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Fishing access agreements and harvesting decisions of host and distant water fishing nations

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ABSTRACT

The declaration of exclusive economic zones (EEZs) granted coastal states sovereign rights over the marine resources in their EEZs and enabled developing coastal states to legally charge access fees to distant water fishing (DWF) nations for access to the resources in these waters. Despite the potential for economic gains, however, the ability of coastal states to benefit from the granting of sovereign rights and to ensure the sustainable use of their fisheries resources depends on how domestic fishing effort responds to the harvesting decisions of the DWF nations. We develop a stylized bioeconomic model to explore the change in fishing behavior of host and DWF nations when the two nations enter into an access agreement with varying levels of access fee. We further conduct an econometric analysis of changes in Pacific island nations' harvesting behavior in response to the harvest decisions of DWF nations using data from the Western and Central Pacific tuna fishery. Our model results show that there is a range of variable access payment levels over which the host nation substitutes benefits from its domestic fishing activity with access payments from the DWF nation and that setting fees in this range can create a trap whereby host nations are forced to trade-off receiving a fair return to their fishery resources through access fees and retaining their own active fleet capacity. Our empirical analysis further shows a gradual shift in the way in which Pacific island host nations responded to the harvest decision of DWF nations as a result of the creation of the 200-nautical-mile EEZ.

1. Introduction

Many developing countries are highly dependent on their natural resource endowments as a source of economic growth and social development [1]. In the case of developing island nations, marine resources in particular make important contributions to GDP and government revenue, and underpin the primary livelihood, food security and opportunities for an increased standard of living of coastal communities [2–4]. However, both the national economies and food security of these developing island nations are highly vulnerable to changes in the coastal environment and the degradation of marine resources [5–8]. Both the immediate and long-term benefits these island nations derive from sustainably exploiting their marine resources, including fisheries, are thus substantial.

Despite the importance of fisheries, many developing island nations lack the harvesting and governance capacity required to capture the full benefits of the fisheries resources found in their waters by themselves [9,10]. Consequently, for many island nations the majority of income gained from fisheries resources often comes from selling access rights to their waters to fleets belonging to Distance Water Fishing (DWF) nations. The fisheries sector in Kiribati, for example, contributes more than 20% of the country's GDP; yet more than 60% of the total catch in their waters is taken by foreign fleets, and additionally around 40% of the government revenues comprise access fees paid by DWF nations [11].

Developing island nations' ability to charge fees for DWF fleets to access their waters depends on whether island nations have property rights over the resources found in their waters. The third United Nations Law of the Sea Convention (UNCLOS) introduced Exclusive Economic Zones (EEZs) extending 200 nautical miles (nm) from the territorial sea baseline of coastal states. The declaration of EEZs granted coastal states sovereign rights over the marine resources in their EEZs and enabled developing island host nations to enter into access agreements with DWF nations. The number and scope of access agreements worldwide has escalated from the time of the first agreement in 1980, for example the European Union now has access arrangements in place to harvest demersal and migratory species, such as tuna, from the territorial waters of coastal states in the African, Caribbean and Pacific regions [12,13]. Pacific island countries have also entered into access agreements with Japan since the end of

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the 1970s, and with other DWF nations, such as the United States, Taiwan, and the Republic of Korea since the 1980s [11,14,15].

A substantial body of literature explores the effectiveness of existing fishing access agreements for enabling developing coastal states to achieve desired economic benefits from their fisheries resources, and describes their impacts on the development of domestic fishing industry and management capacity [14,16–19]. Furthermore, while the exact terms of access agreements are often not publicly available, many studies have investigated the types and structure of different access agreements worldwide [12,13,15,20].

However, knowledge of the way in which access agreements impact the harvesting behavior of developing island nations and their implications for fisheries exploitation remain largely unexplored in the literature. Our overall aim in this paper is to address this gap, in particular by exploring how host nations respond to the opportunity to secure access payments from DWF nations in return for access to the fisheries resource. To the best of our knowledge, there is no study that quantitatively models and evaluates: first, how different levels of access fee affect the harvesting decisions of host and DWF nations; and second, whether the way in which host nations respond to the harvesting behavior of the DWF nations was affected by the creation of the 200-nm EEZs, and thereby their ability to legally demand payment for access to the resources within their waters.

We address these questions using two approaches. In Section 2 we develop a stylized bioeconomic model in which both host and DWF nation fleets exploit a single fish stock located in the host nation's EEZ, and the DWF nation is required to pay a fee to the host nation for access to the fishery. Using the bioeconomic model we analytically examine the way in which the level of access payments affects the harvest decisions of the host and DWF nations[1]. We further use a parameterized version of our model to simulate steady state levels of effort, and hence total biomass, for the two nations and compare these to the case in which the fishery is exploited by the host nation as a sole operator. In Section 3 we conduct an empirical analysis for the Western and Central Pacific tuna fishery, in which various access agreements for harvesting tuna are in place between Pacific island host nations and DWF nations. Using data spanning the period 1969 to 2010, we explore how the tuna harvesting decisions of the Pacific island host nations were affected by the harvesting behavior of different DWF nations in the host nations' EEZs. We explore the way in which this relationship has changed over time by re-estimating our empirical model for various sub-periods.

2. A stylized bioeconomic model of a fishery with access agreement

2.1. Fishery exploitation with access agreement

Fishing access agreements can be bilateral or multilateral [11] and we consider the case of a bilateral agreement, in which two fishing fleets, belonging to a host (H) and distant water fishing (DWF) nation, both of which exploit a fish stock located in the host nation's EEZ. The biomass dynamics is given as

$$\frac{dx}{dt} = F(x) - h_H - h_{DWF} \tag{1}$$

where x is the size of the fish population, $F(x)$ is the natural growth rate of the population, and h_i is the harvest by nation i's fleet where $i = \{H, DWF\}$. We assume that the natural growth of the population is given as $F(x) = rx(1 - x/K)$ where r is the intrinsic growth rate and K is the environmental carrying capacity of the population within the EEZ.

Our interest here is to examine the way in which the host nation maximizes the net benefits from the fisheries resource when they can derive benefit from the fishery either by harvesting the resource themselves or by selling access rights to DWF nations. For the DWF nation to exploit the fish stock in the host nation's EEZ, the DWF nation and the host nation must enter into an access agreement. Such agreements generally require the payment of an access fee comprising two components: a variable fee, which depends on either the DWF nation's catch or gross revenue received from fishing in the EEZ; and a fixed fee, which may include various payments such as development aid, research support and technical assistance [16,20]. We specify the total access fee (AF) as

$$AF = \alpha(Ph_{DWF}) + F \tag{2}$$

where P is the unit price of the fish caught and $\alpha \in [0, 1]$ is an access fee parameter which specifies the proportion of the landed value of fish payable by the DWF to the host nation. The term $\alpha(Ph_{DWF}) \geq 0$ therefore represents the variable fee component and $F \geq 0$ is the fixed fee component of the total access fee.

