Environmental Policy and Political Realities: Fisheries Management & Job Creation in the Pacific Islands[♣]

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I. Introduction

Policymaking in developing countries is nothing if not an exercise in balancing objectives. Government agencies choose to subsidize certain activities, tax others, impose quotas or access-constraints over physical resources, and allocate public investments, based on numerous political and economic objectives. Many of these objectives are deeply intertwined, and it is increasingly clear that environmental and development goals cannot be separated. But policymaking often happens in a political landscape that is dominated by particular, narrowly-defined, and potentially competing objectives. Not least, job growth is an especially salient objective in developed and developing countries alike. Environmental policymaking does not happen in a vacuum, and effective policy choices thus require an understanding of how environmental policy instruments interact with other political goals.

In this paper, we analyze job growth strategies in a developing country context that, like many of the world's poorest regions, is heavily dependent on natural resources. With isolated geography and limited natural resources, Pacific Island Countries and Territories (PICTs) face unique challenges in their pursuit of economic development. Government officials are anxious to create more jobs and communities want more and better opportunities for their children. Tuna is the most valuable natural resource in most PICTs. Fisheries represent both the primary source of domestic food production and the region's most valuable export commodity. Tuna lies at the heart of PICT fisheries. It is by far the largest market of any fishery in the region. Indeed, tuna species represent seven times the value and ten times the volume of all other fish caught in the Pacific Islands *combined*. (Gillett & Bromhead, 2008)

PICTs are searching for the best way to leverage their tuna resources into sustainable economic development as well as job creation. This latter goal is worth emphasizing, as unemployment in the region is often very high and local rhetoric suggests that development strategies that focus exclusively on increasing government revenue without increasing employment are undesirable. At the same time, some policies that appear to foster employment may actually be counterproductive, as the preservation of a healthy tuna stock is a critical element in any successful long-term strategy. This paper develops a model that analyzes the costs and benefits of pursuing different development strategies, with a particular focus on jobs creation and the local socioeconomic factors that drive the optimal policy mix across PICTs.

The choice of environmental policy instruments is of primary importance to foster sustainable economic development and is the subject of extensive studies in developed and developing countries alike (see for example Sterner and Coria, 2011). Some have focused on the interplay – and, more often, the disconnect – between the study of instrument choice and political realities. (Keohone, Revesz, and Stavins, 1998) When adapting instrument choice to a context like ours in the PICTs, one must not only account for the unique challenges of geography and limited resources, but also the specific set of goals of their policymakers. In particular, employment provision is very high on the list of priorities and thus pragmatic policy design should take this into account.

The paper is organized as follows. The next section provides some basic background on tuna fisheries and investment strategies in PICTs. Section III provides a basic economic model that highlights the tradeoffs between revenue generation and employment creation, identifying optimal investment portfolios based on local conditions. Section IV puts the model in context with the development of some general cases. Section V offers some concluding remarks.

II. Background

Four major tuna species are harvested in the PICT's: albacore, bigeye, skipjack, and yellowfin. PICTs generate income from each of these tuna fisheries in a variety of ways that are not mutually exclusive: they operate fishing fleets, they sell the rights to access the tuna in their waters to foreign vessels ('access fees'), and to a lesser extent they process tuna in domestic canneries and loin packing facilities for export. While significant global overcapitalization in purse-seining fleets makes additional investments in domestic fishing capacity a nonviable growth strategy (Evans et al, 2008 ; FAO, 1999), both access fees and processing are potential areas to foster economic growth in the region.[1]

Processing facilities buy raw tuna from fishers, transform it into a product with shelf-life, and then sell those products to international markets through distributors or trading companies. The handful or processors in the region that are vertically integrated brand owners sell directly to their customers. Processing can take two primary forms: canning and/or the production of cooked frozen tuna loins. The appeal of expanding this sector hinges on two assumptions. First, investments in domestic tuna processing capacity will allow PICTs to capture more of the value of the tuna harvested in their waters. Second, it will create significant amounts of local employment. The degree to which these assumptions are likely to hold depend, in turn, on a range of local economic factors. The profitability of establishing processing facilities will depend on the availability of complementary domestic infrastructure that can facilitate the development of a large-scale export business. Since the capital costs of these facilities are substantial, albeit more so for canning than loining, access to capital markets and borrowing costs will also be important. On the employment front, it is also worth noting that many of the jobs created are often viewed as undesirable by the local labor pool (Barclay, 2010).

[1] The analysis developed here generally envisions the markets for yellowfin, skipjack, and bigeye tuna. The market structure for albacore tuna in the Western and Central Pacific is quite distinct, with the majority of fish caught by longliners and shipped whole and frozen (Hamilton et al., 2011).

In contrast, access agreements are simply contractual arrangement that provide foreign vessels with the right to fish in PICT EEZs.[2] Agreements typically define a number of allowable fishing days that can be caught by the foreign entity in exchange for payments in the form of access fees. All PICTs collect access fees and these license/vessel day payments often represent a significant source of government revenue. While access fees do not require significant capital investment, they also do not directly create employment, one of the key goals for many PICT policy makers.[3]

Both of the aforementioned economic development strategies depend critically on the health of the tuna fishery and several tuna species are currently overfished (International Sustainable Seafood Foundation, 2011). Economic studies of bigeye tuna, for example, conclude that a business-as-usual approach, pursued over the next 50 years, would result in net present value loses of US$3.4 billion region wide compared to optimal harvesting (Gillett, 2009). Overfished stocks also create stagnation in local coastal fisheries, which has enormous impacts on local income and nutrition across PICTs (Gillett, 2009). Tuna stocks in the Pacific face serious risks,[4] and ensuring that the resource is both profitable and sustainable for PICTs requires better fisheries management at all levels.

Management efforts over the past decades have attempted to respond to depressed spawning populations and large-scale concern over the health of these fisheries. In the Pacific, the Western and Central Pacific Fisheries Commission (WCPFC) was established under the Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean, with the objective of

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[2] For an overview of the vessel day scheme in the WCPO, see (Shanks, 2010; Havice 2010).

[3] Licensing agreements with foreign vessels could include a condition that the catch be locally landed and processed, shifting the burden of capital investment to the foreign entity – but in this case we would expect the costs of this investment to be capitalized in the licensing fee, decreasing the revenue that could otherwise be gained from foreign access fees.

