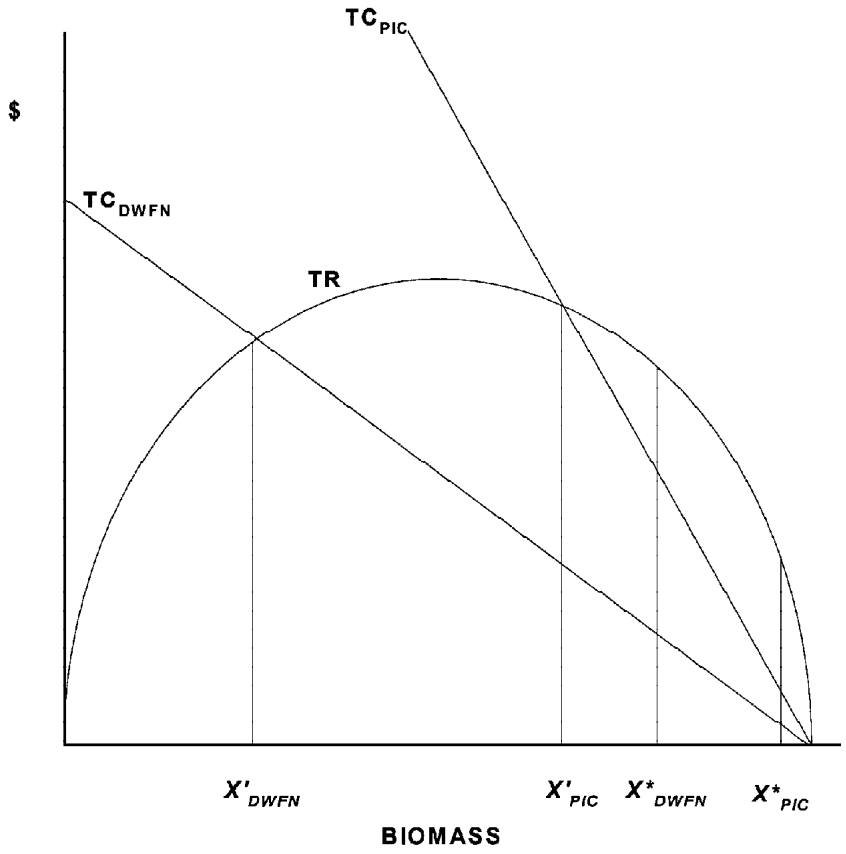

Figure 2. Illustration of Bionomic and Rent-maximizing Biomass Levels for a Distant Water Fishing Nation (DWFN) and a Pacific Island Country (PIC)

Legend: TC = total harvesting costs, TR = total revenue, X'_{DWFN} = bionomic equilibrium for DWFN, X'_{PIC} = bionomic equilibrium for PIC, X^*_{DWFN} = rent maximizing biomass for DWFN, X^*_{PIC} = rent maximizing biomass for PIC

Rents in the Tuna Fisheries

Limited research has been conducted on estimating the rent potential of the WCP tuna fishery. Bertignac *et al.* (2000) use a tuna population dynamics model (spatially disagreggated, multi-gear, multi-species model) to determine an optimal harvest size, age, and technology structure for the fishery, given the objective of maximizing economic rents in the long run. They assume access fees equal to 4% of the gross revenues of DWFNs and that tuna prices vary as a function of the harvest.[6] Their model indicates that the economic rent of the WCP would double if fishing effort were reduced and if exploitation shifted from younger to older cohorts (due to decreased costs and increased prices).

[6] Bertignac *et al.* (2000) estimated the demand elasticity for raw tuna supplied to the canning markets by purse-seine and pole-and-line fleets in the South Pacific to be 1.55 and that of the fresh and frozen tuna supplied by longline fleets to be 2.53.

Their study suggests that the overall level of effort and fleet structure of the fishery are suboptimal. Given that the rent potential is much larger than rents presently accruing from the fishery, that the sustainability of the stock is in jeopardy, and that cooperation is required to maximize long-term revenues from the fishery, several unanswered questions remain. What institutional structure will help ensure one, an increase in total rents; two, an increase in the proportion of the rents that accrue to PICs; and three, the continued sustainability of the resource? The following section provides an innovative model to conceptualize the problem and help design a potential remedy.

