

Economic use value of the Belize marine ecosystem: Potential risks and benefits from offshore oil exploration

Andrés M. Cisneros-Montemayor, F. Gordon Kirkwood, Sarah Harper, Dirk Zeller and U. Rashid Sumaila

Abstract

The announcement of plans for exploratory oil drilling at a number of offshore sites in Belize raised concerns about the risks associated with drilling, particularly given the socio-economic importance of the marine ecosystem. The current economic value of fisheries and marine ecotourism is estimated, along with the potential revenue from offshore oil and potential economic losses stemming from oil pollution, under various assumptions on risk and uncertainty. Marine fisheries and ecotourism are estimated to generate around US\$ 183 million per year. Single-year estimated maximum revenue is higher for oil extraction initially but quickly declines; during a 50 year (two generation) period, total discounted benefits from marine fisheries and ecotourism are estimated at US\$ 5.1 billion, compared to US\$ 3.2 billion from offshore oil revenue. Following a hypothetical oil spill, discounted losses in marine fisheries and ecotourism due to perception and ecological impacts are estimated at US\$ 912 million, with clean-up costs and capital losses of US\$ 6.1–10.4 billion. Considering the short extraction life of oil resources compared to fisheries and ecotourism, the difference in benefits increases substantially in favour of the latter with a longer time horizon. A recent public referendum resulted in a 98% vote against oil exploration and a subsequent annulment of oil concessions pending environmental impact assessments.

Keywords: Economic value; fisheries; ecotourism; oil.

1. Introduction

Belize has a biologically rich marine environment, in large part due to its 300 km barrier reef system, the largest in the Western hemisphere. This reef complex includes three large atolls, hundreds of mangrove islands, diverse tropical intertidal and subtidal barrier and patch reef zones, and extensive lagoonal seagrass beds. This diverse ecosystem supports important fishing and ecotourism industries that rely on the health of the marine environment and generate significant social and economic benefits (Palomares and Pauly, 2011).

Tourism is one of the most important industries in Belize, contributing almost 35% of GDP (World Travel & Tourism Council (WTTC), 2011). Accordingly, there have been concerted efforts to improve tourism management in the country, both by the government and by non-governmental

organizations and the private sector. An important aspect has been the tendency to shift away from traditional “mass-consumption” sites towards smaller-scale ecotourism initiatives that promote the conservation of nature, yet still provide economic and social benefits to mitigate the effects of restricted access to resources (Lindberg *et al.*, 1996; Belsky, 1999). Thus, activities such as recreational fishing, whale watching, shark watching, scuba diving and snorkeling have become a main attraction for tourists to Belize, with some general recognition that investments in the protection of resources and their habitat helps ensure that economic benefits are sustained (Farrell and Marion, 2001; Cisneros-Montemayor and Sumaila, 2010). In addition to infrastructure and marketing, these investments include conservation measures such as marine protected areas or the promotion of tourism operator participation in management plans, monitoring, and enforcement of guidelines and policies.

Marine fisheries are also an integral part for the Belize economy, with the Caribbean spiny lobster (*Panulirus argus*) and the queen conch (*Strombus gigas*) as the main focus of the commercial export-oriented fisheries which

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generate most of this sector's revenue (Huitric, 2005). In the 1960s, fishing cooperatives were established to negotiate better export prices for lobster and conch, which improved economic benefits but also consolidated community solidarity and identity (Price, 1987; Key, 2002). Today, most lobster and conch are exported to the US and Europe, with a small portion remaining for consumption by locals and the growing tourist market (Statistical Institute of Belize, 2009). Seafood is an important part of the diet for the coastal population, where demand is met mainly through reef fish caught by small-scale fishers (Ministry of Agriculture and Fisheries, 2008); in a small coastal country such as Belize, this is a key contribution to national food security. Government reports suggest around 15,000 Belizeans benefited directly or indirectly from fishing activities in 2008 (Ministry of Agriculture and Fisheries, 2008), in addition to an estimated 4,000 people employed in the marine ecotourism sector. With a total work force of around 120,000 (Statistical Institute of Belize, 2009), over 15% of the working population of Belize are directly linked to the marine environment, without considering fishers in the subsistence sector.

