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Public resource, private profit: Investigating tuna subsidies in the IOTC area of compliance

IOTC Scientific Committee Working Paper

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Abstract

Tuna fisheries worldwide are important for both food and economic security. The economic value of these fisheries is generally expressed as gross revenue, or landed value, essentially the product of the ex-vessel price commanded by the fish species and the catch. This can lead to distorted perceptions of the "value" of tuna fisheries. In this paper, we combine landed value, cost and subsidy databases to calculate private rent from tuna fishing, in the case of the fisher or fishing company, and social resource rent in the case of a country. Note that the data source we are using (*Sea Around Us* databased) is currently being updated, and thus our estimates are still based on old data, but will be updated when new data become available. We first present high level estimates for private and social resource rent (i.e., including subsidies) for global tuna fisheries, then dig down for a deeper look at IOTC tuna fisheries. While many countries subsidize their fishing activities, the degree of this differs markedly across countries. The proportion of the landed value that is subsidized by IOTC fishing states ranged from about 10% (Maldives) to over 100% (Seychelles). Tuna fisheries around the globe, and indeed in the IOTC are thus being propped up by distortionary subsidies paid by citizens in a given country to that region's tuna fleets. In the absence of subsidies, it's quite likely that many fisheries would be unprofitable, and therefore, would contain less fishing capacity. This is particularly important when it comes to discussion around allocations being based on historical catch. Fleets that have been subsidized will likely have caught more, meaning subsidies disproportionately impacts allocation decisions. Furthermore, subsidies encourages increased capacity, which can undermine the conservation mandate of RFMOs.

Introduction

Fisheries are a globally important economic sector, with marine and freshwater fisheries providing both income and food for virtually every country on earth. One particular group of fishes, the tunas, is of immense global economic importance, with various species being fished by 82 countries, or 56% of all maritime states, and having a landed value of US $17 billion in 2005 (seaaroundus.org). Tuna products are consumed all over the world, including everything from smoked skipjack eaten domestically, to low- and medium-grade tuna in cans, to high-priced bluefin sashimi served in Japanese restaurants. Since 1950, over 117 million t of tuna have been removed from the ocean, averaging about 2.06 million t per year (seaaroundus.org). Production hotspots in the high seas are shown in Figure 1.

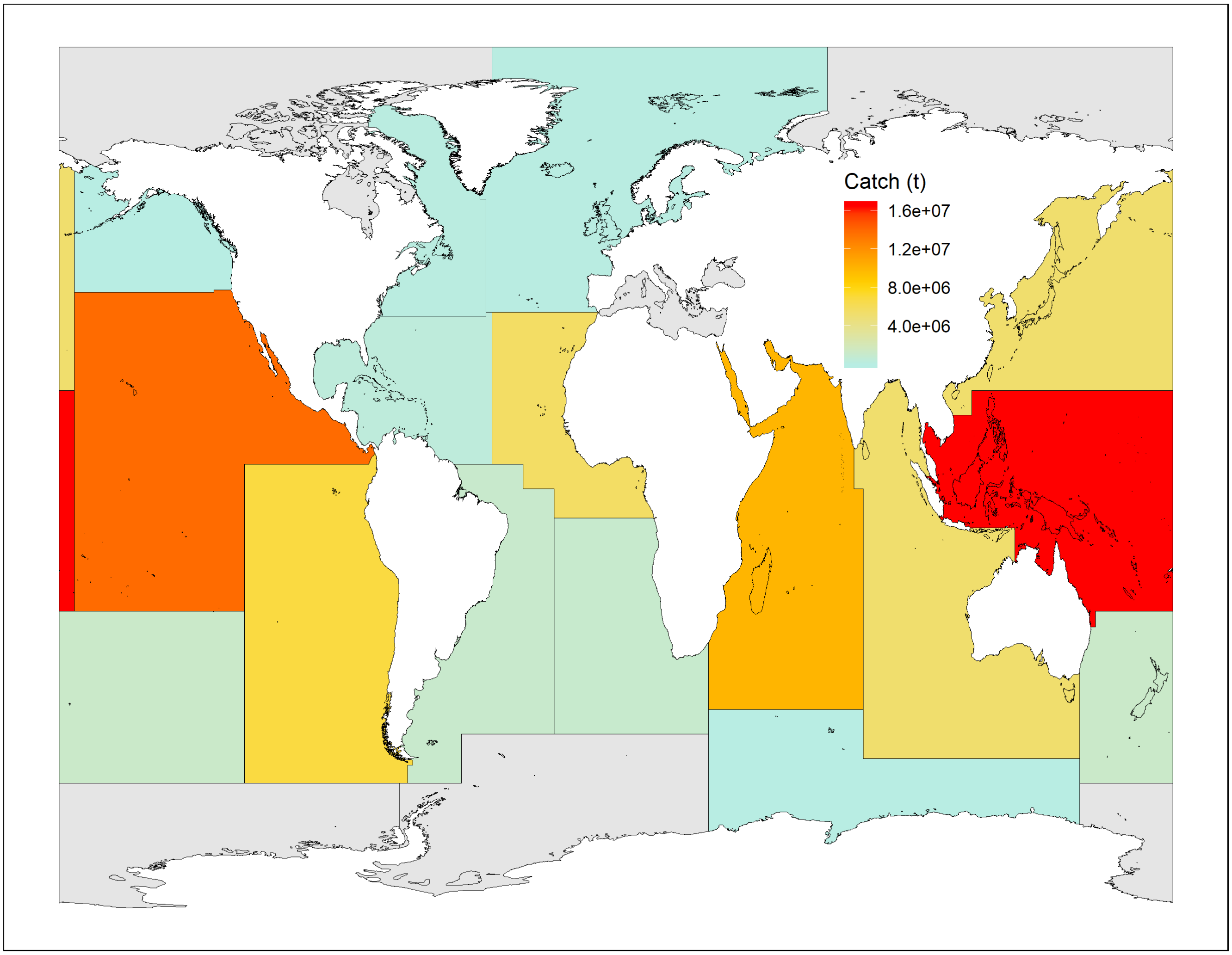

Figure 1. Sum of high seas catch of tuna from 1950-2014 by FAO major fishing region. Total catch 67 million t. A grey region indicates no catch.

The importance of tuna fisheries to regional and global economies has been stated several times in diverse places, everywhere from management reports (Majkowski, 2007; Williams and Terawasi 2009), media and outreach pieces (Pala, 2011; McKenna, 2008; Bailey, 2012) to scientific literature (Collette *et al.*, 2011; Sumaila and Huang, 2012; Sumaila et al, 2013). Often times, however, economic value is viewed solely from the perspective of the landed value, that is, the gross revenue received from landing the fish at port. With few exceptions (for example, Sumaila and Huang, 2012 and Sumaila *et al.*, 2013), the costs associated with fishing these species are generally not reported. Consequently, net revenue, or more generally net benefit, is seldom discussed. The typical focus on gross revenue can distort society's perception of the value of tuna fisheries and give false impressions of the success or lack of success that current management efforts are experiencing. The fact that fishing costs can be hard to obtain probably accounts for the emphasis on gross revenues.