The Model

To assess the potential benefits of cooperation in the WCP tuna fisheries, we develop a model where the aggregate catch is represented by the following Cobb-Douglas production function of the form:

$$Q = K^{\alpha} L^{1-\alpha} S(t; \omega) \frac{\partial S}{\partial t} > 0, \tag{1}$$

where capital letters are used to denote aggregate quantities such that Q denotes total catch, K the industry capital stock, and L the total number of fishers. S denotes a steady-state stock (biomass)[7] of fish for given institutional controls placed on the total catch, represented here by t. Other factors beyond the control of policymakers that may impinge on S are denoted by ω. The policy instrument, t, can be a tax, tariff, or charge on harvest, or the market price of tradable harvesting rights. The price and quantity instruments are identical in this model, as there is no uncertainty over the stock, catch, or prices.

Each of the factors in equation (1) are essential for production, since a zero input of any one factor results in zero output. The relationship depicted in equation (1) may be thought of as a steady-state relationship between total harvest and stocks for a given institutional regime. S is bounded from above by the biological carrying capacity of the ocean and could be zero when the stock is totally depleted. The former is possible when t is relatively large, while the latter arises for lower (including negative) values of t. The above implies a positive association between t and S, as shown by the right-hand side inequality in equation (1), above.

An individual fisher's production function can be depicted as the intensive-form equivalent of equation (1) as:

$$q = k^{\alpha} S, \tag{2}$$

where for ease of notation we write the steady-state stock as S, and small letters are used to denote per-fisher values for the variables in capital letters, individual catch is assumed to be too small to impact on S. Assuming a unit price of fish, the after-tax economic profits accruing to an individual fisher is given by:

$$\pi = (1 - t)q - rk, \tag{3}$$

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[7] Biomass is a composite measure of stock numbers and size, the rent optimisation of which requires considerations around harvest size and technology to be employed.

where r denotes the rental rate on capital. Profit maximization, through the choice of the level of k by individual fishers, yields the steady-state stock of capital as:

$$k^* = \left[\frac{\alpha(1-t)}{r} S\right]^{\frac{1}{1-\alpha}}. \tag{4}$$

Equation (4) shows that the steady-state level of k increases with a rise in capital productivity and/or stock of fish and falls with a rise in the rental rate of capital, but is ambiguous to changes in t. While a rise in t lowers after-tax profits to the fisher, it also raises the steady-state stock of fish. These two effects work in opposite directions on k and are central to being able to use a tax instrument, or an equivalent quantity instrument, to maximize rents and ensure sustainability of the resource.

Each fisher takes t as given in choosing the level of effort, implying that the government acts as a Stackelberg leader in this game. Let the government maximize steady-state rents, R, from imposing a tariff, t, on total catch, Q:

$$R = tQ = tLq = tLk^{\alpha}S. \tag{5}$$

Substituting the steady-state value of k^* into equation (5) and maximizing R, by the choice of t, gives the following first-order condition for the revenue function:

$$\frac{dR}{dt} = a(1-t)^{\frac{\alpha}{1-\alpha}} - \frac{\alpha}{1-\alpha} t(1-t)^{\frac{2\alpha-1}{1-\alpha}} + \frac{a}{1-\alpha} t(1-t)^{\frac{\alpha}{1-\alpha}} S^{\frac{2\alpha-1}{1-\alpha}} \frac{\partial S}{\partial t}, \tag{6}$$

where $a = (\alpha/r)^{\alpha/(1-\alpha)}L$. The expression in equation (6) can be considerably simplified by setting $a = 0.5$ and letting $\partial S/\partial t = \kappa$, a constant. These restrictions neither change the basic structure of the model nor the qualitative findings of the analysis, but simplify equation (6) to the following:

$$\frac{dR}{dt} = \frac{1}{2r}\left[L - (L + 2r - 2\kappa LS)t - 2\kappa LSt^2\right]. \tag{6a}$$