In a bid to boost economic growth, the Government of Belize recently facilitated movement towards potential offshore oil operations (Kirkwood and Matura, 2011), causing concern among many Belizeans about the risks related to this activity. These concerns were heightened by the allocation of concessions for oil exploration to multiple small, recently formed domestic companies with little prior experience. With the Belize GDP at around US\$ 1.4 billion (World Bank, 2013) and unemployment at 16% (Statistical Institute of Belize, 2013), windfall revenues from oil are certainly alluring; however, potential short-term gains should not overshadow serious considerations of potential long-term negative ecological and socio-economic impacts. The recent *Deepwater Horizon* (DWH) spill in the Gulf of Mexico highlighted the need for careful assessment of the costs and benefits of oil drilling near fragile environments (McCrea-Strub and Pauly, 2011). In the Belize example, this becomes more important when potential benefits from oil would mostly accrue to the government directly (there are no plans to process, only to export oil), but the costs would fall on private citizens currently relying on marine ecosystems (Kirkwood and Matura, 2011). Based on the best currently available data, this study estimates and contrasts the economic contribution to the Belizean economy of marine fisheries, ecotourism and offshore oil extraction in order to assess the current economic value of the marine ecosystem and the economic risks from a potential oil spill.

2. Methods

Our methods provide a preliminary assessment of the current and potential economic value of marine fisheries,

offshore oil extraction, and ecotourism, as well as the potential economic losses that would be associated with a large-scale oil spill. The economic indicators used include total revenue, economic impact and employment. These estimates refer strictly to money spent on marine ecotourism or to purchase fish, and do not consider non-use values, thus underestimating total economic value.

For commercial fisheries, total revenue is defined as the landed value of fisheries catch, namely, the total catch multiplied by the price paid to fishers for their product (Sumaila *et al.*, 2007). Catch data included reported data and estimates of unreported catch components (both commercial and subsistence) based on a well-established catch reconstruction approach (Zeller *et al.*, 2007; 2011). Ex-vessel prices used were current dockside prices paid in Belize (R. Graham, pers. comm., Wildlife Conservation Society). For the subsistence sector, the same dockside prices were used to estimate a revenue equivalent (the "shadow" value; Sumaila *et al.* 2007). Revenue from exported catch was based on national trade statistics (J. Villanueva, pers. comm., Belize Fisheries Department).

For marine ecotourism, revenue was defined as expenditures, that is, money spent directly on marine-related activities such as ticket fees, accommodation, lodging and transport costs. Data on the current status and trends of marine ecotourism in Belize were compiled from peer-reviewed literature, government and NGO reports and newspaper articles, including studies of shark and whale watching, recreational fishing and reef and mangrove tourism (e.g., Cohun, 2005; Carne, 2008; Fedler, 2008; Cooper *et al.*, 2009; O'Connor *et al.*, 2009). Values for shark watching were subtracted from total values for diving and snorkeling to avoid double-counting. In its 2011 assessment of the Belizean tourism industry, the WTTC (2011) forecast a yearly growth rate of around 4.5% for economic impacts of tourism. We therefore assumed a more conservative growth rate of 4% per year for our estimations of future revenue from marine ecotourism.

When fishers and tourist operators spend part of their revenue to purchase other goods and services, total economic value increases as spending moves through the economy and employment is generated throughout the process. An economic multiplier (ratio of revenue to total economic value) of 3.46 was used for the commercial fishing sector, taking into account the direct and indirect impacts on the economy (Dyck and Sumaila, 2010). No multipliers were applied to subsistence fisheries as the fish caught by this sector are generally for personal consumption, resulting in a short value chain (Dyck and Sumaila, 2010). For marine ecotourism, when expenditure but not total economic impact data were available, we applied a multiplier of 1.55 as estimated for Belizean sport fishing (Fedler, 2008). All values were converted to 2011

US dollars using the official US inflation rate (Bureau of Labor Statistics, n.d.).

To contextualize the contribution of marine ecotourism to Belize, we calculated an index of relative importance of marine ecotourism for the Central American FAO subregion (www.fao.org). This index is calculated for each country as the average of three components: marine ecotourism participation weighted by total tourist arrivals, tourist expenditures weighted by country GDP, and marine ecotourism employment weighted by total population. The resulting weighted averages are then rescaled relative to the highest-ranked country. In this way, we control for the large socio-economic differences between countries in the region. Data were obtained for each country from a global marine ecotourism database compiled by Cisneros-Montemayor and Sumaila (2010). Data for diving was not available for every country, and so was excluded from this particular analysis.

Potential revenues and economic indicators for offshore oil are based on the following assumptions. If offshore oil exploration proceeds as planned and results in discoveries in line with the Government of Belize's expectations, production could start by 2018, with production increasing to a potential 50,000 bpd (barrels per day; 1 barrel \approx 160 liters) by 2020. These projections are based on the offshore potential of the 150 to 400 million barrels of expected reserves (Cho, 2010). For projection purposes, oil is assumed to be discovered in a single reservoir in an offshore concession.