As we explain in more detail, however, the correct concept for judging fishery performance is *rent*, the benefit received net of all costs associated with obtaining that benefit. Further, for evaluating policy, it is necessary to consider rent from both social and private perspectives. There are three reasons why it is important to view fishery performance from the perspective of rent instead of landed value:

1. Positive rent earned by harvesters is the main force that drives expansions in fishing effort. To successfully manage a fishery, managers must know how their policies affect this *private rent*.
2. Knowing that consumers place a certain value on tuna fishery *outputs* does not shed light on whether a country's citizens benefit from using the resource (i.e., *outcomes*). To answer the latter question one must know what consumers and taxpayers forego to obtain these outputs, i.e., one must know the *social rent*, or net social benefit, the resource generates.
3. Where fisheries have been highly subsidized (as evidenced by a large different in private and social rent), past catches have likely been higher than they otherwise would have been, distorting power dynamics in current negotiations.

In this paper, we draw on the concepts of private and social resource rent, and welfare economics more generally, to analyse the current economic state and societal contribution of global tuna fisheries, making specific reference to IOTC countries and fisheries. Furthermore, we discuss the ramifications of fishing subsidies on IOTC governance more broadly.

Concepts and background

Resource rent

Resource rent is the difference between the revenues obtained and the costs incurred in the resource extraction process (Campbell and Haynes, 1990). Rent is revenue minus the opportunity cost of inputs. Resource rent is an opportunity cost in the sense that the owner foregoes a return in some other line of business as a consequence of investing in the enterprise in question. To say that rent or profit is zero is not to say that firms are essentially broke; rather it means that their investment is yielding no higher return in its present occupation than it could generate if invested elsewhere. We discuss this issue later in the paper.

As explained in the introduction, the value of fisheries, and in particular tuna fisheries, is often reported based solely on gross revenues, or landed values. There are notable exceptions, such as a global study of fisheries rents commissioned by the World Bank (World Bank, 2010). The so-called "Sunken Billions" report assessed the world's fisheries and determined that losses in net potential value of the world's fisheries amounted to approximately US $50 billion, with some of this loss coming as a result of overcapacity and the use of subsidies (World Bank, 2010). The Sunken Billions report calculated the net economic benefits of the fishery to a country once the social cost of subsidies are incorporated; these results are equivalent to the results presented in this paper under the concept of social resource rent. Another study published recently assessed the benefit of rebuilding fish stocks, finding that rebuilding could lead to substantial economic benefits even when the costs associated with rebuilding are factored in (Sumaila *et al.*, 2012).

Our rent calculations are subject to one important qualification. Post-harvest activities such as smoking, canning, loining and freezing, which clearly may generate net revenues for the firms involved, are not accounted for in this study. Vertically integrated companies, of which there are many in the tuna sector, may well earn rents from such downstream activities and these may offset negative rents from harvesting (World Bank, 2010).

In this study, rent is calculated in two ways. The first is private resource rent, which reflects the perspective of fishers or fishing companies. In these calculations, only the benefits and costs accruing to specific individuals or firms involved in the fishery are incorporated. The second is social resource rent, which is calculated from the perspective of entire fishing countries. In these calculations, the cost society bears in subsidizing private fishing fleets must be subtracted from benefits, causing social rent to differ from private rent. In addition, we comment on the method of utilizing large global databases to draw economic inferences about fisheries. In the next section, we discuss welfare economics and fishing subsidies, and follow this up with an overview of global tuna fisheries before proceeding to the analysis.

Welfare economics

Economic analysis of fisheries has generally focused on issues of efficiency, for example overcapacity and races to fish, and has paid less attention to issues of distribution and equity (Bromley 1977; Charles 1988; Weninger2003; Tietze *et al.* 2005; Beddington *et al*. 2007). Any fisheries management decision or policy tool will, however, affect the distribution of resources and the returns earned by various segments of society. Key distributional aspects of fishery policy are related to effects on labour and employment and on food security. Often, there are tensions between the distributional and efficiency goals of fishery policy. For example, a policy to allow foreign fleets into a nation's EEZ may generate larger rental access fee payments than the national fishing industry can deliver, but it may also limit or eliminate employment opportunities for local artisanal fishers (Kaczynski and Fluharty, 2002; Alder and Sumaila, 2004). This is a public policy choice that is seldom explicitly acknowledged by policy makers. The scarcity of fisheries resources, and indeed resources in general, effectively implies that public policy necessarily involves trade-offs.

Welfare economics is the branch of economics that applies microeconomics methods to evaluate how well members of society benefit from the allocation of resources produced by a set of institutions. In the context of a market economy, the fundamental result from welfare economics postulates that a competitive market economy can be efficient under certain circumstances. The efficiency concept is quite general: an economy is not operating efficiently unless all opportunities to enhance one person's well-being without impairing the well-being of others have been exhausted. In the case of fisheries, fish stocks are valuable resources, capable of providing sustained consumption benefits to the world's populations, and withdrawing from these stocks imposes a cost on society in the form of reduced consumption opportunities. Fishing firms that harvest from these stocks do so without bearing the cost that reduced stocks imposes on consumers and other fishers, both in the present and future tense. As a consequence, their incentive is to over-harvest, sometimes to the point of endangering the viability of the resource itself.

While the efficiency goals promoted by welfare economics clearly are not the only considerations that should matter when forming policy, they arguably should be the first considerations. By definition, enhancing efficiency makes available expanded opportunities for society and can provide the resources with which distributional goals can be pursued. Here we use welfare economics not as an analytical tool to measure the efficiency of national fisheries policies, but as a framework that allows us to scrutinize government policies that subsidize fishing fleets. In brief, we question the proposition that government subsidies to fishing promote desirable environmental outcomes, fiscal responsibility, and social welfare. And we add that in the context of internationally-shared fish stocks, subsidies tip the scales of historical power immensely.

The extent to which society as a whole benefits from a commercial fishery is not well-studied. While some researchers have examined the 'multiplier effect' to analyse how a dollar generated in the fisheries sector is amplified throughout the economy (e.g., Dyck and Sumaila, 2010), this does not shed light on social benefits because it does nothing to analyse the trade-off in obtaining that dollar of output: what government expenditures supported that level of production and what is the opportunity cost of such expenditure? Our goal in this contribution is to address social welfare questions by scrutinizing subsidies to tuna fisheries and the private and social rent these fisheries generate.

Subsidies

Subsidies are government interventions that either lower the cost producers face for supplying a good or service, or increase the price they receive (Barg, 1996). Because they affect profits, subsidies alter incentives to produce specific items and consequently alter patterns of production and consumption in a market economy (OECD, 2005). The Organization for Economic Cooperation and Development (OECD) estimates that its member countries provide subsidies of more than USD $400 billion each year to various economic sectors (OECD, 2005).