In the presence of an access agreement, the host nation's profit from the fishery (π_H^{AA}) includes the net benefits from fishing and the access payments received from the DWF nation, such that

$$\pi_H^{AA} = Ph_H - C_H E_H + (\alpha Ph_{DWF} + F) \tag{3}$$

where E_H is the fishing effort and C_H is the cost per unit of fishing effort of the host nation. Similarly, the profit of the DWF nation from the fishery (π_{DWF}^{AA}) includes both the net benefits associated with their own fishing in the host nation's EEZ less the amount they are required to pay to the host nation for access to the fishery, that is

$$\pi_{DWF}^{AA} = Ph_{DWF} - C_{DWF} E_{DWF} - (\alpha Ph_{DWF} + F) \tag{4}$$

where E_{DWF} is the fishing effort, and C_{DWF} is the cost per unit of fishing effort, of the DWF nation.

We assume that the harvest–effort relationship is given by the Schaefer production function, i.e., $h_i = qE_i x$, $i = \{H, DWF\}$ where q is the catchability coefficient [21]. For analytical tractability, we confine our analysis to the equilibrium outcome where the level of biomass remains constant over time, such that

$$\frac{dx}{dt} = 0 \Leftrightarrow x = K\left(1 - \frac{qE_{DWF}}{r} - \frac{qE_H}{r}\right) \tag{5}$$

The DWF nation and the host nation both make harvesting decisions to maximize their economic return to fishing in the EEZ[2].

[1] Our stylized bioeconomic model is developed to characterize the interaction between host and DWF nations' harvesting behaviors. The model is specified with the minimum level of complexity needed to achieve this and is not intended to undertake an empirical evaluation of a specific fishery, such as the Western and Central Pacific (WCP) tuna fishery, on which our econometric analysis is based. For example, our model does not incorporate the migratory nature and natural fluctuations of tuna stocks. See Bertignac et al. [37], Chand et al. [38], and Kompas et al. [39] for bioeconomic models specifically developed for the WCP tuna fishery.

[2] We assume profit-maximizing behavior for both the host and DWF nation in the knowledge that other objectives may guide harvesting decisions. While fishing profit is a major driver of global fishery development [40] and fleet behaviors [41], broader social, economic and political considerations, including food security and supporting artisanal fishing livelihoods, may affect the harvesting decisions of both nations. We also assume that the host nation's ability to exploit the resource, either in conjunction with the DWF nation under an access agreement or as a sole operator (Section 2.2), is not constrained by a lack of fishing capacity or access to technology. We note these considerations as limitations to our study and suggest possible extensions in our concluding remarks.

Given the steady state condition in Eq. (5), the profit-maximization problem of the host and DWF nations can be formulated as

Host nation:

$$\max_{E_H}\left\{PqE_H\left[K\left(1-\frac{qE_{DWF}}{r}-\frac{qE_H}{r}\right)\right]-C_HE_H+\alpha PqE_{DWF}\left[K\left(1-\frac{qE_{DWF}}{r}-\frac{qE_H}{r}\right)\right]+F\right\} \tag{6}$$

and

DWF nation:

$$\max_{E_{DWF}}\left\{PqE_{DWF}\left[K\left(1-\frac{qE_{DWF}}{r}-\frac{qE_H}{r}\right)\right] -C_{DWF}E_{DWF}-\alpha PqE_{DWF}\left[K\left(1-\frac{qE_{DWF}}{r}-\frac{qE_H}{r}\right)\right]-F\right\} \tag{7}$$

The first-order conditions of the profit-maximization problems for the interior case for which $E_H, E_{DWF}, x>0$ are given as

$$C_H = PqK\left(1-\frac{2qE_H}{r}-\frac{qE_{DWF}(1+\alpha)}{r}\right) \tag{8}$$

$$C_{DWF} = (1-\alpha)PqK\left(1-\frac{qE_H}{r}-\frac{2qE_{DWF}}{r}\right) \tag{9}$$

Rearranging Eqs. (8) and (9) to solve for the equilibrium level of fishing effort for the host (E_H^{AA}) and the DWF (E_{DWF}^{AA}) nations when the access agreement is in place yields

$$E_H^{AA} = \frac{r}{q(3-\alpha)}\left[1-\alpha-\frac{2C_H}{PqK}+\frac{C_{DWF}(1+\alpha)}{PqK(1-\alpha)}\right] \tag{10}$$

$$E_{DWF}^{AA} = \frac{r}{q(3-\alpha)}\left[1+\frac{C_H}{PqK}-\frac{2C_{DWF}}{PqK(1-\alpha)}\right] \tag{11}$$

We substitute Eqs. (10) and (11) into Eq. (5) to obtain the equilibrium level of biomass in the presence of an access agreement (x^{AA}), that is

$$x^{AA} = \frac{1}{3-\alpha}\left(K+\frac{C_H+C_{DWF}}{Pq}\right) \tag{12}$$

Eqs. (10)–(12) suggest that, as we would expect, the equilibrium level of biomass increases with the cost per unit of fishing effort for either nation (C_i, $i=H, DWF$) and decreases with the unit price of fish (P) or the catchability coefficient (q). Further, an increase in the per unit cost of fishing effort for one nation increases the equilibrium level of fishing effort of the other nation, i.e., $\partial E_i^{AA}/\partial C_j > 0$, $i,j=H, DWF$, and $i\neq j$.

The equilibrium level of biomass monotonically increases with the access fee parameter (α). However, whether the fishing effort of the host and DWF nations increases or decreases with α is ambiguous. For instance, increasing the access fee parameter increases the equilibrium level of biomass and this motivates the DWF nation to increase its fishing effort (i.e., effort-enhancing biomass effect). At the same time, however, increasing the access fee parameter decreases the effective price of fish for the DWF nation and this discourages the DWF nation from fishing in the host nation's EEZ (i.e., effort-dampening access payment effect). Whether increasing the access fee parameter (α) increases or decreases the fishing effort, therefore, depends on the relative size of the effort-enhancing biomass and effort-dampening access payment effects.

2.2. Fishery exploitation without access agreement: sole operator

When the DWF nation does not have access to fish in the host nation's EEZ, the host nation is a sole operator exploiting the fish stock within the waters of their own EEZ to maximize their profit from the fishery. In this case the profit-maximization problem of the host nation is formulated as

$$\max_{E_H}\left\{PqE_H\left[K\left(1-\frac{qE_H}{r}\right)\right]-C_HE_H\right\}. \tag{13}$$

The corresponding first-order condition is given as

$$C_H = PqK\left(1-\frac{2qE_H}{r}\right) \tag{14}$$

Simultaneously solving Eq. (14) and the equilibrium condition for biomass $x=K(1-qE_H/r)$ yields the steady state fishing effort and biomass, such that

$$E^{sole} = \frac{r}{2q}\left(1-\frac{C_H}{PqK}\right) \tag{15}$$

$$x^{sole} = \frac{1}{2}\left(K+\frac{C_H}{Pq}\right) \tag{16}$$

where E^{sole} and x^{sole} are the fishing effort of the host nation and the equilibrium fish biomass when there is no access agreement in place and the host nation is a sole operator in the EEZ.