[4] Many scientists have been warning for decades of major stock conservation problems in Pacific yellowfin and bigeye tuna in the western and central Pacific Ocean (Report of the fourteenth meeting of the Standing Committee on Tuna and Billfish, 2001); see also Song, et al. 2008.

conserving and managing highly migratory fish stocks, including tuna.[5] Scientists in both the WCPFC and the Inter-American Tropical Tuna Commission have recommended numerous management options, including catch and effort limits, gear restrictions, and time and area closures (Maunder & Harley, 2006), but these suggestions have not been fully implemented. (Sibert, Hampton, Kleiber, and Maunder, 2006)

Better management of tuna fisheries could improve the health of the fisheries, which in turn can improve the livelihoods of local subsistence and commercial fishers and help access fees to appreciate (or at least not depreciate in the face of otherwise declining fish stocks). Management strategies must balance the incentives of fishers, fish processors, and government, in a context where scientific and managerial skills are scarce – thus adoption of effective strategies is not often an easy feat. At the same time, effective management and enforcement is labor-intensive and thus could help local leaders achieve their employment goals. Numerous studies of commercial fisheries show that incentive-based approaches that clearly specify individual and group harvesting rights, establish prices for ecosystem services, and are combined with effective monitoring, oversight, and public research, are key to promoting the economic and ecological health of fisheries. (Grafton et al 2006) Such management strategies require a combination of activities at sea (e.g. on-board observer programs and vessel monitoring), at port, and in back offices in support of the data infrastructure. At least some of these jobs are high-skill, and the generation of these jobs and required training would increase scientific and managerial capacity in the region that could generate spillovers to other sectors of the local economy.

Of course, the highly migratory nature of tuna also poses unique challenges in the management arena. Local investments in fishery health may not be captured locally, making the returns to such investments small to any individual PICT, and generating

[5] The WCPF Convention is the second regional fisheries management agreement to be enacted since the 1995 U.N. Straddling Fish Stocks Agreement was negotiated.

the classic tragedy of the commons problem. Better local coordination could help overcome these externalities, as could coordination with the WCPFC. As we will see in the model that follows, the collateral benefits of job creation will also boost the case for investments in management.

While all relevant parties appear to recognize the need for improved fishery management, the public discussion of development strategies tends to cast the revenue benefits of access fees against the employment opportunities from processing investments, treating sustainable fisheries management as distinct from these two.   Recognizing that management also generates employment benefits suggests that the choice between strategies is more complex.   As a result, we now turn our attention to a series of stylized models of optimal economic development portfolios that illustrate the implicit costs of employment targets and the potentially important role that can be played by management strategies in lowering the costs of meeting those objectives.

III. The Model

In this section, we develop a very simple model of tuna fishery development strategies for Pacific Island Countries and Territories (PICTs). The goal of this model is to extrapolate from many of the socio-political complexities within the region to focus on a core set of investment strategies and the tradeoffs inherent in the pursuit of each of them. In our initial specification of the model, we make the standard assumption that the government's goal is to maximize its revenue given investment opportunities. The government can generate revenue through the sale of fishing access rights and/or investments in the processing sector, with the presumption that government revenue is then used to achieve various social objectives. One such social objective that is frequently raised in the context of PICT economies is employment. It appears, however, to be difficult for many PICT governments to create sufficient numbers of (desirable) jobs directly through the expenditure of government revenue. As such, we also develop a model that explicitly imposes an employment target on the fishery development strategy and examine how this changes the optimal portfolio of investments. Finally, we introduce investments in fishery management as an additional development strategy and examine how this changes optimal decision-making with and without an employment constraint.

III.A. Basic Model – No Employment Constraint

In the basic model, the government can raise revenue through two non-mutually exclusive activities: they can sell access rights to fish in their Exclusive Economic Zones (EEZs) and/or they can invest in tuna processing facilities.[6] Adding fleet investment to the model would necessitate a comparison of returns and job creation under this strategy relative to investments in processing, but otherwise would not change the basic intuition from the model.[7] Letting f denote the access license fee and q_l denote the quantity of licenses sold denominated in standardized units of biomass or fishing days, we can represent government net revenue from the sale of licenses or vessel days as follows:

$$\pi_l = f\left(q_l, \Omega\right) q_l \qquad (1).$$

Two key features are noteworthy. First, the fee for the license will depend on the number of licenses that are sold. Second, the fee for the license will depend on the health of the fishery as captured by the variable Ω, with larger values indicating greater health. In particular, we assume that $f' < 0$ and $f'' > 0$ with respect to q_l and the opposite with respect to Ω, reflecting the fact that the value of the permit

[6] PICTs can also induce this investment by others by tying these investments to fishing access within the EEZ. Functionally, this operates in a manner similar to direct ownership, although the costs of this investment flow through a different channel. This will be discussed in greater detail at the end of Section III.A.

[7] While investments in fishing fleets represent a third option, existing overcapitalization in the industry suggests that this is unlikely to be a desirable strategy. It is worth noting, however, that some PICTs are arguing that existing boats from developed countries should be transferred to them without capacity replacement.

diminishes as fish become more difficult to catch and that this becomes increasingly costly as fish become scarcer.[8] Further, the importance of Ω will depend, in turn, on ex-vessel tuna and fuel prices, since the amount of effort required to catch fish is increasingly important as the costs of boat operation increase.

On the processing side, we will remain agnostic as to the form of processing (e.g. canning versus loin packing), although the capital costs required for each type of facility will clearly depend on these details.[9] Since the capital investments required to develop processing facilities are non-trivial for all forms of operations, they will be a key driver of decisions here. As such, we embed the variable costs of operation, including labor costs[10], into the processing revenue function in order to simplify the model. Letting R_p denote processing revenue and K represent the size of the capital investment (e.g. size and type of plant), the government net revenue function from processing can be represented as follows:

$$\pi_p = R_p(K, X) - rK \quad \pi_c = R_c(K, X) - rK \qquad (2).$$

Clearly, the revenue from processing will depend on the size of the capital investment. It will also depend on an X vector of local characteristics, particularly on the quality of existing infrastructure, including the electric grid, the water supply, and various transportation networks which directly impact the costs of shipment to finished product destinations. Over the relevant range, we make the standard concavity assumption regarding the revenue function with respect to capital expenditure and the quality of local infrastructure, i.e. $R_p' > 0$ and $R_p'' < 0$. The costs

[8] Note that this feature holds if access fees are denominated in biomass or fishing days. If biomass, fishing fleets will incur higher expenditures to meet their catch limit when fish are difficult to capture and thus be willing to pay less for that right. If fishing days, an unhealthy fishery will diminish daily yields and similarly reduce the amount fishing fleets are willing to pay for that right.

[9] While not formally included in our conceptualization, the intuition from our modeling also applies to investments in transshipment facilities.