Subsidies are sometimes 'direct', e.g., a rebate from government that reduces the purchase price a consumer pays. The U.S. uses this form of subsidy to reduce the cost of hybrid cars to consumers. Subsidies can also be 'indirect', e.g., low interest loans or tax exemptions for certain types of investments. In some circumstances, subsidies can be justified by appeals to economic efficiency. Efficiency can indeed be enhanced by subsidizing the production of private goods when the private cost of provision exceeds the social cost, or when the social benefit of consumption exceeds the private benefits. Hybrid car subsidies exemplify the cost rationale: the air pollution cost to society (per mile travelled) can be reduced by switching from an ordinary vehicle to a hybrid, so a subsidy to hybrids can be rationalized. Mortgage interest deductions exemplify the benefit rationale: home ownership is thought to confer benefits to society beyond what the homeowner can capture, so a tax exemption that reduces effective mortgage payments can be rationalized. There can also be a distributional or equity rationale for adopting subsidies that benefit the poor. This motive is reflected in subsidized health care and in low cost food measures such as the U.S. food stamp program.

Political economy, the study of interactions between the economy and a nation's political system, has identified a less benign force in the adoption of subsidies—the ability of organized interest groups to obtain favourable policies from government. An important historical example from the U.S. is a suite of policies that have subsidized the agricultural sector in a variety of ways. A common political economy explanation for this favourable treatment is that farmers have extraordinary political power due to the apportionment of seats in the House of Representatives. Another example from the U.S. is its system of import restrictions on sugar, which amount to price supports for domestic sugar producers since they largely exclude low cost foreign supplies from the U.S. market (for example from Fiji). They represent a politically expedient way to support powerful sugar lobbies in sugar growing states (Lopez, 1989).

When applied to natural resource sectors, subsidies often are both environmentally damaging and a source of economic inefficiency (Frieden and Rogowski, 1996). Environmentally damaging subsidies typically escape public scrutiny because they are indirect or implicit (van Beers and van den Bergh, 2001). 'Perverse subsidies', those that have a negative impact on the environment, the economy, or both, can reduce efficiency in ordinary market outcomes and can impose external costs on both current and future generations (van Beers and van den Bergh; Sumaila and Walters 2005). The observation that subsidies to natural resource sectors often have undesirable side effects prompts one to ask a more pointed question: does a country's policy of subsidizing its fishing fleets make its citizens better or worse off?

In this paper we focus on subsidies specifically to the fisheries sector. A fishery sector subsidy is considered to be any direct or indirect transfer from a government to the fishing sector that confers an economic advantage, thereby encouraging fishers to fish more than they otherwise would (Sumaila *et al.* 2010). Government subsidies to the fishing sector therefore are policies that direct public resources to a small fraction of society. Because of the economic advantage subsidies confer; they tend to exacerbate problems of overcapacity and overfishing (Arnason 1998; Clark *et al.* 2005; Clark 2006). Most of the subsidies now in place support developed country fishing firms, and this poses competitive challenges both for developing countries that seek to participate in the global fisheries sector (Sumaila et al, 2010; Sumaila *et al.* 2013; Sumaila *et al.* 2014) and for smaller fishing firms (Schorr and Caddy, 2007).

Two studies in the 1990s estimated that between US $14-54 billion in subsidies were being transferred to the global fishing sector annually (FAO 1992; Milazzo 1998). A more recent estimate of global fisheries subsidies was calculated by the *Sea Around Us* project and the Fisheries Economics Research Unit. This project resulted in the development of a subsidies database containing information on 148 maritime countries for the year 2003 (Sumaila *et al*. 2010). This study estimated global fisheries subsidies to be between US $25-29 billion, with fuel subsidies making up about 15-30% (Sumaila *et al*. 2010).

Fisheries subsidies can be divided into those that positively affect stock sustainability ("good"), negatively affect stock sustainability ("bad"), and those whose impact is not always clear ("ugly") (Sumaila *et al*. 2010). Good subsidies include those that promote better fisheries management, such as stock assessments and supports for monitoring and enforcement. Bad subsidies include those that increase capacity or directly expand fishing effort. Examples include fuel subsidies, low interest loans, free provision of harbour facilities and support for processing and storage infrastructure. While it is common to think of subsidies as lowering the cost of fishing, they can also act through increasing revenue, e.g., by controlling trade to elevate the prices producers receive.

In this paper, we incorporate empirical measures of subsidies into resource rent calculations. This allows us to partially distinguish between private and social measures of resource rents and to therefore shed light on market distortions. Viewing fishery performance from the perspective of social resource rent, rather than private rent, aligns better with the concepts of welfare economics and speaks to the broader societal benefits (or lack thereof) of fisheries as common pool resources.

Our analysis takes private rent, the difference between the revenue received for landed fish and private harvest cost, as given. We then subtract subsidy expenditures from this amount to derive an estimate of social rent. We do not account for the distorting effect that subsidies can have on landed revenue and harvest costs, however.

Global tuna fisheries

There are seven large tuna species targeted globally that distributed into 23 stocks. The seven large species, all members of the Scombridae family, include albacore (*Thunnus alalunga*), yellowfin (*T. albacares*), bigeye (*T. obesus*), southern bluefin (*T. maccoyii*), Atlantic bluefin (*T. thynnus*), Pacific bluefin (*T. orientalis*) and skipjack (*Katsuwonus pelamis*). Tuna are considered a straddling stock in that they are found in the exclusive economic zones (EEZs) of more than one country, and also in the high seas. But they are a special type of straddling stock, namely "highly migratory species", a term which became prominent in the literature after the 1995 United Nations Straddling Fish Stocks Agreement (UN, 1995). The Agreement was primarily an attempt to facilitate cooperation between fishing nations exploiting a common pool resource, as cooperative management can potentially improve upon uncoordinated exploitation by separate states, both in terms of both economic performance and the sustainability of stocks (Singh and Ballaba 1996; Ostrom *et al*. 1999; Sumaila 1999, Bailey *et al*. 2010).

Of the seven species reported on in this paper, the International Union for Conservation of Nature (IUCN) lists Atlantic and southern bluefin as endangered, bigeye as vulnerable, yellowfin and albacore as near threatened, and only Pacific bluefin and skipjack as of least conservation concern (Table 1) (IUCN, 2011). All three bluefin species exhibit life history traits that make them particularly vulnerable to over-exploitation, including slow growth and late maturity (de Roos and Persson, 2002), compared to their smaller con-specifics. Furthermore, they are temperate water species, which are generally less productive than tropical species (Majkowski 2007). For species such as bigeye and yellowfin, their association with skipjack around floating objects, specifically in the Pacific, makes them susceptible to growth overfishing due to juvenile bycatch (Bailey *et al*., 2013; Langley *et al*., 2009a; Langley *et al*., 2009b). Skipjack stocks in the Pacific are underexploited (ISSF, 2013), and expected future increases in fishing effort for this target species are likely to have a negative impact on yellowfin and bigeye stocks in the region if today's fishing practices continue. Table 1 gives the number of separately managed stocks for each tuna species

Table 1. Information on tuna species, fishing gears, markets supplied, separate stock numbers (ISSF), conservation status (iucnredlist.org), and ISSF relative fishing mortality level (where orange represents

overfishing occurring with inadequate management, yellow represents overfishing with adequate management, to prevent an overfished stock, and green represents no issue with overfishing).