2.3. Impact of access payment on effort and biomass

Comparing Eqs. (10)–(12) with (15) and (16) permits us to determine the way in which an access agreement, in particular the level of the access fee parameter (α), affects the harvesting decisions, and hence effort, of the host and DWF nations and the resulting equilibrium biomass for the fishery. Rearranging Eqs. (10)–(12) and (15) and (16) yields the following result:

Result 1. There is a threshold level of the access fee parameter ($\hat{\alpha}$) below which an access agreement induces a positive level of DWF nation effort in the host nation's EEZ. For levels of α less than this threshold, the fishing effort of the host nation is less, but the total fishing effort in the fishery is greater than when there is no access agreement in place. Thus, the level of biomass in the fishery under the access agreement is less than the level when the host nation is a sole operator in the EEZ. More precisely,

$$\text{If}\quad \alpha<\hat{\alpha}=1-\frac{2C_{DWF}}{PqK+C_H},\quad E_{DWF}^{AA}>0,\quad E_H^{AA}<E^{sole},\quad \text{and}\quad E_H^{AA}+E_{DWF}^{AA}>E^{sole}.\quad \text{Thus,}\quad x^{AA}<x^{sole}.$$

Result 1 implies that the host nation substitutes benefits from its own fishing activity within the EEZ with access payments from the DWF nation when the access fee parameter is below the threshold ($\alpha<\hat{\alpha}$)[3]. Similarly, we find the following result:

Result 2. When the access fee parameter is equal to or greater than the threshold ($\alpha\geq\hat{\alpha}$), there is no incentive for the DWF nation to access the host nation's EEZ. In other words there is no positive level of fishing effort of the DWF nation for which the DWF

[3] As expected, the fixed fee component (F) of the access fee does not appear in either the first-order or steady state conditions for the access agreement fisheries problem described in this paper. While this implies that changes in F do not affect the equilibrium level of effort or biomass in the fishery, there is nevertheless a level of fixed fee that would render fishing in the EEZ unprofitable for the *DWF* nation, regardless of the level of α. In other words, even in the case in which no variable access fee is required ($\alpha=0$), there is a sufficiently high value of F that would dissuade the *DWF* nation from entering into an access agreement with the host nation. Since our interest is in the way in which changes in access fees affect harvesting behavior (and hence effort and biomass), we restrict our discussion in this paper to the variable fee component of the total access fee, noting the link between the threshold level of the access fee parameter ($\hat{\alpha}$) and the level at which F is set.

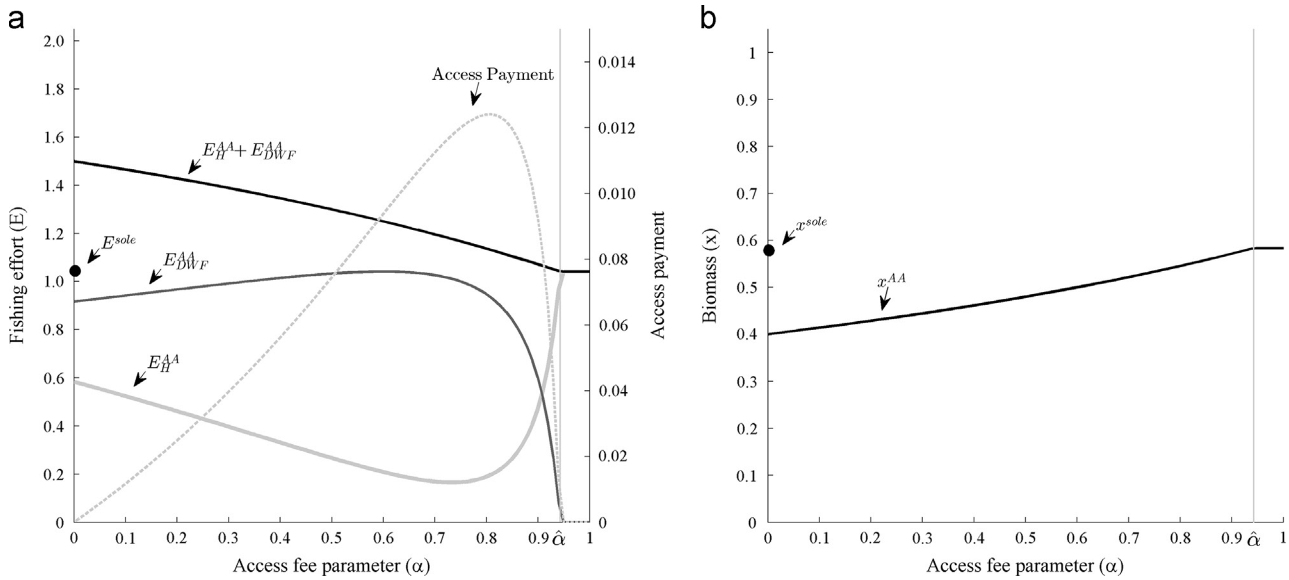

Fig. 1. Effects of access fee parameter on the (a) fishing effort and access payment and (b) biomass. Parameter values are $r=0.25$, $K=1$, $p=3$, $q=0.1$, $C_H=0.05$, and $C_{DWF}=0.01$.

nation's profit from the fishery is positive. For $\alpha \geq \hat{\alpha}$ therefore the host nation effectively becomes a sole operator in the EEZ. That is,

$$\text{If} \quad \alpha \geq \hat{\alpha}, \quad \text{then} \quad E_H^{AA} = E^{sole} \quad \text{and} \quad E_{DWF}^{AA} = 0. \quad \text{Thus} \quad x^* = x^{sole}$$

Fig. 1 visually shows Results 1 and 2 by illustrating the simulated fishing effort of the host and DWF nations (Fig. 1a) and the biomass (Fig. 1b) for different levels of the access fee parameter, varying from 0 to 100% of the DWF nation's fishing revenue[4]. We assume that the host and DWF nations are heterogeneous in terms of the cost per unit of fishing effort with $C_H > C_{DWF}$[5].

Fig. 1a shows that the host and DWF nations enter into an access agreement when the access fee parameter is less than the threshold $\hat{\alpha} = 0.94$. That is, for the parameter values used in our simulation, when the variable fee is set so that 94% or more of the landed value of fish caught by the DWF nation must be paid as an access fee to the host nation, the DWF nation chooses not to fish in the host nation's EEZ and the outcome in the fishery resembles the case in which the host nation exploits the fishery as a sole operator. In contrast, when the access fee parameter is below 0.94, the host and DWF nations enter into an access agreement and the total fishing effort in the fishery is greater than when the host nation is a sole operator. For increases in the value of α over the range $0 \leq \alpha \leq \hat{\alpha}$, the smaller the total fishing effort (Fig. 1a) and, correspondingly, the greater the equilibrium biomass in the fishery (Fig. 1b)[6].

For the case in which an access agreement is in place, the distribution of total fishing effort between the host and DWF nation fleets depends on the level of the access fee parameter (Fig. 1). When $\alpha=0$ there is no access fee payable by the DWF nation, and the fishing effort of the DWF nation exceeds that of the host nation, reflecting the heterogeneity in the cost of fishing effort between the two fleets. For increases in the access fee parameter to $\alpha=0.59$ in our simulation, the host nation reduces its level of fishing effort, substituting increased payments from the DWF nation for revenue from their own fleet's fishing activity within the EEZ. Over this range, the DWF nations' fishing effort increases, reflecting the strength of the effort-enhancing biomass effect relative to the effort-dampening access payment effect in Eq. (11).