The assumed prerequisites and their costs are:

- 200 km² seismic survey to be acquired in 2013; cost US\$ 3 million based on standard industry cost per km² (Ashton *et al.*, 1994);
- Exploration well to be drilled in 2014 (location dependent on seismic survey results); cost US\$ 40 million based on deepwater well analogues. Average water depth in the concession is 1,200 m (depth to target reservoir is unknown). We assume comparability of cost to the Macondo well (Louisiana, US) in 1,500 m of water with a reservoir at 5,400 m below sea level, which was originally budgeted at US\$ 96 million (National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling, 2011);
- Appraisal well to be drilled in 2015 (in line with work commitment); cost US\$ 40 million based on the same cost as the exploration well;
- 150 million barrel reserves field is declared commercial in 2016, and development begins immediately (an optimistic development time);
- Facilities construction and installations, including pipelines etc., and development well drilling to begin optimistically in 2016 to 2019; cost US\$ 1.5 billion, based on a typical deepwater development cost of US\$ 10 per barrel. This compares to the cost of Belize Natural Energy Ltd.'s onshore development of the Spanish Lookout oil field, which is US\$ 8.5 per barrel for the

approximately 15 million barrel reserves (Belize Natural Energy Ltd., 2011);

- Crude oil price is assumed to be US\$ 70 per barrel (price range of US\$ 70-80 over 10 years; OPEC, 2010);
- After a company cost-recovery period for the initial investment, revenue to the Government of Belize is assumed to come in the form of royalties (7.5% of wellhead revenue, i.e., sales revenue minus transport and handling costs), revenue sharing (10% of net revenue) and taxes (40% income tax), as reported by Belize Natural Energy Ltd. (2011).

To calculate present value of revenue through time, we assume a real discount rate of 3% to calculate flows of economic indicators from the different sectors (marine fisheries, marine ecotourism and offshore oil extraction). While private companies often use a higher rate of discount, the 3% rate is considered by some resource and environmental economists to be reasonable if we want to explicitly take into account the interest of future generations (Sumaila, 2004; Sumaila and Walters, 2005; Karp and Tsur, 2011) or consider the fact that we do not know what the discount rates of future generations will be (Weitzman, 2001).

The potential effects of a large-scale environmental impact such as an oil spill on Belize were explored using information gathered from articles and reports that analyzed the economic impact of oil-spill sites around the world, including Alaska and Massachusetts (US), the Brittany coast (France), and Panama (Teal and Howarth, 1984; Jackson *et al.*, 1989; McDowd Group, Inc., 1990; Advanced Resources International, Inc., 1993; Peterson *et al.*, 2003; Culbertson, 2007; Culbertson *et al.*, 2008). These studies suggest that it takes an average of at least three years after spills have been cleaned up for tourism activities to return to pre-spill levels, but that environmental effects continue even after this point to hinder marine fisheries and ecotourism, due to lingering ecosystem impacts that result in poor conditions for tourism or tainted seafood. In the case of mangroves and reef ecosystems, such effects involve the mortality or displacement of marine life of between 20-100% of initial conditions, depending on the type of organism (for example, sedentary species living in mangroves or coral reefs recover much more slowly than fast swimming and migratory species), with visible effects lasting at least 10 years. Because we do not have data to assign impact levels for particular species groups, we assume a very conservative first-year reduction of 70% in overall marine fisheries and ecotourism due to tourism site perception and concerns about seafood contamination, returning to pre-spill conditions after 3 years.

It is important to consider that available studies show that oil spill impacts are both more acute and longer lasting in tropical, low energy ecosystems, making our assumptions quite optimistic. In addition, we assume a further 50%

reduction in fisheries and marine ecotourism due to environmental degradation, returning to pre-spill conditions after 20 years (an optimistic assumption). Thus, impacts from perception and environmental issues in the first year would combine for a total loss of around 85%. To keep this calculation simple, we assume a linear recovery pattern and a constant discount rate of 3% per year. This method for estimating potential economic losses from a marine oil spill is extensively documented and applied in Sumaila *et al.* (2012). Our method does not address chronic pollution events that occur during normal operations, which can also have significant effects on coral reefs (House, 1986; Bak, 1987). The assumption that, aside from an oil spill, oil drilling has no effect on adjacent social and commercial activities is therefore simplistic and most likely overestimates revenue from fisheries and tourism in years in which oil drilling occurs.