Common name	Scientific name	Gears used	Markets supplied	Number of stocks	IUCN status	ISSF relative fishing mortality
Albacore	*Thunnus alalunga*	Longline, troll, pole and line	Canned and frozen	6	Near threatened	1/6 yellow, 5/6 green
Bigeye	*Thunnus obesus*	Longline, handline, Purse seine	Sashimi Canned	4	Vulnerable	2/4 orange, 2/4 green
Atlantic bluefin	*Thunnus thynnus*	Longline	Sashimi	2	Endangered	2/2 green
Pacific bluefin	*Thunnus orientalis*	Longline, trap, purse seine	Sashimi	1	Least concern	Orange
Southern bluefin	*Thunnus maccoyii*	Longline	Sashimi	1	Endangered	Green
Skipjack	*Katsuwonus pelamis*	Purse seine and pole and line	Canned Domestic	6	Least concern	6/6 green
Yellowfin	*Thunnus albacares*	Longline, handline, Purse seine	Frozen Canned	4	Near threatened	1/4 orange, 2/4 yellow, 1/4 green

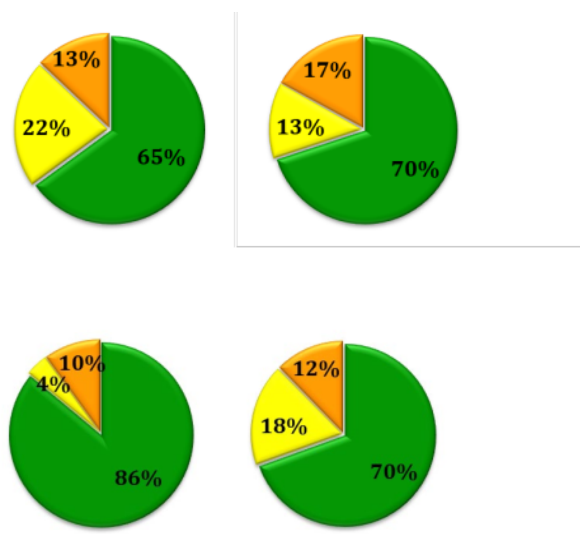

Figure 2. Top: Distribution of stocks of major commercial tunas according to abundance ratings (left) and fishing mortality ratings (right). The percentages correspond to the proportion of the number of stocks with a given ranking. Bottom: Distribution of stocks of major commercial tunas according to abundance ratings (left) and fishing mortality ratings (right). The percentages correspond to the total catch of all stocks with a given ranking.

Effective management of shared fish stocks requires cooperation by several fishing nations (Munro, 1979, Sumaila, 1999, Bailey *et al.*, 2010), and this essential cooperation is facilitated by Regional Fisheries Management Organizations (RFMOs). One of the largest issues RFMOs face is in their inability to control access to the fisheries nominally under their purview. Part of their challenge in meeting conservation targets is due to the nature of catch allocation programmes, and the compromises RFMOs have to continually make to accommodate industry lobbyists and new members (Bailey *et al*. 2013). Beyond institutional difficulties, the physical challenges of enforcing regulations for highly migratory species such as tuna are daunting.

In light of this background, the main objectives of this working paper are threefold. Firstly, to provide a global estimate of global tuna subsidies by species and gear, and to comment on the difference between private and social rent in this context. Secondly, to examine in detail the subsidies present in the Indian Ocean (by species, gear, and country). And thirdly, to offer a commentary on how capacity enhancing subsidies undermine the conservation mandate of RFMOs, and to speculate on the ways in which taking subsidies into account at the RFMO level could help improve conservation and management decisions. We now turn to the methods employed to address these objectives.

For over a decade, the *Sea Around Us* project and the Fisheries Economics Research Unit at the University of British Columbia have been collecting and aggregating fisheries data for most commercially targeted fish species and maritime countries. Here, we combine catch, price, cost and subsidy databases to construct a picture of the current economic condition of global tuna fisheries. Particular emphasis is given to the difference between private and social resource rent. Although the catch and price databases offer data up to 2015, the costs and subsidies databases do not go further than 2005, so a 2005 estimate is calculated in this paper, and all dollar amounts are given in 2005 USD. Detailed methods, including equations can be found in the appendix. Note that the *Sea Around Us* is in the process of updating the cost and subsidies databases, so when new data are available the estimates in this paper will be updated.

Results

Global

Based on our analysis, about \$5.6 billion in subsidies is going to the global tuna fleet. These are broken into good, ugly, and bad (capacity-enhancing) subsidies, as shown in Figure 1a. This is alarming given that the total estimated resource rent (private) to global tuna fisheries is estimated at \$4.7 billion, meaning subsidies are about 20% more than the total private value of the fisheries. This would indicate that the social rent of these fisheries is negative. However, if we only consider bad and ugly subsidies, and ignore good subsidies (like monies going towards fisheries management), then the net social rent remains positive, and is estimated at about \$600 million. The result is that the social rent is about 1/8th of the private rent (Figure 1b). Fundamentally this result suggests that citizens of tuna-fishing countries are generating minimal gains from their fisheries.

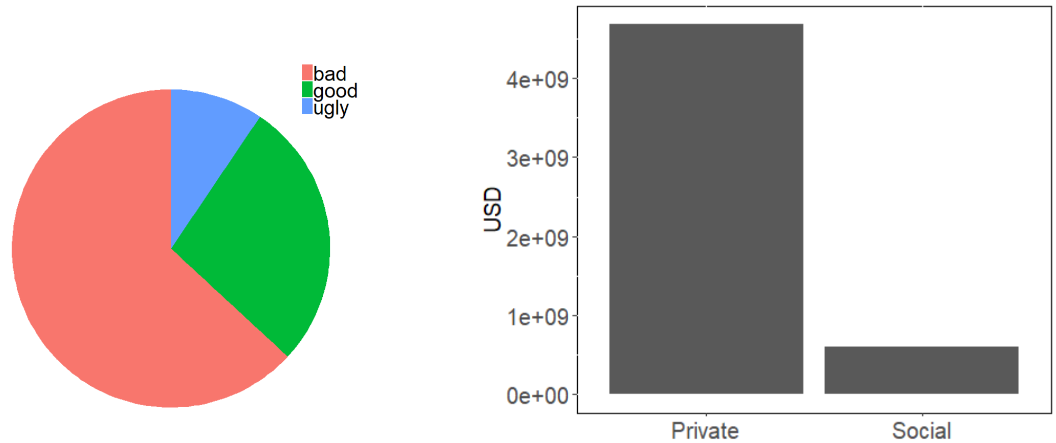

Figure 3a (left). Proportion of the total amount of global tuna subsidies ($5.6 billion) that are characterized as good, bad, and ugly. Figure 3b (right) private and social rent before and after bad and ugly subsidies have been considered, respectively.