Further increases in the access payment parameter to $\alpha=0.73$ in our simulation result in further decreases in the fishing effort of the host nation (E_H^{AA}). This is because the host nation continues to substitute DWF nation access payments for benefits from its own fishing fleet, whereas the fishing effort of the DWF nation (E_{DWF}) falls over this range of α as the disincentive to fish created by the lower effective price of fish dominates the effort-enhancing biomass effect. When the access fee parameter exceeds the threshold ($\hat{\alpha}$), however, the total access fee payable by the DWF nation falls, and the host nation's fishing effort increases to maintain its revenue. Over this range, the DWF nation's fishing effort falls as the gains from the biomass effect continue to decline as the equilibrium biomass under an access agreement approaches x^{sole}, and the proportion of the DWF nation's landed value of the catch that must be paid to the host nation becomes prohibitively high. In effect, as the access fee parameter (α) approaches the threshold value ($\hat{\alpha}$), the host nation substitutes for the loss of benefits from the access fee with increased profits from exploiting the fish population within their EEZ themselves.

3. Empirical assessment of access agreement in the WCP tuna fishery

In this section we use data from the Western and Central Pacific tuna fishery to assess empirically how the harvest of the host and DWF nations evolved over the period 1969 to 2010. In particular, we use econometric models to examine how the relationship between the volume of tuna harvested by the host and DWF nations is affected by the establishment of EEZs that require DWF nations to enter into access or licensing arrangements with Pacific island host (PIH) nations in order to legally fish within their waters.

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[4] Parameter values used in the simulation are $r=0.25$, $K=1$, $p=3$, $q=0.1$, $C_H=0.05$, and $C_{DWF}=0.01$. These values are arbitrarily chosen for an illustrative purpose and to ensure interior solutions for the biomass and fishing effort of the host nation over a range of values for the access parameter $0 \leq \alpha \leq 1$.

[5] Parris and Grafton [18] argue that this assumption is reasonable given DWF nations' ability to profitably harvest tuna in addition to paying access fees.

[6] Higher access fees may also be associated with higher levels of non-compliance with the access arrangement or underreporting of catch to avoid access fees by the DWF nation. The enforcement and compliance of access agreements are beyond the scope of this paper, but see, for example, [10,13,16]. The incorporation of enforcement costs and compliance behaviors of DWF nation fleets is a potential extension of our model.

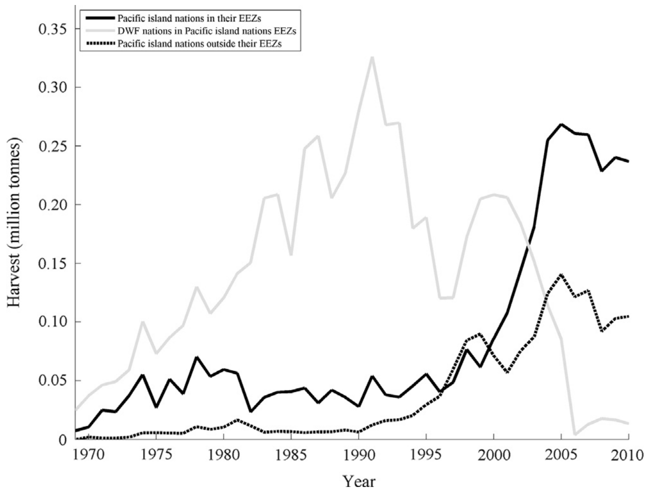

Fig. 2. Total volume of tuna harvested by PIH nations, both within and outside their EEZs, and by the DWF nations in the PIH nations' EEZs for period 1969 to 2010.

3.1. Western and Central Pacific tuna fishery

The Western and Central Pacific Ocean (WCPO) is the location of the world's largest and most valuable tuna fishery [22,23]. The fishery is worth up to $4.1 billion per year and tuna harvested from the region comprises some 50% of the global catch of tuna [24]. The key species that comprise this fishery are albacore tuna (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*). The four tuna species migrate through the WCPO and approximately 57% of the harvests of these four species are taken from the EEZs of the PIH nations [10].

Fig. 2 presents the total volume of tuna harvested by the PIH nations, both within and outside their EEZs, and by the DWF nations in the PIH nations' EEZs for the period 1969 to 2010[7]. The average harvest by the PIH nations in their EEZs increased 32-fold from 230 t in 1969 to 7400 t in 2010. Furthermore, in 1969, no PIH nation caught tuna outside their own EEZ, however, by 2010 their average harvest outside the EEZs was 3273 t. The total volume of tuna harvested by the DWF nations in the PIH nations' EEZs steadily increased from 1969 and peaked in 1991 but then steadily decreased until 2010. Casual observation of the decrease in the DWF nations' harvest in the PIH nations' EEZs since the beginning of the 1990s suggests that it may correspond with the UNCLOS which formally defined the 200-nm EEZs and came into force in 1994.

3.2. Econometric models

Our aim was to assess the relationship between the annual volume of tuna harvested by the PIH and DWF nations, and how this relationship is affected by the creation of the 200-nm EEZs. To achieve this we use two econometric models as specified below:

$$\text{Model1}: \quad h_{ijt}^{H} = \phi h_{ijt}^{DWF} + \beta h_{ijt}^{outside} + z_{it}'\delta + \sum_i \alpha_i C_i + \sum_j \theta_j S_j + \sum_t \gamma_t T_t + \sum_j \varphi_j B_{jt} + \varepsilon_{ijt};$$

and

$$\text{Model2}: \quad h_{ijt}^{H} = \phi_{JPN} h_{ijt}^{JPN} + \phi_{KOR} h_{ijt}^{KOR} + \phi_{TWN} h_{ijt}^{TWN} + \phi_{USA} h_{ijt}^{USA} + \phi_{OTH} h_{ijt}^{OTH} + \beta h_{ijt}^{outside} + \sum_i \alpha_i C_i + \sum_j \theta_j S_j + \sum_t \gamma_t T_t + \sum_j \varphi_j B_{jt} + \varepsilon_{ijt}$$

where the dependent variable (h_{ijt}^{H}) is the volume of tuna harvested by a PIH nation in its EEZ. We index the PIH nations by the subscript i, tuna species by j, and the year by t. As an explanatory variable, Model 1 includes the aggregate harvest of all DWF nations in country i's EEZ for each species j in year t (h_{ijt}^{DWF}). Model 2, on the other hand, includes the individual harvest levels of five major DWF nations catching tuna in the PIH nations' EEZs. They are, Japan (h_{ijt}^{JPN}), the Republic of Korea (h_{ijt}^{KOR}), Taiwan (h_{ijt}^{TWN}), the United States of America (h_{ijt}^{USA}), and other DWN nations (h_{ijt}^{OTH}), which include China, Mexico, Philippines, Spain, Australia, and New Zealand.