As there is little way of knowing the risk of a spill occurring (the proposed oil companies in Belize have no track record to look back on), we calculate the total expected value of deciding to drill under a range of probabilities of a spill occurring and a range of assumptions on the magnitude of subsequent impacts. In each case, the total expected value (*TEX*) is calculated as the sum of economic values assumed to be realized under each scenario weighted by the probability (α) of a spill occurring or not occurring (Walters, 1986):

$$TEX = a \cdot X + (1 - a) \cdot X' \quad [1]$$

where X and X' are the net present value (over 20 years) of fishing, marine ecotourism and oil extraction with and without an oil spill, respectively.

To address uncertainty in our estimation of potential losses, we calculate equation 1 based on a range of assumptions on oil revenue remaining in the country (50%–100% of stated government cut), and the magnitude of total losses, up to three times as large as the baseline estimate. Because we consistently adopt conservative parameter values, the baseline is heavily biased towards underestimation of economic benefits from renewable resources and potential ecological damages from a spill. Consider, for example, that in our estimate of economic benefits we do not account for the values of access to food or clean water or quality of human health; thus, assuming in our sensitivity analysis that we are underestimating the initial impacts from an oil spill provides a more realistic range of scenarios. In terms of costs from oil should a spill occur, we provide a range of estimates based on the cost of clean-up per barrel, namely US\$ 5,066 per barrel (estimate for underwater well blowouts; Advanced Resources International, 1993) and US\$ 8,612 per barrel (the total estimated cost to BP following the DWH blowout, divided by the volume spilled). In addition, we factor in the cost of foregone oil, representing the value of spilled oil that could

Table 1. Economic impact of fisheries in Belize, including direct revenue and indirect economic impact from the various sub-sectors

Sector	Revenue	Indirect impact ^b	Total impact
Commercial (domestic ^a)	6.6	16.4	23.0
Commercial (export)	10.6	26.2	36.8
Subsistence	4.7	n/a	4.7
Total	21.9	42.6	64.5

Note: ^a Includes tourist market; ^b Impact multiplier of 3.46 (Dyck and Sumaila, 2010) applied to all sectors except subsistence. Values are in millions of US dollars.

Source: Authors' elaboration.

otherwise have been sold. We do not assume that all the oil in the field will spill following a blowout, but rather use available data on the average volume of oil spilled in blowouts on nearby Mexican platforms, 1.2 million barrels (American Petroleum Institute, 2009); this volume would represent less than 1% of the total assumed volume.

3. Results

Total annual revenue from the fisheries sector is estimated at US\$ 22 million (Table 1). This includes US\$ 6.6 million in direct domestic revenue, US\$ 10.6 million in export revenue, and a US\$ 4.7 million “shadow” value for the subsistence sector. Export earnings for lobster were estimated at US\$ 7.5 million, while lobster for the domestic market had revenues of US\$ 500,000. Export and domestic revenues from conch catches generated US\$ 3 million and US\$ 193,000, respectively.

The total economic impact of marine fisheries was estimated at US\$ 64.5 million, and direct employment in the commercial fishing sector was estimated at around 3,000 jobs. We were not able to estimate additional jobs created through the indirect benefits of the fishing industry, thus underestimating the total social importance of commercial fishing in Belize.

Marine ecotourism contributes significantly to the Belizean economy, both in absolute and relative terms; estimates suggest that each year, about 160,000 people participate in these activities, generating direct revenues of over US\$ 64 million and a total economic impact of over US\$ 118 million, and supporting almost 4,000 jobs (Table 2).

Employment includes indirect jobs for recreational fishing and diving and snorkeling, but only direct jobs for shark and whale watching, and so is an underestimation. Even so, Belize ranked highest out of all countries in Central America in terms of the socio-economic importance of marine tourism, rivaled only by Costa Rica (Figure 1). Though recreational diving data was not available for this analysis, including it would most likely further strengthen Belize's position (first author's personal observation).

Table 2. Yearly participation, expenditures (revenue) and economic impact of marine ecotourism in Belize, by activity

Activity	Participants	Expenditure	Economic impact	Employment
Recreational fishing ^a	5,800	27.2	61.2	1,860
Diving and snorkeling ^b	148,000	31	48	1,750
Shark watching ^c	2,010	6	9.3	154
Whale watching ^d	370	0.2	0.31	4
Total	156,180	64.5	118.9	3,768

Note: Dedicated shark watching data are subtracted from diving and snorkeling data to avoid double-counting. Expenditure and economic impact values are in millions of US dollars.