Countries

It is not our intention for global tuna fisheries to dig too much into countries, but we do offer some summary statistics here as food for thought. There is significantly greater private & social rent in developed countries vs developing countries, (Kruskall-Wallis: chi-squared (1) = 10.4, p = 0.001), and subsidies (in $ value) are generally greater in developed countries, except for good subsidies which are marginally higher in developing countries. Catch-weighted subsidies ($/t) are higher in developed countries, except for bad subsidies, which are not significantly different between the two groups. Conversely, subsidy intensity (% of landed value) is generally marginally higher in developing countries but this is likely due to the higher intensity of good subsidies. For ugly subsidies, there is a greater intensity in developed countries.

Species

From a species perspective, fishing for yellowfin and for albacore remain unprofitable enterprises (negative social rent) once subsidies are incorporated, and in the case of yellowfin, even just the private rent is negative (Figure 3). Southern bluefin tuna fishing seems to be the most lucrative of the major tuna species, generating about US $5,000/t after subsidies are considered (Figure 3).

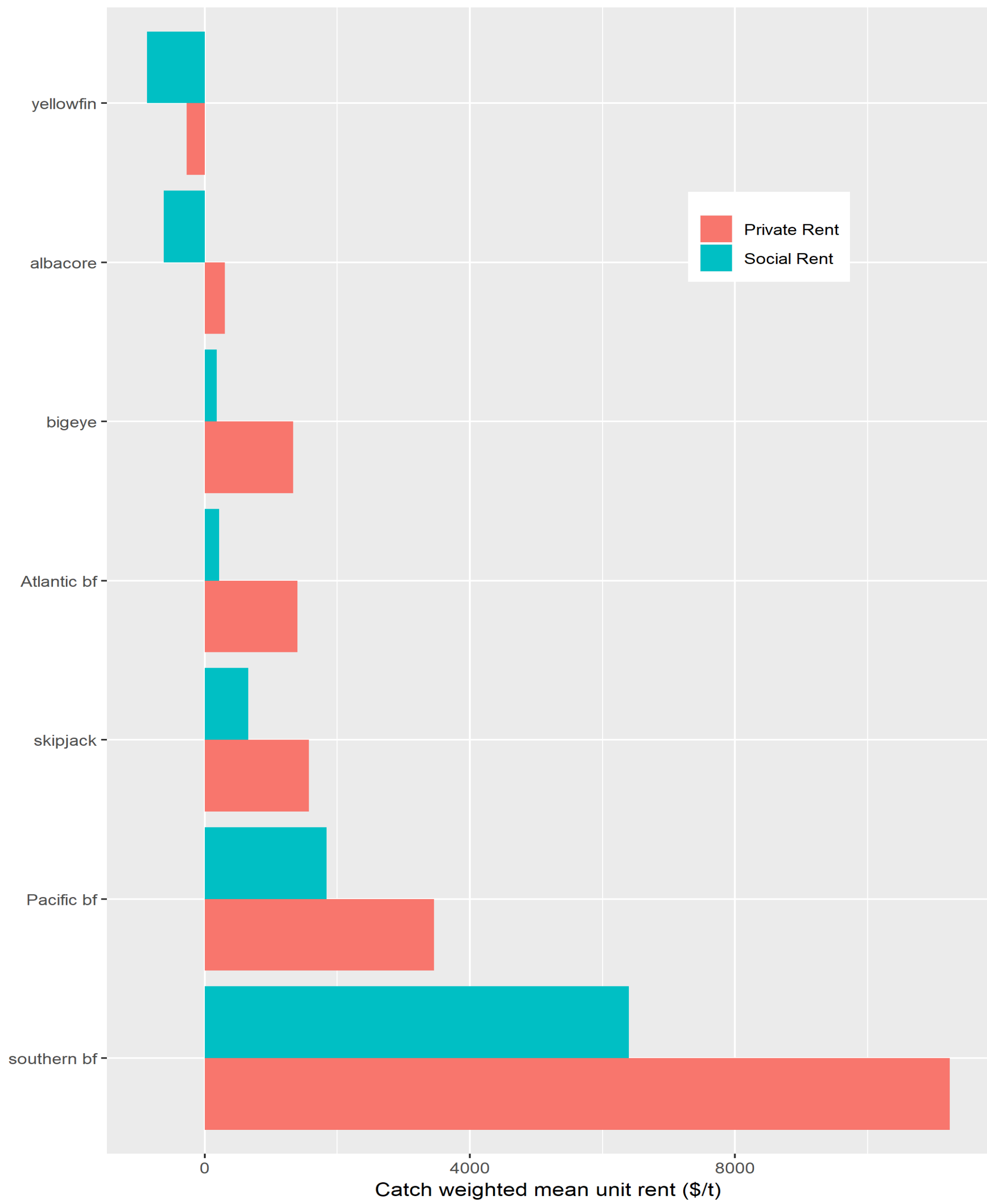

Figure 4. Catch-weighted means by species for private (not including subsidies) and social (including subsidies) rent.

We also calculated the catch-weighted mean unit rent per tonne, or difference in price and cost per tonne, for each major gear type employed in global commercial tuna fisheries (Figure 5). Gillnets, pole and line/hook and line, and purse seine are all profitable fishing methods based on their mean unit rents before and after subsidies are considered. Based on the data at the time of writing, longlining is a fishing method that is negative for private firms and for society.

Figure 5. Catch-weighted mean unit rent (price/tonne minus cost/tonne) by gear type.

IOTC

For the purposes of the IOTC, we extracted data for member states and plotted by country the catch-weighted mean unit rent. This is essentially the difference per tonne of tuna landed between the price per tonne and the cost per tonne. In the case of private unit rent, this is not including the about of subsidized value. For social rent, subsidies are incorporated. Where there is a large difference in the mean unit private and social rent for a given country, that indicates that subsidies play a large role in their fishery. The overall private value of IOTC fisheries (private rent summed across all countries is negative, that in many cases the costs of fishing outweigh the benefits. A word of caution, these results are still based on older *Sea Around Us* data. For this reason we do not wish to point fingers at any country, any gear type, or any species specifically. However, we do think there is some utility in discussing a few observations with the old data, that will inform hypotheses to be tested with the new data.

Figure 6. Catch-weighted mean unit rent: The difference between the price per tonne and cost per tonne without (private) and with (social) incorporating subsidies.

All gear types appear to be subsidized, with longline and gill net not providing net positive benefits to society, while purse seine and pole and line/handline do return benefits (i.e., have a positive social rent) (Figure 7).