[10] Of course, labor costs and availability varies across PICTs and will play an important role in determining the profitability of investments that must ultimately compete in a global market for processed output.

of this investment will principally depend on the borrowing costs, denoted *r*, required to acquire the relevant capital equipment. It is worth noting that these borrowing costs will, in part, reflect the riskiness of the investment and will likely vary across PICTs due to differences in access to capital markets.[11]

Pulling both pieces together, we can express the government's maximization problem as follows:

$$\max_{q_l, K} \quad \pi_l + \pi_p = f(q_l, \Omega)q_l + R_p(K, X) - rK \qquad (3).$$

Optimal investment strategies can then be characterized by the following first order conditions:

$$\frac{\partial f}{\partial q_l} q_l + f = 0 \qquad (4)$$

$$\frac{\partial R_p}{\partial K} - r = 0 \qquad (5).$$

Equation (4) simply illustrates that is optimal to operate as a monopolist when selling access permits. Since PICTs know that selling additional licenses will force them to lower the price for them, they will sell licenses until the point that the marginal revenue product from those licenses equals their production costs, which in this case is zero since the fish are an existing natural resource in the EEZ.[12] It is worth noting that for PNA countries, each nation is allocated a share of total allowable effort for the parties. If this cap is less than the corresponding quantity of

[11] These differences will reflect variation in the riskiness of investments across countries/territories as well as existing bilateral and multilateral agreements that impact borrowing costs.
[12] The pure monopolist result obtains because we assume that permit prices do not depend on the sale of licenses by other countries. If we relaxed this assumption, the optimal strategy would be one that corresponds to monopolistic competition with returns depending on relative market share (e.g. the size and quality of fishing grounds) across the region. For PICTs that are PNA, This will depend on the shares of the total allowable effort allocated to each under the vessel day scheme.

days that would be sold under the pure monopoly regime, countries will sell their full allotment of days.[13] Equation (5) states that the optimal capital investment in processing will occur at the point in which the marginal revenue generated by that capital investment equals borrowing costs. Denote this optimal investment as K^*. Recall that the marginal revenue function will depend, in part, on the quality of local infrastructure X. Recall that our definition of infrastructure is quite broad, including the reliability of electricity and water supplies as well as transportation infrastructure, which will determine the costs of moving product to major markets around the world. Since borrowing costs are non-trivial, it is entirely possible that r will exceed the marginal revenue for all levels of capital investment, and this possibility becomes increasingly likely when existing infrastructure is unsuitable for the processing industry. In this case, the optimal investment in processing K^* will be zero.[14] While our simple model extrapolates to a large degree from geography, it is important to note that distance from port to prime fishing grounds will also influence processing profitability and can be viewed as another component within the vector X.

It is important to note that K^* is a function of both the cost of capital and the quality of infrastructure. Lower X will require a lower interest rate to make processing a good investment. Likewise higher r will require a higher quality infrastructure endowment to make investment worthwhile. In practice K^* will differ depending on the type of processing facility since canning and loining facilities require different levels of capital outlay, different types of infrastructure (e.g. loining requires freezing capabilities) and generate different revenue profiles.[15] It is also worth emphasizing that licensing and processing are non-competitive activities in this

[13] In that case, equation (4) would be modified by a quantity constraint corresponding to effort shares..

[14] Technically, the optimal investment would be negative in our framework, but we are implicitly operating under the assumption that it is not feasible for PICTs to hold a short position on K.

[15] The same is true for transshipment and investments in other port services that are currently common in places such as Majuro.

framework. The optimal number of licenses sold does not depend on processing investments and vice versa.

In practice, the foreign financing of processing facilities is often made a pre-condition for access to PICT EEZs. Similarly, some access arrangements require a fraction of the catch to be delivered to local processing facilities. Economic theory suggests that these preconditions will be capitalized into the price of licenses/vessel days. Thus, imposing these requirements will essentially increase the viability of processing at the expense of revenue from the sale of fishing rights within the EEZ. While incorporating such concessions is beyond the scope of the modeling in this paper, it is important to keep these factors in mind when applying the insights of the model to the experience of individual PICTs.

III.B. Basic Model - Employment Constraint

In this section, we revisit the decision making process when a formal employment target is placed on development strategies in this sector. In particular, we assume that the government requires investments in the tuna fishery to create at least $\hat{J}$ jobs. The government's maximization problem can now be described as:

$$\max_{q_l, K} \quad \pi_l + \pi_p = f(q_l, \Omega) q_l + R_p(K, X) - rK \quad st \quad J \geq \hat{J} \qquad (6).$$

By construction, we assume that the fishing licenses/days sold to foreign fishing fleets do not generate any local jobs[16] and that a processing investment of size K creates J_K jobs.[17] If the optimal capital investment in processing K^* defined in (5) is

[16] While local employment can be made a precondition to the sale of an access license, if this were not desirable absent such a clause, the requirement would be capitalized into the license fee thus reducing revenue from the sale. For the sake of simplicity, we ignore this possibility in our analysis.
[17] Relaxing the assumption of fixed labor inputs for a given capital investment does not change the general intuition of our results, but complicates the analysis under an employment constraint. If labor inputs are not fixed, countries may consider 'optimal' over-employment per unit capital in order to meet the labor constraint in the least cost fashion.

larger than $\hat{K}$, where $J_{\hat{K}} = \hat{J}$, the employment constraint does not bind and optimality is identical to the case without an employment constraint. In the likely case where K^* is less than $\hat{K}$, the optimal investment strategies can be characterized as follows:

$$\frac{\partial f}{\partial q_l} q_l + f = 0 \qquad (7)$$

$$K = \hat{K} \qquad (8).$$

Equation (7) is identical to equation (4), indicating that the optimal number of access permits sold remains unchanged when an employment constraint is imposed. Since permit sales do not create jobs and they do not interact with the profitability of the processing sector, the country continues to operate as a pure monopolist when selling access permits. Since only processing creates jobs, equation (8) simply states that investments in processing will be made until the employment constraint is met. The costs of meeting this constraint are increasing in the size of the jobs gap between what is optimal without an employment constraint and the size of the employment requirement as can be seen in the following expression for those costs:

$$\int_{K^*}^{\hat{K}} R_p(K, X) - rK \qquad (9).$$

Since K^* is decreasing in the costs of capital and increasing in the quality of the local infrastructure endowment (which includes distances from fishing grounds and product markets), these costs will be larger for those PICTs that face high borrowing costs and/or have poor existing infrastructure.