Source: ^a Fedler (2008); ^b Cooper *et al.* (2009); ^c Carne (2008); ^d O'Connor *et al.* (2009).

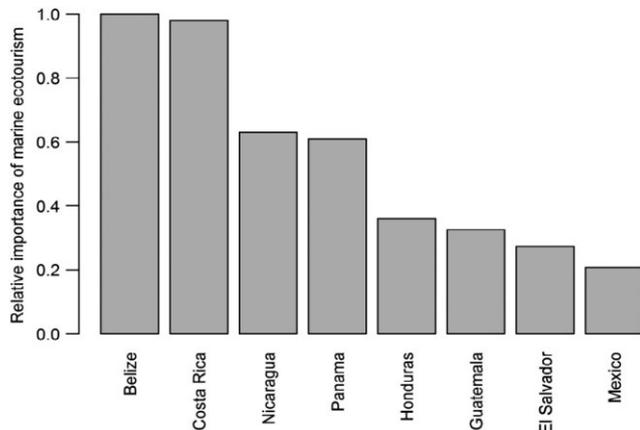


Figure 1. Relative importance of marine ecotourism for countries in the Central American FAO subregion.

Note: Index is the average of marine ecotourism participation weighted by total tourist arrivals, tourist expenditures weighted by country GDP, and marine ecotourism employment weighted by the total population.

Values are scaled relative to the highest-ranked country.

Source: Cisneros-Montemayor and Sumaila (2010).

Along with participation, expenditures and employment in marine ecotourism have grown steadily (Figure 2), although there are some concerns about overcrowding of certain sites and potential impacts on wildlife due to diving pressure and increased boat traffic in the area. Industry growth has recently been led by the consolidation of shark watching, particularly for whale sharks. To compare economic benefits among different industries, we estimated the potential revenue from the proposed offshore oil field exploitation in a concession north of Lighthouse Reef Atoll (Figure 3).

Given our assumptions on effective field volume and the allocation and revenue-sharing schemes (see section 2), our results suggest that, over the total life of the well (about 20 years), the Belize Government would receive a total of US\$ 3.2 billion in discounted revenue, about 43% of total revenues from the field. Approximately 36% of revenue would accrue to the oil company, with further revenue administered by the company for use in development (14%), operation (6%) and exploration (1%).

Offshore oil exploration is particularly risky due to its propensity, in the event of an oil spill, to impact large areas

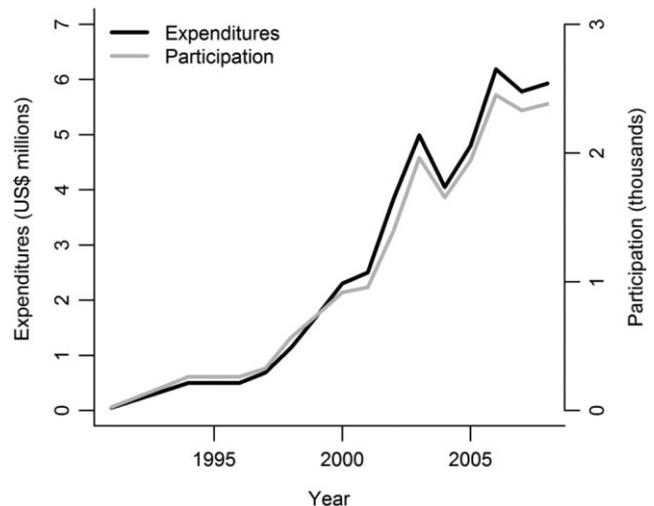


Figure 2. Shark and whale watching participation and expenditure in Belize.

Source: Hoyt (2001); Carne (2008); O'Connor *et al.* (2009); Cisneros-Montemayor and Sumaila (2010).

(both horizontally and vertically) that are difficult or impossible to protect or restore once they have been damaged. Even with conservative estimates of initial fisheries and marine ecotourism reduction and recovery times, both from consumer perception and ecosystem status, results suggest that, over a twenty year period following an oil spill, total losses in the marine fishing and ecotourism sectors would total US\$ 317 and 595 million in present value, respectively, for a total of around US\$ 912 million in losses. Clean up costs could total US\$ 6.1–10.3 billion, with an additional capital loss of US\$ 84 million in foregone revenue (the value of the oil spilled). This does not include costs stemming from health or food security effects, or any other non-market or social cost, and so represents a very conservative estimate of potential losses.