Equation (6a) shows the revenue function is cubic in the tax rate, t, since its first derivative is quadratic. Solving for the two turning points for t in terms of revenues, R, yields:

$$t^* = \frac{-(L + 2r - 2\kappa LS) \pm \sqrt{(.)^2 + 8\kappa L^2 S}}{4\kappa LS}. \tag{7}$$

Inspection of equation (7) suggests that R is minimized for the negative value of t^* and maximized for the positive value of t^*. This relation is depicted in figure 3. A subsidy of t^*_x leads to the stock being driven to zero such that revenues are nil. Note that as t^* increases from t^*_n to positive values, revenue increases. Hence, t^*_n has a knife-edge property. Revenue is maximized at t^*_p, which is also a stable equilibrium. The implication for policy is clear—the policymaker raises any positive tax rate or sets the total allowable catch (TAC) for the harvesting rights to the point where revenue is maximized, this being akin to following the arrows leading to t^*_p. The

immediate question the model raises is how to set a level *t* for the WCP tuna fisheries so as to maximize rents from the fisheries.

To arrive at t^*_p, the assumption of a single policymaker is crucial, and this finding supports results of game-theoretical models of straddling stock fisheries (*e.g.*, Arnason, Magnusson, and Agnarsson 2000) that show that competitive games lead to exhaustion of the fishery, whereas cooperative games (which produce single policymaker-type conditions) can maximize long-term returns from the fishery. This need for cooperation has been recognised in the UN Fish Stocks Agreements, where RFMOs are required to manage straddling and highly migratory fish stocks. The following section presents a proposed multilateral governance structure for the WCP to achieve the desired outcomes of this model—cooperation between PICs and DWFNs.

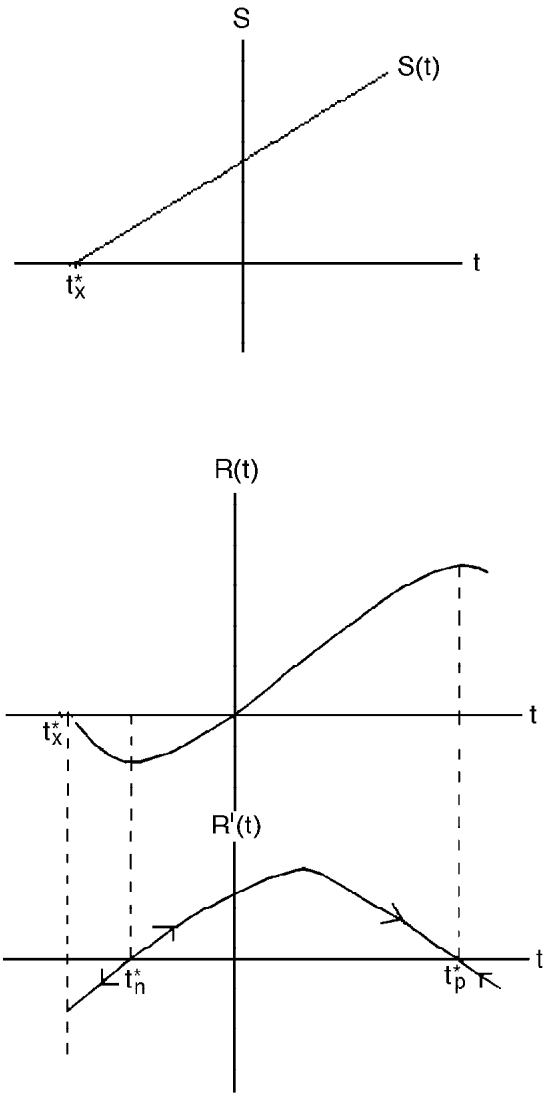

Figure 3. Stock of Fish (*S*), Resource Rents (*R*), and Tariff Rates (*t*)

Towards a Cooperative Governance Structure for the Western and Central Pacific Tuna Fisheries

Successful governance of fisheries, at a minimum, requires the following. First, fishers should be actively involved in the comanagement of the resources (Grafton 2000). Second, total exploitation rates are accepted by most resource users and set at levels that ensure ongoing sustainability of the fishery. Third, fishers have both a long-term interest in the resource and individual incentives, which help ensure that private or self-interest is compatible with the collective good. In addition to these criteria, multilateral governance of fisheries also requires that all countries *voluntarily* cooperate in joint management, abide by the agreed to rules of exploitation, and support a mechanism for restricting new entrants into the fishery.[8]