Our primary interest is in estimating the parameter ϕ in Model 1 and parameters ϕ_s $s \in \{JPN, KOR, TWN, USA, OTH\}$ in Model 2. The sign and size of the estimated coefficients suggest the extent to which a PIH nation's harvest in its EEZ responds to the harvest by the DWF nations. For instance, a negative coefficient $\phi < 0$ means that the greater the tuna harvest by the DWF nations within the PIH nations' EEZs the lower the harvest by the PIH nations. As suggested by our bioeconomic model (Fig. 1a), the PIH nations may decrease their catch in their EEZs and allow DWF nations to harvest in their waters in exchange for an access payment. More precisely, we test the null hypotheses of:

$H_0 : \phi = 0$ against $H_A : \phi \neq 0$ for Model 1; and

$H_0^k : \phi_k = 0$ against

$H_A^k : \phi_k \neq 0, s \in \{JPN, KOR, TWN, USA, OTH\}$ for Model 2

We initially assess the effects of the creation of EEZs on the relationship between the harvesting decisions of the PIH and DWF nations by splitting the sample into two sub-sample periods. The first sub-sample period covers the years before the UNCLOS came into force in 1994 and the second sub-sample period spans the period 1994 to 2010. It is, however, important to note that several alternative years could have been chosen to delineate the two sub-samples corresponding to pre- and post-UNCLOS. For example, PIH nations first declared their EEZs at the end of the 1970s and, while their bargaining power was low, they attempted to collect access fees from DWF nations since around 1980 [14,17,19]. Further, the UNCLOS, which formally defined the 200-nm EEZs, was signed in the beginning of the 1980s (see Table 1). To examine how the estimated relationship between the harvesting decisions of the PIH and DWF nations responds to the choice of sub-sample periods, we re-estimate the parameters using different sub-sample periods: 1969 to 1980; 1981 to 1990; 1991 to 2000; and 2001 to 2010.

In both Models 1 and 2, we also include the PIH nations' harvest outside their EEZs ($h_{ijt}^{outside}$) as an explanatory variable. The coefficient of this variable indicates whether the PIH nations substitute the catch of tuna in their own EEZs with their catch outside the EEZ ($\beta < 0$). A 5×1 vector of z_{it} in Models 1 and 2 contains other explanatory variables, including the real GDP per capita, trade openness as a share of exports and imports in total GDP, total net Official Development Assistance (ODA) from the Development Assistance Committee (DAC) members who catch tuna in the PIH nations EEZs, the real price of imported crude oil in the United States (as a proxy measure of fishing cost), and the FAO Food Price Index. Further, both models include dummy variables, C_i, S_j, and T_t to allow for the country-fixed effects, such as the size of the EEZ and land area, species-fixed effects, such as biological characteristics, and time-fixed effects, such as temporal variations in the environment and in governance arrangements, such as regional fisheries management organizations. The levels of total biomass of the four tuna species, B_{jt} are also included as explanatory variables in the model.

3.3. Data

Data on the harvest of tuna species in the WCPO is drawn from the Sea Around Us Project [25]. The original data set contains the harvest

[7] The PIHs in our sample are Fiji, Kiribati, Marshall Islands, Micronesia, Palau, Papua New Guinea, Solomon Islands and Vanuatu (see Table 1).

Table 1
List of Pacific island host nations, distant water fishing nations, and tuna species in the sample.

Pacific island host (PIH) nations	DWF nations	Tuna species
Fiji (1982/1982)	Australia (1982/1994)[a]	Albacore
Kiribati (na/2003)	China (1982/1996)	Bigeye
Marshall Islands (na/1991)	Japan (1983/1996)	Skipjack
Micronesia (na/1991)	Mexico (1982/1983)	Yelloefin
Palau (na/1996)	New Zealand (1982/1996)	
Papua New Guinea (1982/1997)	Philippines (1982/1984)	
Solomon Islands (1982/1997)	Republic of Korea (1983/1996)	
Vanuatu (1982/1999)	Spain (1984/1997)	
	Taiwan (na)	
	United States (did not sign and ratify)	

[a] The numbers in parenthesis are the years in which the country signed/ratified (or acceded) UNCLOS. http://www.un.org/depts/los/reference_files/status2010.pdf (last accessed 19 August) 2014).

of a range of species by different countries from all oceans including the high seas. In order to separate the data on the tuna harvest by PIH and DWF nations in the WCPO from other harvests, we filter the data according to species type and sea areas as defined by FAO (Area 71). The data on the real GDP per capita at 2005 international prices (*rgdpch*) and trade openness (*openk*) are taken from the Penn World Table 7.1. We take the data on the total net ODA from OECD.Stat [26], the annual imported crude oil price from the U.S. Energy Information Administration [27], and the FAO Food Price Index from [28]. The data on the total biomass of each tuna species in each year are taken from the RAM Legacy Stock Assessment Database [29]. The final data set consists of a cross-section of eight PIH nations, ten DWF nations, and four tuna species, spanning the years from 1969 to 2010. Table 1 summarizes a list of PIH, DWF nations and tuna species included in the sample.

3.4. Estimation results

The estimation results of Models 1 and 2 are presented in Table 2. The regression models generally fit the data well as the explanatory variables are jointly significant at the 1% level and the two regression models explain about 40 and 65% of the variation in the harvest by the PIH nations.

The estimation results of Model 1 show that the aggregate harvest by the DWF nations within the PIH nations' EEZs is positively related to the harvest by the PIH nations ($\hat{\phi} > 0$) in the first sub-sample period 1969 to 1993, but negatively related ($\hat{\phi} < 0$) in the second sub-sample period 1994 to 2010. More precisely, our estimation results show that, prior to 1994, the annual volume of tuna harvested by the PIH nations in their EEZs increased on average by 0.2 t for every 1 t increase in the harvest by the DWF nations, *ceteris paribus*. By contrast, using the data in the second sub-period 1994 to 2010 our estimation results show that the harvest by the PIH nations decreased on average by 0.16 t for each additional tonne of harvest by the DWF nations in the PIH nations' waters. The change in sign for the estimated coefficient may indicate a change in the way PIH nations respond to the harvest by the DWF nations in PIH nations' waters. That is to say, despite the fact that the PIH nations did not exploit the tuna on the same scale as the DWF nations until the 2000s (Fig. 2), these nations were competing with the DWF nations for the harvest of tuna in their EEZs during the first sub-period 1969 to 1993[8]. Conversely, the DWF nations' harvest acts as a substitute for PIH nation's own harvest subsequent to 1994 when the 200-nm EEZs officially came into force.

In Model 2, the positive estimate of $\hat{\phi}_{JPN} = 0.86$ suggests that the PIH nations and Japan were competing for the harvest of tuna within the PIH nations' EEZs prior to 1994. For the same sub-period, however, the coefficients for other DWF nations are of mixed sign and statistically insignificant, providing no evidence of the competition or substitution in fishing between the PIH nations and these DWF nations prior to 1994. These results suggest that the significant substitution effect detected in Model 1 for the first sub-period may reflect that Japan was the major fishing state prior to the end of the 1980s [17,19].

Our results of Model 2 for the second sub-period 1994 to 2010 show that the harvest by the Republic of Korea and Taiwan are negatively related with the harvest by the PIH nations at a statistically significant level ($p < 0.10$). Similar to the results of Model 1, this suggests that the PIH nations substituted their own harvest with that of the two DWF nations after the 200-nm EEZs officially came into force.