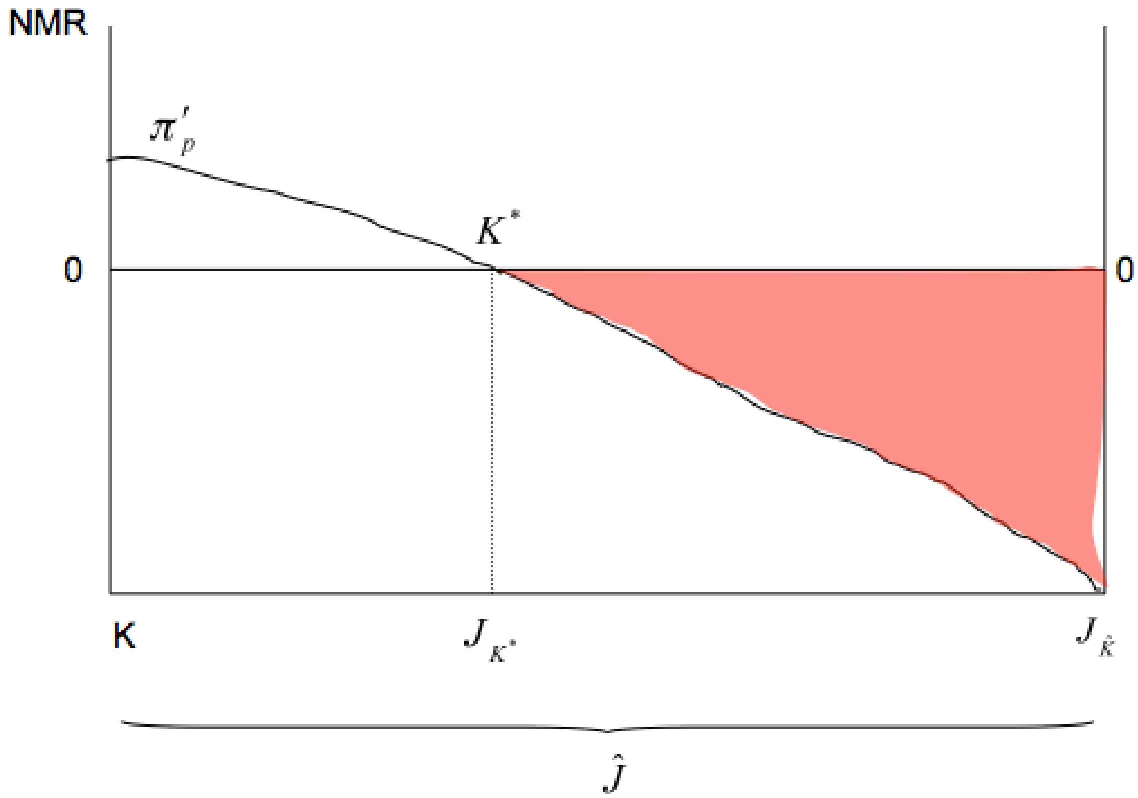

Figure 1: The Costs of Employment Constraint – Processing Only

Figure 1 illustrates the optimal capital investment decision. The y-axis measures net marginal revenue (NMR) and the x-axis measures employment, with its length corresponds to the employment constraint. Absent an employment constraint, optimal investment occurs at the point where the NMR (which is net of capital costs) associated with an additional capital investment in processing equals zero. Meeting the employment constraint requires additional investment. The costs of this additional investment are represented by the shaded triangle in Figure 1, which precisely corresponds to the costs described in equation (9). Higher borrowing costs and/or poor infrastructure shift the NMR curve downward, increasing the size of the triangle, corresponding with increased costs of meeting the employment constraint.

III.C. Fishery Management

In this section, we introduce the possibility of investments in fishery management, such as monitoring and verification, which can improve the health of the fishery Ω. Recall that the fee for access permits depends on fishery health and let that value be represented by V_{Ω}, which is implicitly defined by equation (4). We can express the government's net revenue function from an investment in fishery management of size *m* as follows:

$$\pi_m = V_{\Omega} \cdot \Omega(m, E) - c_m m \qquad (10).$$

As per usual, we assume that fishery health is increasing in management investments as a decreasing rate. Fishery health in a given region also depends on the degree to which the rents associated with health benefits are captured externally by neighboring countries/territories, e.g. the nature of the commons problem in the region and thus the degree of management coordination across EEZs. If most of the benefits from improving fishery health are dissipated by fish migration or increased fishing intensity amongst neighbors, corresponding to a large *E*, the returns to management will be quite small. In this regard, it is worth noting that the vessel day scheme for PNA countries, which is a transferable effort rights-based management program, is designed to increase the revenue from the fishery and mitigate this commons problem, at least within the PNA territories. We assume that local fishery health is decreasing in *E* at an increasing rate. Noting that c_m represents the per unit cost of the management investment[18], the optimal investment in management can be characterized as follows:

$$V_{\Omega} \frac{\partial \Omega}{\partial m} - c_m = 0 \qquad (11).$$

[18] We assume constant costs per unit management since, as will be clear in the paragraphs that follow, most of the management investment is in labor and our presumption is that wages are relatively flat in this domain.

PICTs should invest in management up until the marginal revenue from permit sales due to improved fishery health equals the costs of improving that health. When externalities across fishing regions are high, this optimal investment may well be zero.[19] [20] The key insight arises, however, when one recognizes that management strategies create jobs. Thus, when operating under an employment constraint, that objective can now be met with management jobs as well as (instead of) those in processing. Let J_m denote the number of jobs created by a management investment of size m. Assuming an interior solution[21], optimal investments in management and processing will now be determined by choosing quantities such that the marginal cost of producing jobs across the two strategies is equated:

$$V_\Omega \frac{\partial \Omega(\tilde{m}, E)}{\partial m} - c_m = \frac{\partial R_p(\tilde{K}, X)}{\partial K} - r \quad st \quad J_{\tilde{m}} + J_{\tilde{K}} = \hat{J} \tag{12}$$

By recognizing that investments in fishery management are a source of employment, we now reduce the costs of meeting the jobs constraint by the following:

$$\left(\int_{\tilde{K}}^{\hat{K}} R_p(K, X) - rK \right) - \left(\int_{m^*}^{\tilde{m}} V_\Omega \cdot \Omega(m, E) - c_m m \right) \tag{13}$$

[19] Again, we assume that investments are implicitly constrained to be non-negative.
[20] The impact of positive management investments on optimal permit sales (defined in (4)) is ambiguous and will depend on the degree to which quantity and quality are complements or substitutes in the access fee production function f( ). In the likely case where these are complements, these investments will lead to an increase in optimal permit sales.
[21] If the marginal cost of producing the last job required to meet the constraint under management is less than the marginal cost of producing the first job under processing, then all jobs will be created through management and optimal investment in processing will be zero unless it is profitable absent the employment constraint. Given the relatively modest costs of creating jobs through fishery management, it is unlikely to be optimal for all jobs to be created through the processing sector.