The biggest difficulty in obtaining cooperation of all parties in fisheries governance is to meet the participation constraint; that is, ensure each party is at least as well off with cooperation than without it. In addition, a mechanism must also exist to ensure that a cooperative outcome can be monitored and enforced with sufficient penalties to discourage noncompliance. In the case of the WCP tuna fisheries, substantial benefits exist for all parties in terms of cooperation. These include the potential for tuna to be caught at an older age, thus significantly raising the price per kilogram of the fish harvested. If stocks are being economically overexploited, as argued by Bertignac *et al.* (2000), reduced harvests have the potential to raise the present value of rents from the fisheries. A cooperative agreement, that includes restrictions on new entrants, can also raise future returns by reducing rent dissipation. Moreover, if cooperation permits the creation of exclusive, tradable, and divisible harvesting rights, it allows fishers with the highest marginal net returns to increase their share of the harvest, thus increasing the rents in the fishery. Finally, if harvesting rights are not made region-specific, with the exception of imposed bans for biological reasons to protect spawning areas and young cohorts, fishers have the flexibility to fish wherever it is economically optimal (without being confined to state boundaries), further increasing efficiency in the fishery.

To help meet the criteria for improved management from the WCP tuna fisheries, a multilateral governance mechanism for tuna (MGMT) is proposed. Our proposal puts into practice the model presented earlier. However, the details of how to establish a MGMT require a great deal more empirical research and would also be subject to considerable negotiation that goes beyond the scope of this paper. Central to a successful MGMT would be a Tuna Commission that would act as a single policymaker and would use either a price or quantity instrument (represented by t in our model) to control harvests and yield desirable steady-state levels of the tuna stocks. Given the virtual political impossibility of imposing a differential fee or price instrument on PICs and DWFNs, we explore only the case of harvesting rights or quantity controls that would correspond to a price t.

This proposed management scheme encourages voluntary cooperation amongst PICs and DWFNs with an incentive of increasing long-run revenue. An outline of what the proposed institutional structure could be, and the details that would need to be addressed by all parties in establishing a MGMT, are provided under a series of headings. These include the functions of the Tuna Commission, the initial allocation of harvesting rights, the setting of a TAC, monitoring and enforcement, and the potential benefits for PICs and DWFNs.

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[8] Munro (1996) emphasizes that without restriction on new entrants, any cooperative agreement will almost certainly be unstable because extra effort by entrants reduces the benefits from cooperation relative to noncooperation.

Multilateral Governance and the Tuna Commission

At the core of the MGMT would be a Tuna Commission that would arbitrate disputes, facilitate cooperation, set harvest levels for the whole region, and support the exclusivity of tuna harvesting rights. Current DWFNs and PICs would be members of the Tuna Commission, and each would be allocated *gratis* annually renewable tuna harvesting rights (THRs) based on a formula that, while reflecting both coastal state rights and past catch levels of DWFNs, would be the outcome of negotiations.[9] THRs would be freely tradable over a 12-month period and divisible. Member countries (both DWFNs and PICs) would have the right to assign their allotted THRs in whatever fashion they wish, provided that they were ultimately used by a vessel registered by one of the countries party to the commission. Monitoring and enforcement of management regulations in the high seas would be undertaken by the Tuna Commission, but with the assistance of member countries. On a cost recovery basis, the Tuna Commission could also assist in the policing of the EEZ of PICs, if so invited, but would have the right to verify that coastal states and DWFNs were in compliance with management regulations. To help ensure self-policing, violations of management rules and regulations (such as overfishing or fishing in prohibited areas) could involve punishment of both the vessel owner and the member country under which flag it operates.

To help ensure a more competitive market for THRs, each member country could be required to surrender 3% of their allocation every year to the Commission to be sold by tender to the highest bidder (the design and frequency of the tender is a matter for further research). This initial allocation draws from the experience of trading sulfur dioxide allowances by US electric utilities—the world's largest pollution permit trading scheme. Holders of sulfur dioxide allowances are obliged to provide 2.8% of their total allocation at an auction held once per year. Revenue from the auction is returned to the utilities based on the proportion of allowances they contributed to the auction. The auction process has helped to "jump start" the trading of sulfur dioxide allowances, provided an important price signal to prospective buyers and sellers about the value of allowances (Joskow, Schmalensee, and Bailey 1998), and yielded important information to assess the market performance of the scheme (Carlson *et al*. 2000).