Our econometric analysis further enables us to examine the relationship between the PIH nations' tuna harvest in their own EEZs and other explanatory variables included in the models. For instance, the negative coefficient of the PIH nations' harvest outside their EEZs (β) suggests that the PIH nations' harvest in the areas outside their EEZs acted as a substitute for fishing within their own waters. We also find no evidence that the PIH nations increased the harvest within the waters of their own EEZ in response to an increase in the total biomass in the first sub-period from 1969 to 1993. Conversely, in the second sub-period, the PIH nations' harvest within their waters and the total biomass of both albacore and bigeye were positively related. The estimation results further suggest that the greater the PIH nations per capita GDP the lower the volume of tuna harvested by these nations in their EEZs during the period 1994 to 2010. By contrast, there is no statistical evidence of such a negative relationship between the PIH nations' tuna harvest and the level of economic development for the first sub-period 1969 to 1993.

While the PIH nations have a high degree of trade openness, their generally narrow production bases result in a limited range of exported goods and services. The main exports include tourism (Fiji, Palau Vanuatu), fish (Kiribati, Marshall Islands, Micronesia), and other agricultural products, such as copra and sugar [30]. For Model 1 we find that, for the period 1969 to 1993, the higher the share of international trade in a PIH nation's GDP the greater the volume of tuna harvest by the PIH in its own waters. By contrast, in the second sub-period 1994 to 2010, we find no evidence of a statistically

[8] A positive relationship between the harvests by the PIH and DWF nations can result when both nations are responding to changes in the stock size within the PIH nation's waters. For example, a large migration of the stock to a PIH nation's EEZs may increase the harvest by both the PIH and DWF nations. In the absence of data on the stock biomass within each country's EEZ over time, however, the temporal stock effect within a country's waters needs to be controlled by other explanatory variables. Our econometric models partly control for this stock effect by including the total biomass of the four tuna species as explanatory variables. Further, the country- and time dummies jointly account for country- and time-specific variation, such as a large migration of the stock to a host nation's EEZ (country-fixed effect) in a particular year (time-fixed effect).

Table 2
Estimation results: dependent variable is harvest by the Pacific island nation in own EEZ.

Variable	Model 1		Model 2	
	1969–1993	1994–2010	1969–1993	1994–2010
Harvest by all DWFNs in host nations' EEZs (t)	0.21 (0.087)**	−0.16 (0.087)*		
Harvest by Japan in host nations' EEZs (t)			0.86 (0.14)***	−0.11 (0.072)
Harvest by USA in host nations' EEZs (t)			−0.27 (0.20)	0.46 (0.43)
Harvest by Republic of Korea in host nations' EEZs (t)			0.22 (0.14)	−0.60 (0.35)*
Harvest by Taiwan in host nations' EEZs (t)			−0.37 (0.42)	−0.21 (0.082)**
Harvest by other DWFNs in host nations' EEZs (t)			0.022 (0.20)	−0.27 (0.23)
Harvest by Pacific island host nation in other EEZs and high seas (t)	−0.65 (0.22)***	−0.28 (0.17)	0.36 (0.28)	−0.30 (0.18)*
Real per capita GDP ($)	0.014 (0.14)	−3.31 (1.67)**	−0.083 (0.11)	−3.23 (1.67)*
Trade openness (%, share of exports and imports in total GDP)	53.08 (14.30)***	−47.64 (44.75)	3.35 (9.21)	−42.71 (43.32)
ODA (million $)	12.01 (2.83)***	−80.16 (30.21)***	5.44 (1.92)***	−79.31 (29.15)***
Real imported crude oil price ($/barrel)	19.84 (28.03)	210.1 (142.9)	1.59 (19.80)	207.7 (142.0)
FAO food price index	10.28 (26.74)	270.4 (203.5)	−2.12 (20.35)	258.7 (203.7)
Biomass of albacore (t)	−0.006 (0.008)	0.028 (0.015)*	−0.003 (0.005)	0.027 (0.014)*
Biomass of bigeye (t)	−0.009 (0.012)	0.12 (0.067)*	−0.007 (0.008)	0.12 (0.066)*
Biomass of skipjack (t)	−0.002 (0.001)*	−0.001 (0.003)	−0.002 (0.0009)*	−0.0005 (0.003)
Biomass of yellowfin (t)	−0.002 (0.002)	0.002 (0.003)	−0.001 (0.001)	0.002 (0.003)
Constant	−2707.9 (5797.9)	−5948.9 (17835.7)	4016.3 (5229.8)	−5497.8 (18093.0)
Year dummy	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes
Species dummy	Yes	Yes	Yes	Yes
R-squared	0.431	0.397	0.650	0.399
F-statistic (*p*-value)	0.000	0.000	0.000	0.000
Number of pooled observations	500	408	500	408

*** 1% Level, robust standard errors are in parentheses.
** 5% Level, and robust standard errors are in parentheses.
* 10% Level robust standard errors are in parentheses.

significant relationship between trade openness and tuna harvest. These results suggest that, when the PIH nations were able to legally charge access fees to the DWF nations, the PIH nations did not increase the harvest of tuna as their trade openness increases.

The coefficient of ODA is statistically significant at the 1% level in Models 1 and 2 and for both sub-periods, and the sign of the coefficient changes from positive to negative between the two sub-periods in both models. The positive coefficient prior to 1994 suggests that an increase in aid payments to PIH nations was associated with an increase in their tuna harvests in their EEZs. During the second sub-period, however, an increase in aid payments is associated with a decrease in tuna harvests. One possible explanation for this is that the PIH nations used these aid payments to increase their fishing capacity when aid was initially made; yet the foreign aid had a detrimental impact on the fisheries development in a longer term [20][9]. Another potential reason for the negative coefficient of ODA in the second sub-period is that, while the PIH nations' harvest increased during the period (Fig. 2), the development assistance associated with the volume of tuna caught by the DWF nations within the PIH nations' waters decreased given that aid packages were often negotiated with access agreements[10]. For example, the harvest by Papua New Guinea in its own EEZ has consistently increased since 1994. During the same period, however, both the real value of ODA provided by the DWF nations to Papua New Guinea and the harvest by the DWF nations in Papua New Guinea waters decreased.

3.5. Sensitivity analysis

To examine the sensitivity of our estimation results to our choice of sub-sample periods we re-estimate Model 1 using four different sub-sample periods: 1969 to 1980; 1981 to 1990; 1991 to 2000; and 2001–2010. The estimates of the coefficient ϕ with their 95% confidence intervals for each sub-sample period are summarized in Fig. 3.

[9] Our data unfortunately does not let us distinguish aid payments made to the PIH nations that have been negotiated in exchange for cheap access payments as part of fisheries access agreements from those that are independent of such agreements. As well as stifling PIH nations' efforts to develop their own fisheries, the former have been attributed with decreased transparency and flexibility of government spending, and increased risk of aid withdrawal [20].

[10] The correlation coefficient of ODA and the tuna harvest by the DWF nations in the PIH nations' EEZs is 0.16 suggesting that a decrease in aid payments is associated with a decrease in the DWF nations' harvest.