While binding employment constraints can only be met through over-investing in labor, some of the excessive investment that would have taken place in processing can now be replaced with less expensive over-investment in management.[22]

The relative advantage of investments in processing versus management under an employment constraint will depend on three critical elements that are likely to differ across PICTs – the quality of infrastructure that is complementary to processing activities, borrowing costs, and the degree to which the returns to better management can be internalized. When borrowing costs are high, infrastructure is poor, and management externalities are small, management strategies will clearly dominate. When the opposite is true, processing strategies will be preferred. Intermediate cases will depend on relative magnitudes, with optimality characterized in (12) and the cost savings associated with the usage of management as an employment strategy described in (13).

[22] In practice crewing requirements on purse-seiners also represents another avenue for job creation. As with the case of processing requirements, the costs of crewing rules will be capitalized into the price foreign fleets are willing to pay to fish in PICT EEZs. In this case, optimal management jobs will be determined by comparing their costs to the implicit costs of jobs creating through crewing requirements as well.

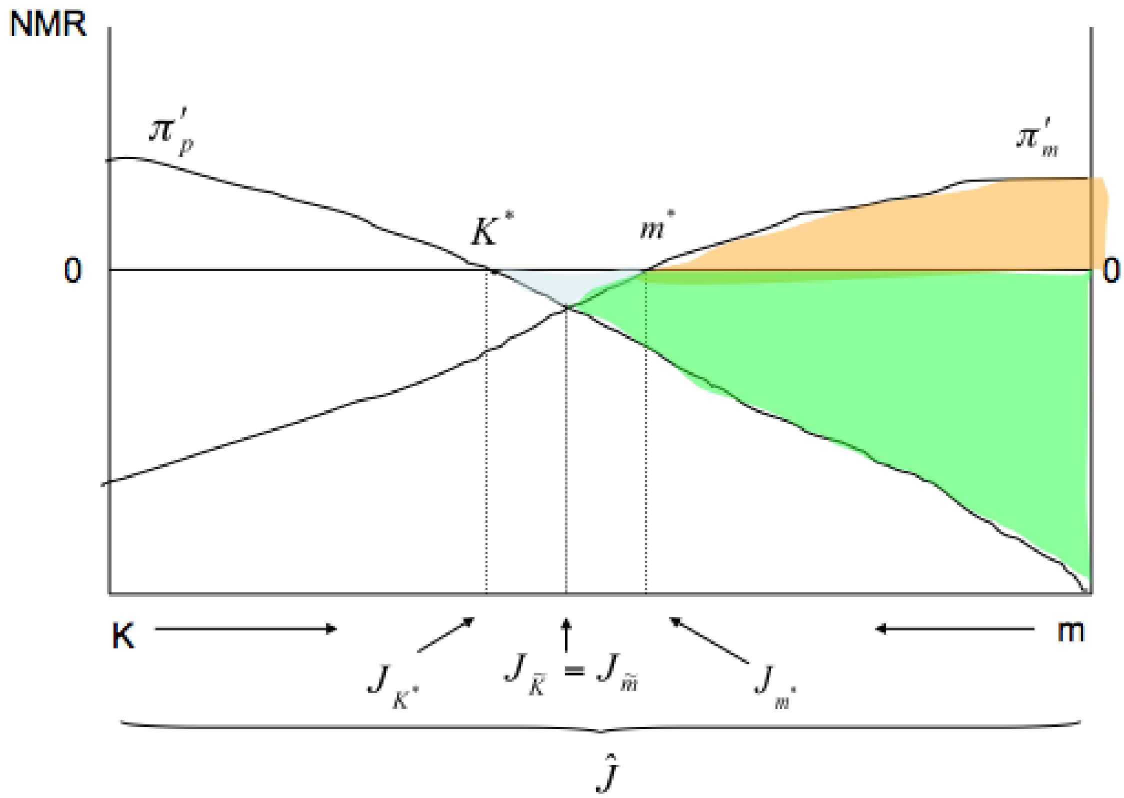

Figure 2: The Costs of Employment Constraint – Processing and Management

Figure 2 plots the net marginal revenue associated with investments in processing and management. Capital investments in processing are increasing from left to right and management investments are increasing from right to left, with the total length of the x-axis corresponding to the jobs constraint. The optimal amount of each investment corresponds to the point where the net marginal returns from additional investments are zero: K^* and m^*. As the figure is drawn, optimal investments are not sufficient to meet the employment constraint so additional investments will be made in each according to (12). The costs of meeting this constraint are now a fraction of those under processing only -- the small blue triangle instead of the blue triangle plus the green polygon corresponding to the large pink triangle in Figure 1. Moreover, investments in management under this scenario have generated some positive revenue, represented by the orange triangle that offset some of these costs. It is also worth noting that, even in the case where optimal investment in management is zero because its diffuse benefits do not outweigh its costs, as long as the NMR curve for management intersects the NMR curve for processing somewhere on this figure, some investment in management will be worthwhile to meet the jobs constraint and that investment will lower the costs of meeting the employment target.

IV. Applying the Model

In order to understand the impacts of this economic model, it is helpful to understand the regional magnitudes of the relevant metrics. Limited data availability and the complex and varied terms of each investment make a hard empirical analysis impossible. As a result, this section will paint in broad empirical brush strokes with the goal of developing a broad typology for analyzing the investment decision.

The two markets most critical to tuna fishery development are the market for access fees / fishing days and the tuna processing industry. The value of fisheries and aquaculture in the Western and Central Pacific Ocean (WCPO) in 2007 was US$2 billion of which offshore fishing contributed 75% (Gillett, 2009). The region is the largest tuna fishery in the world and is a patchwork of overlapping sovereign exclusive economic zones (EEZs) and bodies of international water. While foreign fleets are free to fish in international waters, subject to Western and Central Pacific Fisheries Commission (WCPFC) membership or cooperating non-membership, governments can impose constraints on or require payment from fleets in their territorial EEZs. From 2002-2007 about 20% of the WCPO fish was caught in international waters with the remaining 80% caught in Pacific island EEZs or archipelagic waters. The right to fish in an EEZ is extremely valuable and PICTs currently license the right to fish in their sovereign EEZs by charging access fees and the sale of licenses (through negotiations or treaties) or by the sale of vessel days for PNA countries.