Following the successful example of the sulfur dioxide scheme, all proceeds of the tuna tender would revert back to members based on their contribution to the tender. All parties would have the option of offering up to a 100% of all their THRs via tender, should they wish. One of the key benefits of the tender process would be to provide information to PICs regarding the market rent for harvesting tuna that is currently kept confidential by PICS and DWFNs under the present bilateral treaty arrangements. Thus PICs, at their option, could continue to engage in bilateral or multilateral treaties with DWFNs with the benefits of this extra information from the tender process to inform these negotiations.

Ongoing and overhead costs of the Tuna Commission would be paid for by a levy on the value of the tuna catch. Countries not party to the original agreement would be permitted to become part of the Tuna Commission for a negotiated fee, but would be obliged to lease annual THRs from existing members to harvest tuna.[10] This approach, using "transferable membership," has been shown by Pintassilgo and

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[9] These rights assume that the members of the Commission acquire collective *de facto* property rights to the resource as shown to be required for successful cooperative governance by Munro (2000).

[10] Such an arrangement precludes the necessity of creating "individual transferable memberships" as proposed for the Northwest Atlantic Fisheries Organisation (NAFO) by Munro (1996) or a two-tier allocation system proposed for the same organization by Grafton and Lane (1998).

Costa Duarte (2000) to help resolve the potential new member threat to reduce rents and would help give existing country members an ongoing, long-term interest in the fisheries.

Initial Allocation of Harvesting Rights

It is envisaged that the biggest stumbling block to the successful creation of the MGMT would be the initial allocation of THRs. The expected return from joining the multilateral agreement for each party would have to exceed the payoff from not joining. Although cooperation may *potentially* benefit all parties, the possibility exists for strategic bargaining by one or more parties such that a proposed allocation may offer some parties less than they would receive without cooperation. Thus, in the absence of complete information on the "threat points" of each party to the agreement, the possibility exists that noncooperation is a stable equilibrium. Such a situation would resemble the non-cooperation that sometimes occurs with the exploitation of common pools, such as oil fields, where joint or cooperative behaviour is hampered by asymmetry in information about the value of the parties' own and others, drilling rights (Libecap 1989).

Arnason, Magnusson, and Agnarsson (2000) and Brasao, Costa-Duarte, and Cunha-e-Sa (2000) have also argued that cooperative multilateral governance is not stable unless side payments are feasible. Nevertheless, the cooperative solution can generate much higher aggregate profits than other solutions, giving ample incentives to reach an agreement. Recent cooperation by all parties (with the exception of Japan) in the form of the MHLC suggests that DWFNs and PICs are able to negotiate in favor of their collective interests.

Total Allowable Catch (TAC)

Our proposal is that the Tuna Commission would impose a TAC on all tuna species for the whole region through which they migrate. We suggest that the TAC would not specify where the fish could be caught, except designating no-fish zones based on spawning and regeneration patterns of the fish stocks. The setting of the TAC would be informed by biological research by the Secretariat of the Pacific Community and consistent with the yield that maximizes the present value of rents in the fishery. We suggest that the TAC be assessed regularly and revised and updated using an optimal feedback rule as part of an active adaptive management approach, as outlined by Grafton, Sandal, and Steinshamn (2000).

Bertignac *et al*. (2000) suggest that the TAC for all tuna species would almost certainly be less than current rates of exploitation. This implies a reduction in the overall current fishing effort. A lower harvest rate may also be justified by the precautionary principle of management, as the current exploitation rate is viewed by some as imposing a risk on the sustainability of some tuna species (Secretariat of the Pacific Community 2002). The reduction in harvest in our model would correspond with an increase in t to the point where steady-state revenues are maximized.

