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To Poach or Not to Poach an Endangered Species: Elucidating the Economic and Social Drivers Behind Illegal Sea Turtle Hunting in Baja California Sur, Mexico

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Abstract Despite complete legal protection, improvements in infrastructure, and market conditions that provide easier access to other protein sources, illegal poaching of sea turtles for consumption in Baja California Sur (BCS), Mexico remains a major threat to their recovery. Few studies have focused on understanding the economic and social drivers behind this activity, which is fundamental to determining best practices for discouraging it. From June 2007 to April 2008 we conducted eight in-depth, semi-structured interviews with sea turtle poachers at five coastal communities in BCS to determine the drivers influencing them. The most prevalent reasons for illegal poaching were direct economic benefits, lack of law enforcement and ease of escape from or bribery of authorities, and strong family tradition. Our results suggest that to reduce illegal poaching it will be necessary to better enforce existing environmental laws, reduce social acceptance of sea turtle hunting throughout the region, educate fishers on the ecological importance of sea turtles, and show fishers direct economic benefits from non-consumptive use of sea turtles, such as ecotourism.

Keywords Baja California Sur · Mexico · Sea turtles · Black market · Poaching · Law enforcement · Fisheries · Illegal wildlife trade

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Introduction

Directed harvest of wildlife for food is considered to be a major threat to biodiversity and the consumption of rare wildlife continues to negatively affect many vulnerable populations (Diamond 1991; Bennett and Rao 2002; Milner-Gulland *et al.* 2003). Sea turtles, which have been exploited since at least 5000 BC, have been heavily impacted by overharvesting (Frazier 2003). Today, despite well-documented national and international laws aimed at protecting sea turtles, poaching remains a major threat to many populations worldwide (Campbell 2003).

One of the most intensely overexploited areas has been Baja California Sur (BCS), Mexico, where sea turtles have been utilized since the early 1400s for food, medicine, and

decoration (Garcia-Martínez and Nichols 2000; Nichols 2003; Senko *et al.* 2009). Turtle meat has traditionally been served at weddings, Christmas, Mother's Day, Sundays, and most frequently at Easter (Garcia-Martínez and Nichols 2000; Nichols *et al.* 2003; Senko *et al.* 2009). Although recent studies have demonstrated possible health risks associated with the consumption of sea turtle products (Aguirre *et al.* 2006; Fussy *et al.* 2007; Senko *et al.* 2009), the blood is used to treat anemia and asthma, the oil for childhood respiratory problems, and internal organs are sometimes used in soups (Caldwell 1963; Mack *et al.* 1982; Felger and Moser 1987; Senko *et al.* 2009).

The populations of all five sea turtle species that inhabit the coastal and offshore waters of BCS have declined precipitously largely due to poaching and by-catch in fisheries (Gardner and Nichols 2001; Nichols 2003; Koch *et al.* 2006, 2007), starting in the 1950s (Garcia-Martínez and Nichols 2000). Between 1962 and 1967, Mexico was producing more sea turtle products than any other nation (O'Donnell 1974; Koch *et al.* 2006) and by the 1970s, sea turtle populations were unable to reproduce fast enough in the face of increasing regional and global demand (Clifton *et al.* 1979). To address these declines, the Mexican government banned the harvest of sea turtle eggs in 1978 and 2 years later issued a quota limiting the number of sea turtles that could be taken commercially (DOF 1990). However, populations continued to drop and in the face of increasing international pressures the government declared a complete ban on the use of sea turtles throughout Mexico in 1990 (DOF 1990; Garcia-Martínez and Nichols 2000; Senko *et al.* 2011).