Access fees represent approximately 5-8% of the landed value of the tuna catch.[23] While these fees may appear low at first blush, the substantial and highly variable operating costs of fishing operations imply that they can represent a substantial fraction of industry profits. Total access fees grew by 25% between 1999 and 2007 to US$78.5 million region wide (Gillett, 2009).

Investments in processing can take the form of canning facilities or loin-packing plants. Loin-packing is a lower value-adding technique where raw fish are processed into loins which are sold to canneries or other value-adding fish processing facilities. Canning requires more capital-intensive equipment but processes the tuna into a market-ready canned product. Tuna processing (canning and loin-packing) facilities on PICTs tend to be medium-sized and employ from a few hundred to a few thousand workers (Barclay, 2010). Region wide, tuna processing employed 11,116 people in Pacific Island countries in 2008, 77% of whom were in Papua New Guinea (Gillett, 2009)[24]. Pacific Island Territories also have tuna processing industries, particularly American Samoa where the canneries employed 17,395 people in 2008 (Gillett, 2009). It is worth noting, however, that at least some of this labor was imported rather than domestic. The scope for the creation of additional jobs through new processing facilities remains unclear. The vast majority of canned tuna caught in the WCPO is processed in Thailand, where cheap labor costs and scale economies make them an industry leader (Barclay, 2010) (Hamilton et al., 2011).

While the value of investments in on-shore processing as part of a development strategy for PICTs has received a considerable amount of attention in the literature, conclusions have been mixed (Barclay and Cartwright, 2007). Moreover, nearly all studies have relied on qualitative analyses and expert opinion. Hard data on the

[23] While the focus of our analysis is on the quantity of permits sold, it is also worth noting that there remains the opportunity to expand revenue growth from extant permits. Papua New Guinea, for example, was able to increase its access fee revenues by 134% between 1999 and 2003 simply by putting in place basic institutional reforms (Barclay and Cartwright, 2007).

[24] Note these figures do not include numbers for Indonesia or the Philippines.

returns to processing investments have been quite elusive. . One notable exception is the recent study by Evans et. al. (2008) which concluded that PICTs could realize potential profits of US$952 per ton if they could combine domestic purse seiner fishing with on-shore processing and canning (as opposed to US$80 per ton in direct revenue from access fees) (Evans et al., 2008). But that profit was measured as Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA). EBITDA excludes capital expenditures, which the same study claimed would be US$2500 per ton (Evans et al., 2008). Because PICT governments often give concessions to domestic fishers and processors, the study projected that government revenue would actually *fall* with increases in domestic processing (Evans et al., 2008). In addition, if multiple PICTs pursued this strategy simultaneously, it would create an environment of price competition between islands and put pressure on any potential profits of such an operation.

Nevertheless, building a domestic tuna processing industry may be possible and profitable for some countries with established infrastructure and larger industrial and capital bases. PICTs are quite heterogeneous and optimal investments will depend upon local characteristics. For the purposes of illustration, the discussion that follows will divide PICTs into two broad types: 'large' islands that have sizable populations, land area and domestic commercial activity outside of the fishing sector and 'small' islands that have limited populations, land area and domestic commercial activity outside of the fishing sector.

As highlighted earlier, the chief alternative to creating jobs through processing is investments in fishery management. A comprehensive management strategy will include a combination of activities at sea, at port, and in back offices in support of the data infrastructure. Management includes the collection of data on annual and operation-level catch and effort as well as data on catch composition and vessel and fishing gear characteristics. Fishery monitoring for unlicensed fisherman and the intentional mislabeling of species is also important. Since most of these activities are labor-intensive, employment opportunities will be created in a wide range of activities. These include port inspections, port sampling, vessel monitoring systems, vessel registries and/or licensing databases, logsheet programs, vessel characteristics and activity documentation, observer programs, catch landings and transshipment monitoring (Oceanic Fisheries Programme Secretariat of the Pacific Community, 2003).[25] These management jobs are often described as more desirable than those creating in processing facilities, although those that involve lengthy periods at sea may be less attractive for some. In the cases that follow, we ignore these job quality differences. Including them would skew our conclusions toward larger investments in fishery management activities.

The magnitude of job creation through investments in management is rather difficult to quantify, but some basic numbers are illustrative. It is estimated that purse-seiners spend approximately 43,750 sea days per year and that longline and pole and line vessels spend 579,060 sea days per year within the Western and Central Pacific (Gillett, 2007). If observers spend an average of 150 days at sea per year, 100% coverage on purse seiners and 5% coverage on the other vessels would generate roughly 500 jobs. Since PICTs appear committed to those levels of coverage, additional employment opportunities for observers will arise from expanding coverage on longliners and pole and line vessels.[26] Every 10 percentage point increase in coverage on those vessels creates another 400 jobs, with complete coverage generating as much as 3800 additional observer employees.

The prospects for employment for in-port management activities appear smaller. A busy port with 2-4 longliners unloading daily will typically require one port entry manager, 2 port samplers to collect length-frequency data, and 5 employees to manage data. Transshipment activities could add another 2 full-time-equivalent employees, suggesting that a busy port would typically employ approximately 10 individuals (Brogan, 2011). Expanding employment in this sector will come through

[25] In fact, some countries, particularly the Solomon Islands and the Federated States of Micronesia (e.g. Pohnpei) have made sizable investments in these forms of management.
[26] It is important to note, however, that the economic viability of pole-and-line fishing in the Pacific Islands going forward is uncertain (Gillett, 2011).

improvements in those well-run active ports – improved port sampling and data management could double on possibly triple the number of employees in a busy port (Brogan, 2011) – as well as the expansion of such monitoring to other less developed sites. Clearly, the aggregate number of potential port management jobs that could be created will depend on the number of active ports in the region.

IV.A. 'Large' PICTs

'Large' PICTs, like Papua New Guinea, are characterized by: a relatively diverse portfolio of domestic industries, established transportation, electrical and port infrastructure, larger populations, access to low-interest capital, larger GDP and islands that have significant land mass. Under such conditions, non-trivial investments in processing, particularly when employment is a significant concern, may be desirable.