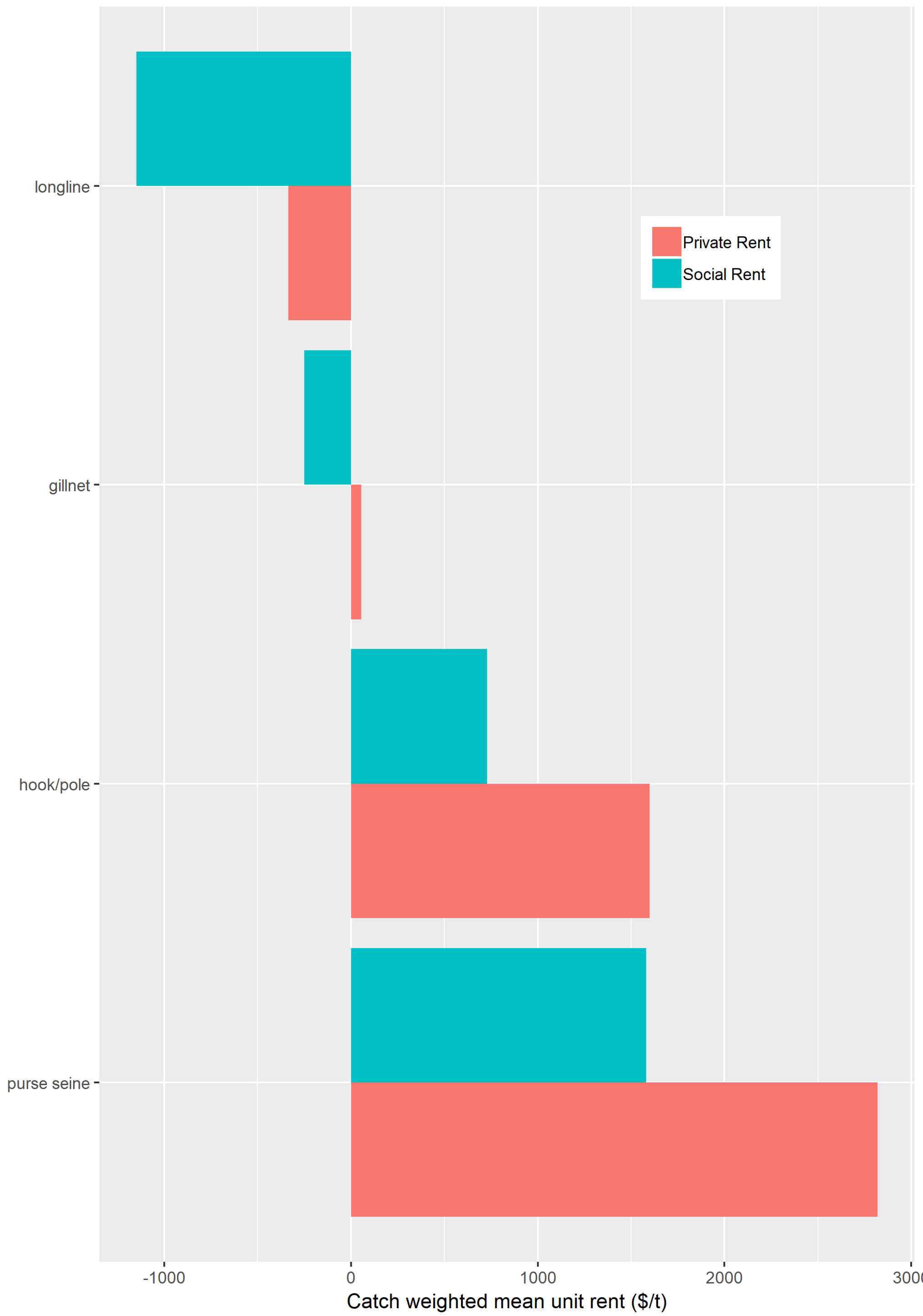

Figure 7. Catch-weighted mean unit rent (price/tonne minus cost/tonne) by gear type.

The countries in the IOTC vary in terms of their subsidies intensity: calculated as the proportion of their landed value that is subsidized. On the low end, Taiwan, Sri Lanka, Comoros, and Maldives all subsidize the least, under about 13% of the landed value. On the high end, France, Belize and Kenya all subsidize about 75% of their landed values, while the Seychelles subsidized more than 100% of their landed value (Figure 8).

Figure 8. Subsidy intensity (proportion of landed value that is subsidized) by country.

Discussion

Tuna fisheries clearly provide substantial revenues in the form of landed value for fishing nations. Once costs and subsidies are accounted for, however, the net social rent from global tuna fisheries is negative, and this is true in the Indian Ocean as well. There are vast differences in the distribution of rent by country, species, and by fishing gear. Furthermore, there is a substantial difference in private and social resource rent. Currently, subsidies amounting to over US$5 billion are estimated to be transferred to the tuna fishing sector from national governments annually. This is money that countries are choosing to put into various fishing sectors may not be providing positive economic returns for the country and, no doubt, is fueling overexploitation of tuna stocks. The widespread practice of using public funds to disinvest in public resources should be questioned.

We mentioned in the introduction that it is important to consider (social and private) rent and not just landed values for several reasons. We discuss these reasons below.

Incentives for fleet expansion

While our analysis illuminates subsidy-induced differences between social and private rents, it does not give a complete picture of the distortions that subsidies can cause. A subsidy generally will expand effort, which will reduce the stock over the long run and this can be regarded as costly on purely ecological grounds. Expanded effort also has purely economic consequences. A smaller stock can lead to higher private harvest costs than would be realized without the subsidies, since achieving a given catch from a diminished stock requires more effort. A subsidy-induced increase in effort can also lead to higher prices and reduced supplies for consumers if exploitation is pushed to the point where additional effort reduces yields. These outcomes, which are ultimately caused by subsidies, affect the private rent that fisheries generate.

Opportunity cost of subsidies

Yes, a country can choose to subsidize an industry if it has reason to do so, whether for economic, social, environmental reasons. Yet, rarely does one hear questioned the opportunity cost of that transfer. In the case of fisheries, subsidies has fuelled the overfishing crisis, but are they even more problematic than that, in that it is money the government is not using to promote other things: Data monitoring, enforcement, or marine protection for example. But even more so, that money may have been used in totally different ways, on education, infrastructure, health care, etc.

Issues for RFMO governance

Probably most interesting to RFMOs are the ways in which subsidies can undermine the conservation regime. To explain this, we draw on principle agent theory, and specifically, the double principle-agent problem. This problem is explained in Bailey et al., (2015), in the case of Indonesia (Figure 9. Essentially, the principle agent problem is that resource owners (the government in this case) has the task of developing a set of incentives that gets the resource users (fishers) to act in a way that best meets the objective of the owners. The incentive gap emerges as the gap between what the owners want and what the agents want. In the case of internationally shared fish stocks, however, there are in fact to principle agent gaps. The first relates to the RFMO as the principle, in this case the IOTC, where IOTC must set the rules, norms, and incentives by which member states need to operate. IOTC would like member states to operate in a way that helps the RFMO reach its conservation mandate. But at the same time, members states themselves are also principles, and need to set the rules, norms, and incentives by which fishing companies within their jurisdiction need to operate. We argue that fishing subsidies undermines this relationship between the RFMO as principles and member states as agents because it will be increasingly hard for IOTC to manage effort (for example, through reduction conservation measures) when fleets are highly subsidized and have spent decades developing as a result of those subsidies.