If no oil spill occurs, benefits from marine fishing and ecotourism in present value (discounted) terms are estimated at US\$ 5.1 billion over a two generation (50 year) period. During the same time period, estimated benefits to the Belize Government from oil extraction total US\$ 3.2 billion. Revenues from oil are not assumed to generate further economic impacts, as these are captured directly

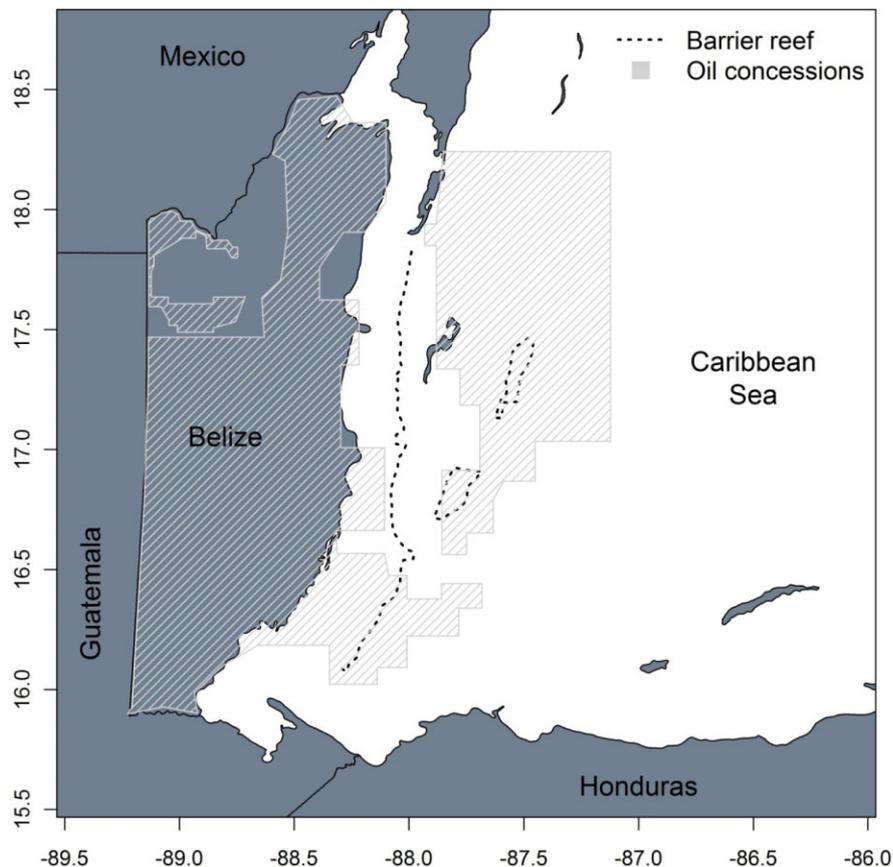


Figure 3. Offshore oil concessions in Belizean waters.
 Source: Adapted from Geology and Petroleum Department (2010).

Table 3. Economic impacts over 50 years to the Belizean economy for sectors considered in this study

	Economic impact (millions of US\$)		
	Average yearly	Maximum yearly	50 year total
Commercial fishing	64	64	1,728
Marine ecotourism	130	142	3,418
Subtotal	195	207	5,146
Offshore oil	89	647	3,201

Note: All values are in millions of US dollars; 50 year total present values were calculated using a 3% real discount rate.
 Source: Authors' elaboration.

from the company by the Government; given that all oil is exported (there are no refineries in Belize), there is no significant post-extraction value chain (Kirkwood and Matura, 2011). As most revenue from non-renewable resources is in the form of windfall gains (Figure 4), average annual benefits over longer time spans are greater from renewable resources, in this case an average of US\$ 195 million per year over 50 years from marine fishing and ecotourism compared to US\$ 89 million per year from offshore oil extraction over the same time period (Table 3).

It is important to note that we assume a rather conservative growth rate for tourism (4% per year).

To integrate risk and uncertainty into our estimates, we calculated the total expected value of all three marine environment-based industries if oil drilling were allowed, given a range of assumptions on the magnitude of losses to fisheries and marine tourism that would result from an oil spill, as well as the cost per barrel of clean-up. Results show that, depending on assumptions on oil revenue, discount rate, the magnitude and clean-up costs of a spill, and its impact on other industries, an 11-30% chance of an oil spill occurring would lead a rational manager to a business decision to not drill under any circumstances (Table 4). Most importantly, even the most conservative estimated loss, US\$ 7 billion, is five times the size of the current Belize GDP; needless to say, long-term national-scale economic impacts would be severe.