Figure 3 illustrates the optimal investment strategy for 'large' PICTs. In this case, the effective costs of large-scale capital investments are lower due to cheap access to credit and the ability to leverage existing and complementary infrastructure, leading to optimal investments in processing that may be substantial and generate considerable employment. Indeed, Papua New Guinea has made incredible strides in building out local canneries. Since higher levels of capital investment are subject to diminishing returns, investments in fishery management can still play a role in lowering the costs of meeting the employment constraint, even in 'large' PICTS. Optimality under the employment constraint will again lead to investments $\tilde{K}$ and $\tilde{m}$, but in this case processing may make up the lion's share of economic development strategy. It is also worth noting that the efficiency gains in job creation from instituting a management regime are magnified if management generates substantial improvements to the health of the fishery.

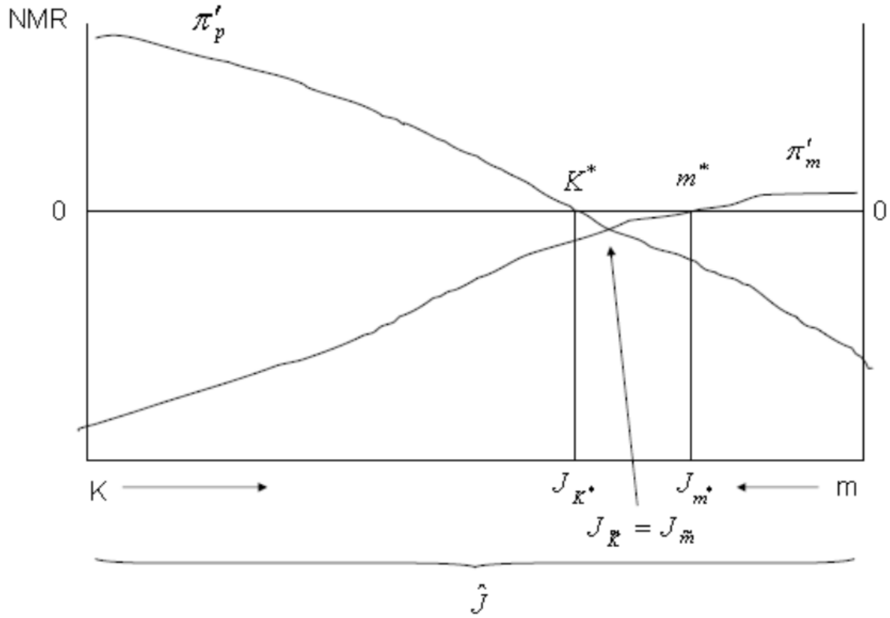

Figure 3: Optimal Investment Strategy – 'Large' PICTs

IV.B. 'Small' PICTs

'Small' PICTs, like Kiribati, are characterized by: few domestic industries, little transportation, electrical or port infrastructure, small populations, limited access to low-interest capital, smaller GDPs and very little landmass. The availability of sufficient quantities of non-brackish water is also a concern for many "small" PICTs. Under these conditions, building a domestic tuna processing industry may not be an effective development strategy.

Figure 4 depicts the likely optimal investment strategy for "small' PICTs. In this case, high capital costs and limited infrastructure make investments in processing unprofitable at any level (K^*=0). While the management strategy depicted in the Figure is not hugely profitable, it still manages to meet the job constraint at a lower cost than investments in processing (i.e. the two marginal profit functions do not intersect). 'Small' PICTs that find their effective cost of capital a bit lower, may find small investments in processing, presumably the less capital-intensive loin packing, optimal under a significant employment constraint. Such a scenario would be depicted by an intersecting marginal profit lines in Figure 4, but under most reasonable assumptions the vast majority of employment would still be created through investments in management.

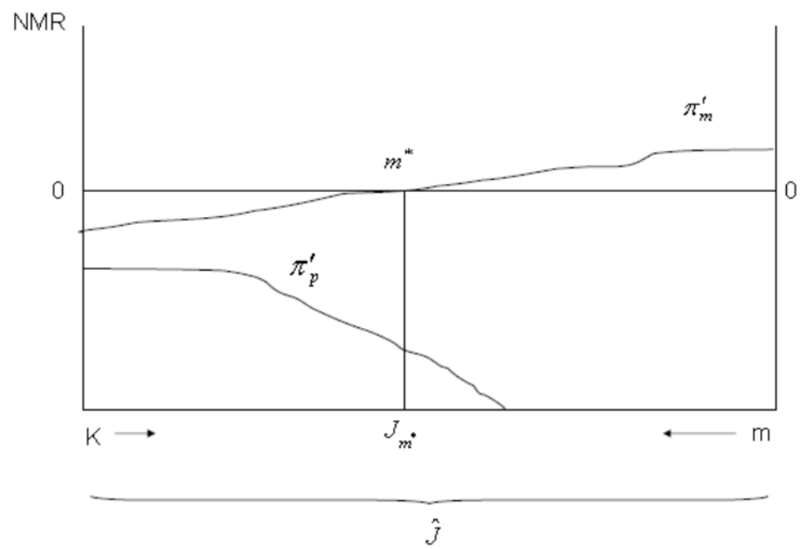

Figure 4: Optimal Investment Strategy – 'Small' PICTs

Thus, 'small' PICTs appear better off focusing on establishing a significant tuna management regime. This approach allows them to create jobs more efficiently (i.e. at less cost per job created) and is likely to improve the health of their fishery. The fishery improvement can, in turn, increase returns to domestic fishing as well as increase revenue from licensing agreements in the long-run.

V. Conclusion

Pacific Island Countries and Territories (PICTs), like most nations of the world, have expressed a strong interest in both economic development and jobs creation. The fishing sector, and particularly tuna, represents the key area through which these objectives will be reached for most PICTs. While the sale of access permits / vessel days to foreign fishing fleets provides much needed government revenue, it does not generally produce domestic employment. As a result, many PICTs have begun to focus their attention on establishing processing capacity. In this paper, we have argued that investments in sustainable fisheries management represent a third avenue for encouraging development and creating employment opportunities.

Economic modeling highlights the implicit costs of employment targets and reveals important tradeoffs across fishery development strategies. Optimal investment portfolios depend critically on a range of local characteristics, including access to credit, existing transportation and manufacturing infrastructure, and coordination and cooperation across neighboring fisheries. As a result, there is no single best development path for PICTs, but rather a collection of best strategies that are tailored to the heterogeneous and idiosyncratic situations that characterize each specific location.

Modeling suggests that some engagement in the sale of access rights to foreign vessels is universally desirable, particularly because it provides a relatively risk-free means to generate revenue. The relative size of optimal investments in processing and management are much more context specific. 'Large' PICTs with access to low 'effective' capital costs, due to low borrowing costs and the presence of complementary industrial infrastructure, may be able to create jobs and generate positive returns on investment in domestic tuna processing, either in the form of canning or loining. 'Small' PICTs with little access to low-interest capital are better off creating jobs through investments in fishery management. Those with moderate capital costs may find a more even mix of activities optimal.