Monitoring and Enforcement

While acknowledging the PICs sovereignty in allocating their own funds to monitoring and enforcement purposes, it is envisaged that the Tuna Commission would bear most of the monitoring and enforcement burden due likely to economies of scope

and scale. For example, aircraft used in one jurisdiction could also be used in another EEZ, or for high-seas monitoring (Grafton 2000). Costs of monitoring compliance are also likely to decrease over time with technological improvements. For example, the installation of a video on each vessel, which can be monitored through satellite, will enable the Tuna Commission to verify fishing activity. Video monitoring, coupled with a Vessel Monitoring System (VMS) where vessels are fitted with an automatic location communicator that sends signals via satellite giving vessel location, speed, and heading would be a cost-effective approach to ensuring compliance. Vessels not fitted with such equipment, or not registered in a member country, would be prohibited from fishing in both the high seas and the EEZs of the PICs.

The proposed institutional structure is likely to encourage self-enforcement, as holders of THRs would help monitor illegal fishing, as noncompliance by others decreases the economic rents accruing from their own quota. Similar self-enforcement mechanisms have been shown to be effective in other fisheries (Duncan and Temu 1997). Moreover, further self-enforcement can be assured by penalizing the entire country's fleet for law infringements made by individual vessels bearing that country's flag. Thus, vessels from each country would have the incentive to monitor fishing activity of vessels from their own country.

Potential Benefits

The proposed governance structure offers substantial benefits to both PICs and DWFNs. First, cooperation gives greater scope for countries to set a regional TAC for tuna that will help to maximize the regional resource rents, potentially increasing every country's net returns from fishing. Second, cooperation would also allow tuna to be caught at an older age, thereby increasing returns per kilogram, as well as ensuring the total harvest was set at a rent-maximizing level. Third, the approach provides a way to prevent free access into the fisheries and mitigates the "race to fish" while complying with United Nations agreements on fisheries. Fourth, it allows tuna to be traded at its marginal value and in a more competitive structure that can benefit both coastal states and low-cost tuna harvesters. Fifth, it provides the opportunity for countries to reap the benefits of economies of size and scope in the management and monitoring of tuna resources.

Concluding Remarks

It is clear from the literature that the PICs are not maximizing net returns from the WCP tuna fisheries, and that current management is not ensuring the long-term sustainability of fish stocks. A model, new to the literature, is developed that illustrates that long-term net revenue of highly migratory and straddling fish stocks is maximized through the introduction of tax-like controls, or an equivalent quantity instrument, by a sole policymaker. The model indicates that the PICs could increase long-term net revenue by cooperating with each other and DWFNs to achieve sole policymaker-type outcomes.

The paper provides an application of this model to the WCP tuna fisheries in a proposed new governance structure for the region that encourages cooperation amongst PICs and DWFNs. The cooperative structure has the potential to offer significant benefits to both existing DWFNs and PICs.

The proposed multilateral governance mechanism for tuna would create a Tuna Commission that would be answerable to participating member countries and com-

ply with the United Nations Fish Stocks Agreement (as has been created in the Western and Central Pacific Tuna Commission). Initial membership would be granted to PICs with EEZs in the region and current DWFNs. Each member country would be allocated *gratis* annual transferable, divisible tuna harvesting rights that would be allocated to both DWFNs and PICs on a negotiated formula. The harvesting rights could be used by any vessel legally registered and authorized to fish by one of the member countries. Every authorized vessel would also have to comply with all management and monitoring regulations set down by the Tuna Commission.

To promote a competitive market for harvesting rights, each member would surrender a small proportion (say 3%) of its annual allocation to the Tuna Commission for tender to the highest bidder, but would receive the full receipts from such sales. In addition, member countries would have the option of tendering up to 100% of their annual allocation if they believed it would generate a higher return than using the rights themselves or leasing them on a bilateral basis. New country entrants into the tuna fisheries would be permitted for a negotiated fee, but they would need to lease tuna harvesting rights from existing members to be able to fish.

Our proposed multilateral governance structure for the management of tuna is intended to be a first step in the adoption of a rent maximizing, but sustainable, governance framework for the region. The greatest difficulty associated with establishing such a structure will be the initial allocation of tuna harvesting rights and the setting of the regional TACs. These potential hurdles are the subject of further research.

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