4. Discussion

Current annual revenue from marine fisheries and ecotourism in Belize is estimated to be over US\$ 86 million, resulting in an annual economic impact of US\$ 182 million (Tables 1 and 2). In contrast, the maximum single-year

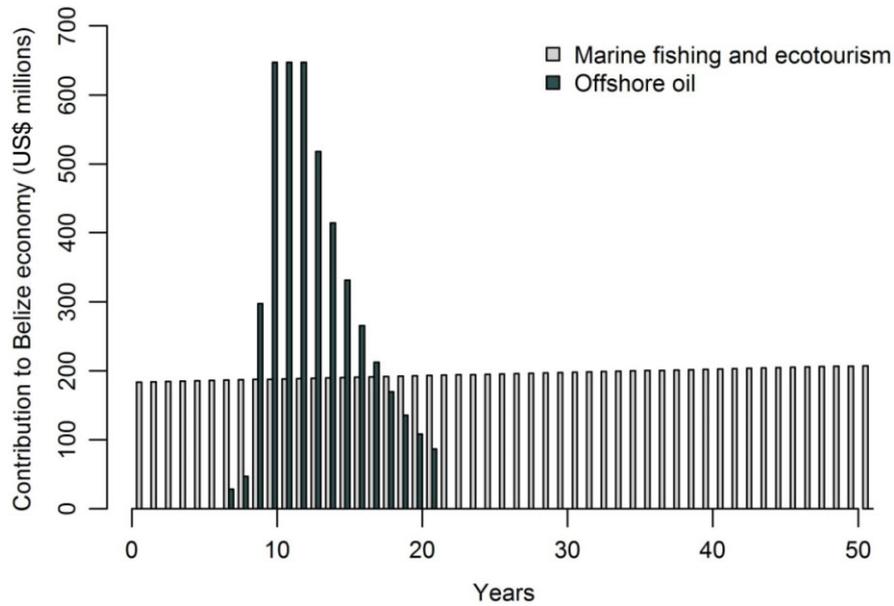


Figure 4. Yearly economic impacts of marine fishing and marine ecotourism and potential revenue from offshore oil to the Belize economy over 50 years.

Note: A yearly growth rate of 4% was applied to the ecotourism sector; for all sectors, estimates are not discounted.

Source: Authors' elaboration.

Table 4. Acceptable risk (probability) and economic cost of an oil spill (relative to baseline estimate and the clean-up cost per barrel for oil spilled)

	Acceptable risk (probability)					
	Local revenue (100%)			Local revenue (50%)		
	Oil spill cost to marine fisheries and ecotourism					
	Baseline	2 × baseline	3 × baseline	Baseline	2 × baseline	3 × baseline
Clean-up cost	Baseline	2 × baseline	3 × baseline	Baseline	2 × baseline	3 × baseline
5,066 US\$/bbl	0.31	0.29	0.27	0.19	0.17	0.15
8,612 US\$/bbl	0.22	0.21	0.2	0.13	0.12	0.11

Source: Authors' elaboration.

revenue from a hypothetical oil extraction operation was estimated at US\$ 647 million. However, over a fifty-year time horizon representing only two generations, total benefits from marine fisheries and ecotourism equaled US\$ 5.1 billion, compared to US\$ 3.2 billion from oil extraction over the same time period (Table 3). Thus, the benefits from the sustainable use of renewable resources over time can be expected to be much higher than those for the extraction of non-renewable resources (Figure 4) which, as in the case of offshore oil, may include significant risks to the environment and associated human benefits.

In contrast with generally rising unemployment rates in Belize, marine ecotourism is currently flourishing (Figure 2) and has positioned the country as a top tourist destination in Central America (Figure 1); accordingly, the industry is beginning to provide an alternate livelihood option for fishers. Furthermore, subsistence fisheries in

many coastal villages provide a major source of protein that contributes significantly to national food security (Gibson *et al.* 2005), though they are often overlooked in fisheries statistics and economic evaluations (Zeller *et al.* 2006; 2007). In considering the impacts of oil drilling on unemployment, it is important to highlight that the lack of a secondary processing industry for oil means there would be little job creation for locals, while chronic or large scale pollution from oil would negatively impact industries that are currently sustainable (House, 1986; Kirkwood and Matura, 2011).