Despite this ban, as well as over three decades of widespread protection on mainland nesting beaches and improvements in infrastructure and market conditions that provide easier access to other more reliable and less risky protein sources (e.g., see Senko *et al.* 2009), fishers in BCS continue to illegally harvest sea turtles in large numbers (Gardner and Nichols 2001; Nichols 2003; Koch *et al.* 2006, 2007; Peckham *et al.* 2008; Mancini and Koch 2009; Senko *et al.* 2011). Over the past decade, sea turtle harvest along the Baja California peninsula and Sonoran coast was estimated to be as high as 35,000 a year^{-1} (Nichols 2003). The meat is consumed domestically, traded locally, or sold via a network of well-organized black market circuits to local, regional, and even international markets (Garcia-Martínez and Nichols 2000; Gardner and Nichols 2001; Delgado and Nichols 2005; Koch *et al.* 2006; Mancini and Koch 2009; Senko *et al.* 2009). A single poacher from one BCS coastal lagoon admitted to hunting and selling more than 100 metric tons (5,000 turtles or approximately 625 turtles year^{-1}) of endangered East Pacific green turtle (*Chelonia mydas*) over an 8-year period during the 1990s (Nichols and Safina 2004). In addition, the highest ranking government representatives publicly consume sea turtles, the meat is regarded as a symbol of power among people with authority, and the illegal sea turtle trade is sometimes tied to Mexican drug trafficking (Mancini and Koch 2009; Senko *et al.* 2011).

There is a growing number of studies to assess legal and illegal sea turtle fisheries (e.g., Bell *et al.* 2006; Grazette *et al.* 2007; Campbell *et al.* 2009), yet few have examined the factors that motivate fishers to engage in illegal harvesting (Troëng and Drews 2004). Most of the illegal fishery models currently used are based on Becker's (1968) and Stigler's (1970) theories, where an individual engages in an illegal activity in an attempt to maximize profits if subject to a budget constraint. This implies that a fisher's decision to fish illegally or not is based exclusively on profit-maximizing criteria, and any penalties incurred are considered a cost of illegal fishing (Charles *et al.* 1999). An alternative theory presented by Kohlberg (1984) suggests that the decision to engage in an illegal behaviour is driven by moral and social values. Social learning theories suggest that illegal behaviour can be conditioned or induced by local social norms defined as "shared understandings about actions that are obligatory, permitted, or forbidden" (e.g., Ackers 1985; Baland and Platteau 1996). This implies that if a person lives in a situation where everybody breaks rules, the behaviour will be considered socially acceptable and will be imitated if either economically or socially beneficial (Bandura 1977).

Understanding why people decide to engage in an illegal activity is fundamental to determining best practices for discouraging it (Keane *et al.* 2008). This paper highlights the economic and social factors that motivate fishers to engage in illegal sea turtle hunting. We conducted semi-structured interviews with well-known sea turtle poachers to gather data on illegal hunting and black market trade in BCS and estimated the costs and benefits of poaching sea turtles through an illegal fishery model adapted from Sumaila *et al.* (2006). By using both qualitative and quantitative approaches, we aim to elucidate the economic and social drivers of illegal sea turtle hunting and provide insights that may ultimately lead to better deterrent strategies throughout the region.

Material and Methods

Study Area and Population Baja California Sur is 900 km long and stretches between 22°52′N and 28°00′N and 109°25′W and 115°05′W (Fig. 1). It has the longest coastline of all Mexican states (nearly 2,222 km) and includes many islands of volcanic and continental crust origin, mostly located in the Gulf of California (Thomson *et al.* 1979). There are over 500,000 people living in BCS,