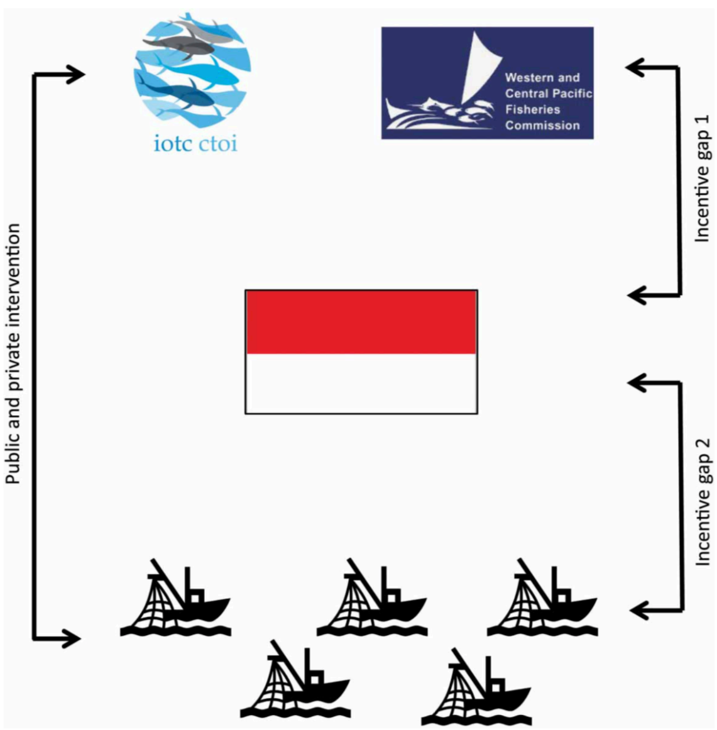

Figure 1. The double principal–agent problem.
Source: Boat image by Louis Prado, the Noun Project.

Figure 9. The double principle agent problem, where RFMOs have to set up incentives to get member states to act in the way that best suits the RFMO, while the member states themselves have to set up incentives to get fishers/fishing companies to act in the way that best suits the member state.

For the double principle agent problem, it's important to understand who the principles and agents are, what the cause of the incentive gap is, and who is best suited to address and close the gap. This is no small feat but worth a hard look at from the perspective of RFMOs.

Additionally, where fisheries have been highly subsidized (as evidenced by a large different in private and social rent), past catches have likely been higher than they otherwise would have been, distorting power dynamics in current negotiations. This is particularly true when it comes to allocation negotiations as historical catch has been, and continues to be, a contentious issue. If high amounts of subsidies lead to over-capacity, then they have led to some countries (those that subsidize) a disproportionate amount of access to the catch potential in the past. If equity is a concern for RFMOs, as it should be given the language in UNCLOS and in the Fish Stocks Agreement, then the extent to which past subsidies have impacted equity at the table today should be a concern.

Albacore, skipjack, yellowfin and bigeye

Globally, fishing for albacore and bigeye, species that are considered near threatened and a conservation concern by the IUCN and reported as fully exploited by scientists (ISSF 2012; Langley *et al.* 2009b, IUCN 2011, Collette *et al*. 2011), still offers positive private rents. Fishing for skipjack tuna, an underexploited species (ISSF 2012), is currently returning both positive private and social resource rents. Skipjack tuna make up over half of all global tuna catches (ISSF 2012). Our observation that fishing for this species offers positive social rent suggests that effort is likely to increase in these fisheries. Some of the efficiencies of skipjack fishing come from the use of fish aggregating devices (FADs) by purse seiners, which reduces fuel consumption (Miyake *et al.* 2012). The use of FADs by purse seiners is known to result in mortality of juvenile bigeye and yellow fin tuna, however, and measures to mitigate this mortality have been the topic of many WCPFC meetings in recent history. These measures, if successfully put in place, could result in increased costs to purse seiners in the region, and decrease private and social rents generated by this fishery in the future. This in turn would most likely result in less effort or capacity in this fishery than would otherwise be predicted.

Conclusion

Subsidies for natural resource extraction sectors, including fisheries, petroleum and agriculture, have been criticized as perverse tools that encourage disinvestment in nature's capital (Porter, 1998; van Beers and van den Bergh, 2001; Clark *et al*., 2005; Amegashie, 2006). Subsidies are sometimes adopted to promote expansion of sectors that confer social benefits beyond what private investors can capture; subsidies for renewable energy are defended on these grounds. Still, it is reasonable to ask whether or not the arguments used in the past to justify subsidizing a particular sector are still applicable (van Beers and van den Bergh, 2001). Even if elimination is clearly warranted, the path to reform is unlikely to be easy. Once instituted, subsidies tend to develop political constituencies that will resist their removal.

Subsidies can encourage overcapitalization (Arnason 1998; Clark 2006; Sumaila *et al.* 2010), and for fish populations that are fully or overexploited, increased effort resulting from overcapitalization will lead to decreased stock size, leading to reduced resource rent for all fishing nations. Furthermore, excess capacity in global tuna fisheries is thought to contribute to management challenges and to hinder effectiveness of RFMOs (Miyake *et al.* 2012). We have outlined here some explicit ways that that may be true, particularly in the context of the double principle agent problem, and in the context of allocation negotiations.

It is possible that countries generate social benefits from fishery subsidies that offset the economic and ecological waste these subsidies cause, but to date no one has demonstrated this empirically. For many countries, government sponsored, taxpayer supported subsidies are contributing to economic losses, in addition to ecological losses. It has been proposed that society's disinvestment in its natural resources should be deducted from it gross national product (Hartwick, 1990), a practice that would provide a better picture of a country's economic well-being. Greater accountability in how the governments of fishing nations spend public money, coupled with improved management by RFMOs, are needed to reduce the gap between private and social resource rents generated from global tuna stocks.

As van Beers and van den Bergh (2001) point out, these steps toward reform have "been hampered by existing institutions and polices that are often supported vigorously by vested interests of various stakeholders". Nevertheless, improved management of natural resources may depend as much on the removal of perverse policies as it does on the adoption of new policy innovations. Ultimately, the continued use of subsidies by individual fishing nations is a perfect example of the prisoner's dilemma, where private self-interest over-shadows what would be best for the collective good: an international tragedy of the commons. The welfare economics framework, as applied here, makes clear that public money is being used to fuel the overexploitation of the oceans to the detriment of all who depend on their bounty.

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Appendix

Detailed methods

Catches

The global catch database is based on data provided by the Food and Agriculture Organization of the United Nations (FAO), which are then supplemented by unreported and unregulated catch reconstruction data (Zeller *et al*. 2007). Catches are assigned to geophysical marine areas either through the existence of direct data of where a catch occurred, or through a rules-based allocation algorithm taking into account which countries have access to what species, and where and how species are distributed throughout the oceans (Watson *et al*. 2005). The catch database begins reporting catches in 1950, and, at the time of writing, contains estimates of species catches by country and by gear up to the year 2006. Catches (*h)* of species (*s*) by gear type (*g*) and maritime country *(m)* for the 2005 year are used here.