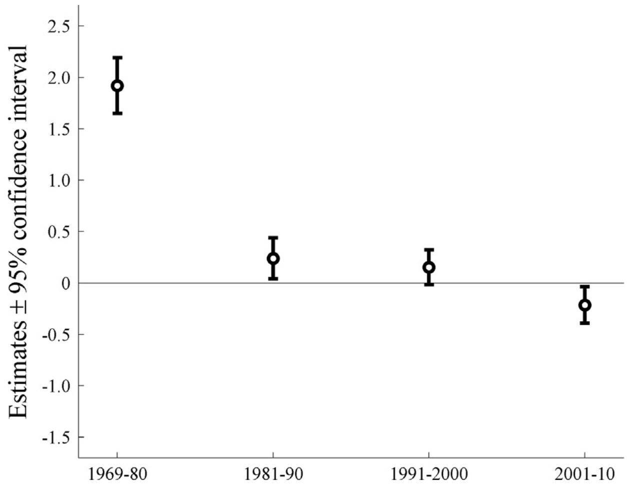

Fig. 3. Sensitivity analyses: estimates of the coefficient ϕ in Model 1 for the sub-samples of 1969–1980, 1981–1990, 1991–2000, and 2001–2010.

In general, the estimated value of the coefficient is smaller for later sub-periods. In particular, the estimates are positive and statistically significant at the 5% level for the first two sub-periods, 1969 to1980 and 1981 to 1990. In other words, during the 1970s and 1980s, the PIH nations caught more tuna within their own EEZs when the volume of tuna harvested by the DWF nations increased, *ceteris paribus*. This competition in fishing between the two fishing fleets, however, diminished over time. During the third sub-period 1991 to 2000, the estimated coefficient of the DWF nations' harvest is positive but, unlike the two earlier sub-periods, the coefficient is not statistically significant. In contrast to earlier sub-periods, for the most recent sub-period from 2001 to 2010, the estimated coefficient of the DWF nation's harvest has a statistically negative sign, suggesting that the PIH nations caught less tuna within their own EEZs as the harvest by the DWF nations increases. The PIH nations, therefore, substituted their own harvest with the harvest by the DWF nations in exchange for access payments.

4. Concluding remarks

When the 200-nm EEZ was formally established by the UNCLOS, coastal states gained sovereign rights over the marine resources found in their EEZs, enabling them to capture increased wealth from the fisheries within their waters by choosing either to displace DWF nations who had previously fished these stocks and exploiting the resource themselves or legally requiring foreign fleets to pay access fees [31]. Despite the potential for economic gains, however, many developing coastal nations have failed to fully realize the benefits from their fishery resources that this change promised [16,32]. For example, a lack of governance capacity is a major obstacle for many Pacific island nations to profit from their fisheries resources [10]. Furthermore, it has become apparent that host nations are in many cases not receiving access payments that truly reflect the resource rents available from their fisheries [13,14,20,33]. This failure is due to a variety of factors, including an imbalance of bargaining power between host and DWF nations [32],[11], the inability of host nations to effectively enforce the terms of access agreements and the incentive DWF nations have to underreport their harvests [12,16] and the fact that the short term economic needs of host nations may not be consistent with long term economic and social development goals [11].

The ability of coastal states to benefit from the granting of sovereign rights and to ensure the long-term conservation and sustainable use of their fisheries resources depends on how domestic fishing effort responds to the harvesting decisions of the DWF nations operating under different access arrangements. To date, however, there has been no study that has quantitatively evaluated this relationship. This paper contributes to the literature in this area by developing a stylized bioeconomic model that explores the changes in fishing behavior of host and DWF nations when the two nations enter into an access agreement with varying levels of access fee. Our second, and arguably main, contribution is an econometric analysis using data from the Western and Central Pacific tuna fishery to empirically examine how creation of the 200-nm EEZs affected the way in which host nations respond to the harvesting decision of the DWF nations.

Our bioeconomic model results show that the impact of access agreements on the harvesting decisions of a host nation, and the resulting equilibrium biomass in the fishery, depends on the relative size of net benefits expected from its own fishing and the access fee payable by the DWF nation. We identify a range of variable access payment levels over which the host nation substitutes benefits from its domestic fishing activity within its own EEZ with access payments from the DWF nation. That is to say, when access fees are set at relatively low levels, aggregate fishing effort in the fishery is high, the benefit to the host nation from the access payment is small and, due to high fishing pressure, equilibrium biomass is lower than is the case for either the sole operator or when access fees are set at a relatively high level. This result reinforces observations of the increased fishing pressure and risk of collapse of exploited stocks in tropical regions, such as Western Africa and Western and Central Pacific regions, where various access agreements between the developing coastal states and DWF nations were made with low access fees [11,20,33]. Furthermore, while increasing the access fee over this range can boost total access payments and reduce aggregate fishing pressure, potentially providing valuable financial contributions to governments and contributing to meeting conservation goals, it will also strengthen the imperative for host nations to substitute foreign for domestic effort in the fishery, potentially reducing the direct and indirect benefits to the economy of local production.

Our empirical results further show a gradual shift in the way in which Pacific island host nations responded to changes in the harvest levels of DWF nations over the study period 1969 to 2010. In essence we find evidence that the catch of Pacific island host nations was increasingly displaced by DWF nation catch over this period as host nations substituted their own harvest with that of the DWF nations in more recent years. During the 1970s and 1980s, prior to UNCLOS coming into force and when the host nations attempted but largely failed to collect access fees from the DWF nations [19,22], these nations increased the harvest of tuna within their own EEZs in response to the harvest by the DWF nations in the same waters. While no statistical relationship was identified during the 1990s, our empirical results show that the previous competitive response was reversed during the 2000s, as the Pacific host nations' harvest in own EEZs decreased with increased harvests by the DWF nations.

Overall, our study reinforces the importance of understanding how developing coastal states respond to the harvesting decision of DWF nations and to changes in institutional arrangements governing the use of fisheries resources. Fisheries resources in the states' territorial waters can potentially make important contributions to economic growth and social development, particularly for developing small island states where alternative resources and livelihoods are limited.

[11] In response to this and also due to the migratory nature of tuna species, the Pacific island countries have implemented collective bargaining with DWF nations. However, the success of collective access fee arrangements has been mixed and fees remain low [32].

For coastal states attempting to capture the social and economic benefits of fishery resources in their EEZs, the ability to demand DWF nations pay a fee in return for access to the resource may be a two-edged sword. As originally envisaged, access fees provide a legal mechanism for coastal nations to secure a share of the economic rent generated by DWF nations which can then, if used wisely, underpin the development of domestic fishing capacity and infrastructure. Our results, however, suggest that, when set low, access fees create a trap for host nations, whereby attempts to secure a fair share of the value of DWF nation catches by increasing fees and 'domesticating' the benefits of fisheries through increased host nation participation in fish harvesting must be traded-off. The tendency to tie cheap access fees with foreign aid in fisheries access agreements may have pushed developing coastal states in the region into this trap [20].

The behavior of host and DWF nations and their responses to changes in management and policy are significant sources of uncertainty in the management of fisheries resources located in the EEZs of developing coastal nations. As in other fisheries management contexts, understanding this behavior and the implied policy trade-offs is central to achieving fisheries policy objectives [34]. The design and implementation of access and other management arrangements that provide incentives that effectively align fishers behaviors, in particular their harvest decisions with the conservation, economic and social objectives of developing coastal nations [35] remains a key challenge.