Distribution of benefits and of risk is a key issue to integrate into open deliberations on alternative uses for natural resources. In this case, revenue from oil sales would flow to private companies and the central Government, while the majority of current benefits from marine fisheries and ecotourism are captured by and remain within local

economies and communities. Companies and governments apply higher discount rates to future benefits, as they seek to maximize profits in the short-run (in the government's case, perhaps only four years). Communities that rely on natural resources for food and employment in the long-run, and which will not directly receive benefits from oil, have a much different perception of risk. A group of NGOs recently (February 2012) held a public referendum on proposed plans to drill in Belize, resulting in a 98% vote against oil exploration (*Ambergris Today*, 2012). Subsequent litigation (April 2013) resulted in the annulment of all offshore oil concessions, with the decision stating that “allowing oil exploration before any assessment of its effects on the environment is not only irresponsible, but reckless, especially in a situation where Belize may not be fully capable of handling effectively an oil spill” (*San Pedro Sun*, 2013). Clearly, this process highlights advances in public awareness and participation in resource management, and will no doubt prove a landmark ruling for future cases in similar settings.

Assessments of natural resource damages are challenging (Boyd, 2010), but post-spill analyses over a range of environments have shown that impacts of oil spills can be substantial and long-lasting (e.g., Jackson *et al.*, 1989; Peterson *et al.*, 2003; Garza-Gil *et al.*, 2006; Loureiro *et al.*, 2006; McCrea-Strub *et al.*, 2011; McCrea-Strub and Pauly, 2011), both from an ecological and economic viewpoint. Social impacts, non-market and long-term economic effects, including anxiety and loss of health and morale or limited access to clean food and water, are much more difficult to capture quantitatively. With the improved information, travel, and market options available to consumers around the world, real and perceived degradation of the marine environment can also rapidly impact regional industries. For example, hotel and charter cancellations following the DWH blowout occurred well before the first ecological effects were reported (Oxford Economics, 2010). Health concerns over seafood tainted with pollutants can also have serious and persistent effects on the market for local products. The perception of environmental degradation or potential health concerns can continue to impact the region for years to come, even after visible pollutants have dissipated (Sumaila *et al.*, 2012). Though they are very difficult to quantify, these types of effects must be nonetheless be weighed against potential temporary benefits from industries that could harm otherwise lucrative and sustainable activities.

Our analyses and estimates are an attempt to do the most with limited available data, but this study is not intended to serve as a formal environmental impact assessment that should be performed in conjunction with governmental, non-governmental and private groups to be truly representative. Nevertheless, results strongly suggest that offshore oil exploration in Belize, as currently discussed (Figure 3), would prove very risky for existing industries that depend on a healthy marine environment. Formally

assessing risk re-affirms the central message of this study: there is no doubt that revenue from oil extraction could be significant, but it also exposes the nature-based economy of Belize to a potentially catastrophic scenario. In the wake of the DWH well blowout (technically similar to proposed drilling sites in Belize), BP, one of the world's largest and most experienced oil drilling firms, agreed to pay at least US\$ 20 billion in damages, and estimated total clean-up and recovery costs will be US\$ 42.2 billion (BP, 2013a; 2013b). These have come in the form of quick-response and long-term containment and clean-up, ongoing monitoring and compensation for lost wages but required litigation and considerable pressure from the US Government. It is highly doubtful that the recently formed firms originally slated to drill in Belize (or the Government itself) have the financial or technological means to elicit a similar response if a spill were to occur (Jones, 2010) and this figure alone (excluding the penalties and compensation paid by the other companies involved in the DWH incident) is over 84 times the size of Belize's “Superbond”, currently in renegotiations after the country's problems with meeting interest payments (*Reuters*, 2012).

Under the best scenario, offshore oil can provide significant short-term economic gains, but over time, total economic benefits from oil are less than those of sustainable industries that profit directly from adequate environmental protection. The short-term economic and political allure of oil revenue, together with other policy issues such as large coastal development projects, overfishing or unchecked tourism growth must thus be balanced with a long-term view of sustaining social and economic benefits as well as livelihoods for future generations. Natural resources should be used for human benefit, but not before answering the key question, who benefits and who bears the costs?

Acknowledgments

This is a contribution from the *Sea Around Us* project and the Global Ocean Economics Project, scientific collaborations between the University of British Columbia and the Pew Charitable Trusts, Philadelphia. The authors thank Dr. Rachel Graham (Wildlife Conservation Society) for dockside fish prices, Andrew Dyck and Vicky Lam (Fisheries Economic Research Unit) for ex-vessel price and fishing cost data, and Jamie Villanueva (Ministry of Agriculture and Fisheries) for national landings and export data, as well as Dr. Daniel Pauly and three anonymous reviewers for comments on the manuscript. Andrés M. Cisneros-Montemayor acknowledges support from the Mexico National Science and Technology Council.

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