Prices

Although the FAO publishes information on the price of processed fish products, data on ex-vessel prices (i.e., the first-hand prices that fishers receive when they land their fish) are not always easy to come by. To fill this information gap, an ex-vessel price database was constructed in 2007 as a way of translating data on catches into landed values (Sumaila *et al*., 2007). Ex-vessel price is the price that fishers receive when they land their fish, i.e., the unprocessed value. This combination of prices and catches allows researchers to attach landed values to species in time and space. In developing the database, prices were entered either directly from available data, or were calculated from a rules-based algorithm (Sumaila *et al*., 2007). The algorithm allowed weighted means to be applied within years, countries and/or taxa, with the quality of the data being tracked along the way (Sumaila *et al*. 2007While the database was updated in 2010 (Swartz *et al.,* 2012), 2005 prices are used here for consistency with the other databases.

Price (*p*), and the catch volume (*h*), determine the landed value of the catch, or the gross revenue (*TR*) a fisher earns from a given fishing trip. The 2005 landed value is computed for each of our seven tuna species of interest (*s*) and for each maritime country (*m*). Thus, the total revenue country *m* receives for fishing species *s* with gear *g* is calculated as:

$$TR_{m,s,g} = p_{m,s}h_{m,s,g}, \quad \forall_{m,s,g}$$

The total revenue to country *m* for a given year is simply the sum of the total revenues for each tuna species caught and for each gear type used.

$$TR_m = \sum_{s,g} TR_{m,s,g}, \quad \forall_m$$

Similarly, total or mean revenue by species or gear can be calculated by summing across all maritime countries for each gear and species.

Costs

Fishing costs play a major role in determining the behaviour of fishers and fishing fleets. Until 2011, however, reliable estimates on the cost of fishing were not consistently published or adequately summarized. There are several reasons for the lack of data, including the extensive amount of effort required to collect cost information and the lack of reporting requirements for this type of information by government agencies (World Bank, 2010, Lam *et al.* 2011). Therefore, a fishing cost database was developed in 2011, aimed at quantifying costs for various types of fishing gears in all maritime countries for the 2005 year (Lam *et al.* 2011). Data were gathered from secondary sources such as grey literature, and government, FAO and consultant reports, along with requests for information from global partners (Lam *et al.* 2011). The authors were able to source information on, or interpolate data for, countries that made up 98% of the global fisheries catch (Lam *et al.* 2011).

Fishers face two main types of costs, fixed and variable. Fixed costs include outlays that do not vary with the level of fishing operations, but remain roughly constant so long as the firm remains in business. These costs include insurance, depreciation on equipment, docking or mooring fees, and the opportunity cost of the owner's investment in boat and gear. This latter category is the return that funds invested in these items could earn if invested elsewhere in the economy, i.e., a normal profit on investment in the enterprise. Variable costs are those that vary with the level of fishing activity, for example, fuel, bait, crew provisions, gear and boat maintenance, and labor costs. The information reported by Lam *et al.* (2011), and used in this analysis, include both fixed and variable costs, and a normal profit estimate, and are thus economic costs of fishing, as opposed to accounting costs.

For the purposes of this paper, cost estimates for purse seine, pole and line, longline, gillnet and hook and line gear are of particular interest, as they combined for over 96% of all tuna catches in 2005. Unit costs (*c*) are expressed on a per tonne basis for each gear type (*g*). The lowest cost of fishing, US $259/t as published in (Lam *et al.* 2011), was for purse seining in some South American and Caribbean countries. The highest unit cost of fishing, US $7,092/t, was for longlining by South Pacific Island countries (Lam *et al.* 2011). Where cost data were missing for a particular geo-political entity for which catch and price data existed, global mean unit costs, weighted by catch tonnage, were used. This imputation method was used for territories of certain countries, such as American Samoa. Separate cost estimates for tuna fishing are unavailable for American Samoa because it is a United States entity, but using estimates for the U.S. in general was deemed inappropriate due to American Samoa's size and location. To avoid making a judgment between whether U.S. costs or costs similar to other Pacific Island nations were more representative of American Samoa, global mean costs weighted by catch, were used for the gears utilized.

The total cost (*TC*) for country *m* fishing with gear *g* on species *s* in 2005 is thus given as:

$$TC_{m,s,g} = c_{m,s,g}h_{m,s,g}, \ \forall_{m,s,g}$$

where $c_{m,g,s}$ indicates cost per ton. The total cost of fishing to country *m* is then calculated by summing over all gears and species:

$$TC_m = \sum_{s,g} c_{m,s,g}\, h_{m,s,g}, \quad \forall_m$$

Subsidies

The subsidies database (Sumaila *et al.* 2010) contains the computed subsidy intensity (λ), which is defined as the proportion of a country's total landed value that is subsidized (all subsidy categories combined) (Table 3). Because it is not currently known what amount (absolute or relative) of a nation's subsidies go directly to supporting the tuna fishing sector, we use the intensity as a proxy and apply it to the landed value of fishing for tuna species. For example, if a country had a reported subsidy intensity of 0.25 in Sumaila *et al.* (2010), and its landed value of all tuna species combined in 2005 was US $1 million (based on the price and catch databases), then we would conclude that subsidies amounting to US $250,000 were transferred by that country's government to the tuna fishing sector (Table 3).

INSERT TABLE 3 HERE

The subsidy intensity for tuna fishing companies ranged from 0.04 to 1.26, with a mean value of 0.34. (Table 3)(Sumaila *et al.* 2010). This means that on average, one third of the value of fisheries is subsidized by national governments. This intensity is applied to the estimated landed value (or total revenue, as defined above) for the 2005 year for each country for each fish species as follows:

$$TS_{m,s} = \lambda_m TR_{m,s}, \quad \forall_{m,s}$$

Rent

Resource rent as applied to fisheries is formally defined as the difference between the total revenue and the total cost of fishing As explained earlier, the rent a resource generates for a private firm may differ from the rent it generates for society as a whole. An individual harvester or harvesting firm will incur only a portion of the cost of fishing if the fisher’s government subsidizes fishing activities. In such cases, the private rent the fisher realizes will exceed the social rent that society as a whole earns. Both private and social measures of rent are calculated here. All of these calculations incorporate the opportunity cost of investments in fishing equipment, i.e., a normal rate of return on capital.

Private rent is computed simply by subtracting total costs incurred by the harvesting firm, $TC_{m,g,s}$, from total revenue. This is done for the 2005 year for each country and species caught with each gear:

$$\pi_{m,s,g} = TR_{m,s,g} - TC_{m,s,g}, \ \forall_{m,s,g}$$

The social, or subsidy-adjusted resource rent (π^{λ}) for each country is computed by subtracting that portion of total cost that is covered by government subsidies: . This adjustment reflects the fact that private rent incorporates only a portion of the costs of fishing:

$$\pi^{\lambda}_{m,s} = \pi_{m,s} - TS_{m,s}, \ \forall_{m,s}$$