A number of limitations of our analyses offer direction for useful extensions to the two modeling approaches presented in this paper. We examine equilibrium effort and biomass in the fishery using a simple stylized bioeconomic model which assumes that both host and DWF nations behave as profit maximizers. Exploring alternative drivers of harvest behavior and recognizing the broader social, economic and ecological context within which resource access and exploitation decisions are made is needed. We also assume that the host nation's ability to exploit the resource, either in conjunction with DWF nation under an access agreement or as a sole operator, is not constrained by a lack of fishing capacity. Allowing for capital constraints and the non-malleability of capital [36], as well as the costs of monitoring DWF nation catch and the likelihood of their non-compliance [10] are important extensions. The refinement of data used in our empirical estimations also presents opportunities for further developing our insights into behavioral changes in the Western and Central Pacific tuna fishery. For example, our current analysis uses the declaration of EEZs to proxy the ability of host nations to recover payment from DWF nations for access to fishery resources within their territorial waters. In future research, data capturing the historical evolution of individual bilateral access agreements in the region, fee levels and associated aid payments would allow researchers to more accurately identify changing patterns of harvesting behavior of each host and DWF nation.

References

[1] Barbier E. Natural resources and economic development. Cambridge and New York: Cambridge University Press; 2005.
[2] Gillett R. Fisheries in the economies of the Pacific island countries and territories. Mandaluyong City: Philippines; 2009.
[3] Smith M, Roheim C, Crowder L, Halpern B, Turnipseed M, Anderson J, et al. Sustainability and global seafood. Science 2010;80-(327):784–6.
[4] FAO. The state of world fisheries and aquaculture: opportunities and challenges. Rome: Food and Agricultural Organization of the United Nations; 2014.
[5] Sadovy Y. Trouble on the reef: the imperative for managing vulnerable and valuable fisheries. Fish Fish 2005;6:167–85.
[6] Allison EH, Perry AL, Badjeck M-C, Neil Adger W, Brown K, Conway D, et al. Vulnerability of national economies to the impacts of climate change on fisheries. Fish Fish 2009;10:173–96.
[7] Bell JD, Kronen M, Vunisea A, Nash WJ, Keeble G, Demmke A, et al. Planning the use of fish for food security in the Pacific. Mar Policy 2009;33:64–76.
[8] Hughes S, Yau A, Max L, Petrovic N, Davenport F, Marshall M, et al. A framework to assess national level vulnerability from the perspective of food security: the case of coral reef fisheries. Environ Sci Policy 2012;23:95–108.
[9] Mwikya M. Fisheries access agreements: trade and development issues. Geneva, Switzerland: International Centre for Trade and Development; 2006.
[10] Hanich Q, Tsamenyi M. Managing fisheries and corruption in the Pacific Islands region. Mar Policy 2009;33:386–92.
[11] Gagern A, van den Bergh J. A critical review of fishing agreements with tropical developing countries. Mar Policy 2013;38:375–86.
[12] Kaczynski VM, Fluharty DL. European policies in West Africa: who benefits from fisheries agreements? Mar Policy 2002;26:75–93.
[13] Le Manach F, Chaboud C, Copeland D, Cury P, Gascuel D, Kleisner KM, et al. European Union's public fishing access agreements in developing countries. PLoS One 2013;8:e79899.
[14] Schurman R. Tuna dreams: resource nationalism and the Pacific Islands' tuna industry. Dev Change 1998;29:107–36.
[15] Havice E. The structure of tuna access agreements in the Western and Central Pacific Ocean: lessons for vessel day scheme planning. Mar Policy 2010;34:979–87.
[16] Alder J, Sumaila UR. Western Africa: a fish basket of Europe past and present. J Environ Dev 2004;13:156–78.
[17] Petersen EH. Institutional economics and fisheries management: the case of Pacific Tuna. Edward Elgar Publishing; 2006.
[18] Parris H. Tuna dreams and tuna realities: defining the term maximising economic returns from the tuna fisheries in six Pacific Island states. Mar Policy 2010;34:105–13.
[19] Hannesson R. The exclusive economic zone and economic development in the Pacific island countries. Mar Policy 2008;32:886–97.
[20] Petersen E. The catch in trading fishing access for foreign aid. Mar Policy 2003;27:219–28.
[21] Schaefer M. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bull Math Biol 1991;53:253–79.
[22] Petersen EH. Economic policy, institutions and fisheries development in the Pacific. Mar Policy 2002;26:315–24.
[23] Barclay K, Cartwright I. Governance of tuna industries: the key to economic viability and sustainability in the Western and Central Pacific Ocean. Mar Policy 2007;31:348–58.
[24] Sumaila UR, Dyck A, Baske A. Subsidies to tuna fisheries in the Western Central Pacific Ocean. Mar Policy 2014;43:288–94.
[25] Watson R, Kitchingman A, Gelchu A, Pauly D. Mapping global fisheries: sharpening our focus. Fish Fish 2004;5:168–77.
[26] OECD. OECD Stat; 2014.
[27] EIA. Short-term energy outlook real and nominal prices; 2014.
[28] FAO. FAO food price index;; 2014.
[29] Ricard D, Minto C, Jensen OP, Baum JK. Examining the knowledge base and status of commercially exploited marine species with the RAM legacy stock assessment database. Fish Fish 2012;13:380–98.
[30] IMF. Asia and Pacific small states: raising potential growth and enhancing resilience to shocks. Washington DC: International Monetary Fund; 2013.
[31] Hanich Q, Tsamenyi B. Exclusive economic zones and Pacific developing island states-who really gets all the fish? 2006.
[32] Parris H. Can tuna promote sustainable development in the Pacific? J Environ Dev 2006;15:269–96.
[33] Le Manach F, Andriamahefazafy M, Harper S, Harris A, Hosch G, Lange G-M, et al. Who gets what? Developing a more equitable framework for EU fishing agreements Mar Policy 2013;38:257–66.
[34] Fulton EA, Smith ADM, Smith DC, van Putten IE. Human behaviour: the key source of uncertainty in fisheries management. Fish Fish 2011;12:2–17.
[35] Grafton RQ, Arnason R, Bjørndal T, Campbell D, Campbell HF, Clark CW, et al. Incentive-based approaches to sustainable fisheries. Can J Fish Aquat Sci 2006;63:699–710.
[36] Clark C, Clarke F, Munro G. The optimal exploitation of renewable rresource stocks: problems of irreversible investment. Econometrica 1979;47:25–48.
[37] Bertignac M, Campbell H. Maximizing resource rent from the western and central Pacific tuna fisheries. Mar Resour Econ 2000;15:151–77.
[38] Chand S, Grafton RQ, Petersen E. Multilateral governance of fisheries: management and cooperation in the western and central Pacific tuna fisheries. Mar Resour Econ 2002;18:329–44.
[39] Kompas T, Che TN. Economic profit and optimal effort in the western and central Pacific tuna fisheries. Pac Econ Bull 2006;21:46–62.
[40] Sethi S, Branch T, Watson R. Global fishery development patterns are driven by profit but not trophic level. Proc Natl Acad Sci USA 2010;107:12163–7.
[41] Van Putten IE, Kulmala S, Thébaud O, Dowling N, Hamon KG, Hutton T, et al. Theories and behavioural drivers underlying fleet dynamics models. Fish Fish 2012;13:216–35.