It is important to note, however, that the economics of the processing industry suggests that some investment in tuna fishery management appears optimal even for large PICTs when employment targets are part of the development strategy. Management creates desirable jobs, some of which will help to build local human capital that could contribute to the expansion of other island industries. With regional cooperation, management could also supplement government revenue and boost economic growth with little investment risk.

In the long-term, better management of fisheries will help to ensure the survival of one of the PICTs' most valuable natural resources. In turn, healthy tuna stocks improve the composition and availability of biomass in the fishery. This healthy marine ecosystem improves the lives and livelihoods of the principal constituencies of PICT governments -- subsistence fishers as well as commercial and coastal fishers who serve the local market. Large, healthy tuna stocks would also expand government revenues. Access fees that license the right to harvest the fishery and the value of vessel days for PNA countries would appreciate, as time spent in the fishery becomes more valuable and the knowledge gained through management improves the bargaining position of PICTs when negotiating agreements.

While many of the extant benefits from better fishery management have long been recognized, its ability to create high-quality employment opportunities has generally been overlooked. For many PICTs, this may represent the lowest cost strategy for jobs creation, and coupled with the sale of fishery access to foreign vessels, can form a strong basis for an economic development plan. Better regional cooperation could transform management costs into additional revenue over the longer term, making this coupled strategy more appealing for a larger number of PICTs and further enhancing its contribution to regional economic growth. Future research should focus on estimating the implicit costs of the pre-conditions placed on the sale of fishing licenses / vessel days so that the true costs of job creation through processing, or even crewing requirements, can be compared to those associated with investments in management. Additional data on economic impact multipliers by country for various development strategies would also deepen the analyses and enhance policy discussions on strategies to move forward.

References

Barclay, Kate (2010). "Impacts of tuna industries on coastal communities in Pacific Island countries." *Marine Policy* 34, 406-413.

Barclay, Kate and Ian Cartwright (2007). "Governance of tuna industries: The key to economic viability and sustainability in the Western and Central Pacific Ocean." Marine Policy 31, 348-358.

Barclay, K. & Cartwright, I. (2008). *Capturing Wealth from Tuna: Case Studies from the Pacific*. Australian National University Press and Asia Pacific Press.

Brogan, Deidre (2011). Fisheries Monitoring Supervisor, The Oceanic Fisheries Programme, Secretariat of the Pacific Community. Personal communication.

Evans, D., Philipson, P., Barnabas, N., Roberts, P., Geen, G., Movick, J., Onorio, B., Brown, C. (2008). Final report on the Pacific Islands Forum Fisheries Agency DevFish Project, *Development of a Regional Strategy to Maximize Economic Benefits from Purse Seine Caught Tuna*.

Food and Agriculture Organization (1999). *The management of fishing capacity: A new but crucial issue for sustainable world fisheries.* Technical report, Rome, Italy.

Food and Agriculture Organization (2002) Fisheries Department, *The State of World Fisheries and Aquaculture.*

Gillett, R., & Bromhead, D. (2008). Tuna for Tomorrow ? Some of the Science Behind an Important Fishery in the Pacific Islands. *Asian Development Bank and Secretariat of the Pacific Community*, Manila, ISBN 978-971-561-651-5.

Gillett, Robert (2007). *Notes on the Costs of a Regional Observer Program for the Western and Central Pacific Fisheries Commission*.

Gillett, R. (2009). Fisheries in the Economies of Pacific Island Countries and Territories. Asian Development Bank, ISBN: 978-971-561-708-6.

Gillett, Robert (2011). "The Promotion of Pole-and-Line Tuna Fishing in the Pacific Islands: Emerging Issues and Lessons Learned." Pacific Islands Forum Fisheries Agency.

Grafton, R. Q., Arnason, R., Bjørndal, T., Campbell, D., Campbell, H. F., Clark, C. W., Connor, R., Dupont, D. P., Hannesson, R., Hilborn, R., Kirkley, J., Kompas, T., Lane, D. E., Munro, G. R., Pascoe, S., Squires, D., Steinshamn, S. I., Turris, B. R., & Weninger, Q.

(2006). Incentive-based approaches to sustainable fisheries. *Canadian Journal of Fisheries and Aquatic Sciences*, 63, 699-710.

Hamilton et al (2011). "Impact of Industry and Market Drivers on the Global Tuna Supply Chain." Pacific Islands Forum Fisheries Agency.

Havice, Elizabeth (2010). "The structure of tuna access agreements in the Western and Central Pacific Ocean: Lessons for Vessel Day Scheme planning." *Marine Policy* 34, 979-987.

International Sustainable Seafood Foundation (2011). "Status of the World Fisheries For Tuna: Stock Status Ratings 2011." ISSF Technical Report 2011-04.

Keohane, N., Revesz, R. L., & Stavins, R. N. (1998). The Choice of Regulatory Instruments in Environmental Policy. *Harvard Environmental Law Review*, 22, 313-367.

Maunder, M.N. & Harley, M.N. (2006). Evaluating tuna management in the eastern Pacific Ocean. *Bulletin of Marine Science* 78, 593-606.

Miyake, P. (2005). Historical Developments of Tuna Fisheries and Their Catches. Second Meeting of the Technical Advisory Committee of the FAO Project – Management of Tuna Fishing Capacity: Conservation and Socio-economics. *FAO Fisheries Proceedings No. 2*, ed. W. H. Bayliff, J. I. de Leiva Moreno, & J. Majkowski, Food and Agricultural Orginaztion of the United Nations.

Oceanic Fisheries Programme, Secretariat of the Pacific Community. (2003). *Capacity of Pacific Island Countries and Territories to Meet the Likely Data Requirements of the Western and Central Pacific Fisheries Commission.*

Shanks, Steven (2010). "Introducing a transferable fishing day management regime for Pacific Island countries." *Marine Policy*, 34, 988-994.

Sibert, J., Hampton, J., Kleiber, P., & Maunder, M. (2006). Biomass, Size, and Trophic Status of Top Predators in the Pacific Ocean. *Science*, 15, 1773-1776.

Song, Y-H., Scheiber, H., & Mengerink, K. (2008). Ocean Tuna Fisheries, East Asian Rivalries, and International Regulation: Japanese Policies and the Overcapacity/IUU Fishing Conundrum. *University of Hawaii Law Review*, 30, 97-165.