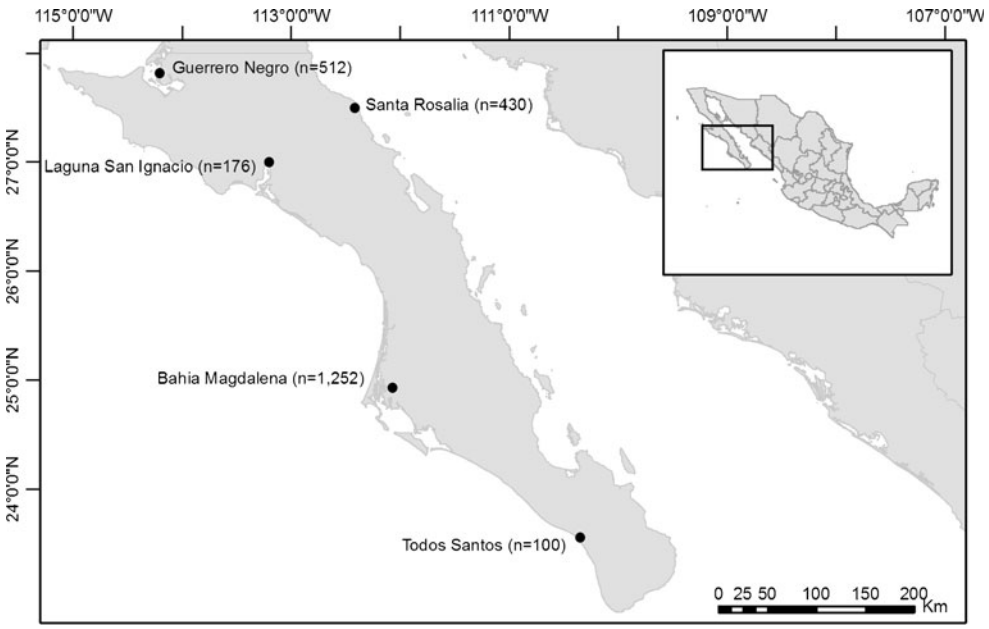

Fig. 1 Map of the Baja California Sur, Mexico region where illegal fishers were interviewed. "n" refers to the total number of fishers in each region (SAGARPA, 2007)

mostly in the cities of La Paz and Los Cabos; the remainder of the population lives in more than 4,000 small towns and villages (INEGI 2005). Five sea turtle species inhabit the coastal and offshore waters of BCS: East Pacific greens (*Chelonia mydas*) and loggerheads (*Caretta caretta*), both listed as endangered, olive ridleys (*Lepidochelys olivacea*), listed as vulnerable, hawksbills (*Eretmochelys imbricata*) and leatherbacks (*Dermochelys coriacea*), both listed as critically endangered (Marquez 1990; IUCN 2009).

Marine fisheries have historically been among the most important economic activities in BCS, with the squid and sardine fleets being the most productive (CONAPESCA 2003). Artisanal fisheries represent 8.3% of the total income of BCS, but employ approximately 15% of the working population directly, with many more people indirectly benefitting from the fishing industry (INEGI 2005). In BCS, fishers target 122 out of the 650 marketable species available. The most popular commercial species include sardines, tuna, and various species of clams (SAGARPA 2006). There are also high-value species such as abalones (*Haliotis* sp.) and lobsters (*Panulirus* sp.), but these are limited to a small number of cooperatives in North Pacific BCS (Bórquez-Reyes *et al.* 2009). The artisanal fishery fleet in BCS includes 3,633 officially registered boats (*pangas*) (SAGARPA 2005) and typical fishers earn approximately $84 USD per week (STP 2007). These data were confirmed through interviews carried out during 2006–2008 by Mancini and Koch (2009), who found an average salary of around $80 USD per week. Fishers generally earn more (up to $800 USD per week) for a period of 2–4 months in areas where lobster and abalone fishing is possible (A. Mancini unpublished data).

Interviews with Poachers From June 2007 to April 2008 we conducted in-depth, semi-structured interviews with eight well-known fishers who actively or previously poached sea turtles (F1–F8). We targeted 12 well-known poachers and 10 initially agreed to participate in our study. Of those 10, two changed their minds once the interview started. Refusal to participate in all four cases was due to the extremely sensitive nature of the topic. The fishers were from five coastal communities where we formerly detected black market trade of sea turtles (see Mancini and Koch 2009). In the communities where we chose to conduct interviews, the poachers had been identified during previous consumption-related research (Mancini and Koch 2009). During informal talks, we understood that these poachers were well-known by both the authorities and inhabitants of the same communities, and in some cases they had been helped by important people to avoid prosecution.

Due to the illegal and clandestine nature of sea turtle poaching, there was an inherent risk that participants might bias the information (Sheil and Wunder 2002; Mancini and Koch 2009). To mitigate this, a local and trusted person was selected from each community to establish a reciprocal trust and rapport, minimize possibilities of miscommunication, and acquire credibility amongst poachers. The prospective interviewees were briefed as to the scope of the interview, the kind of questions they would be asked, and the nature of the research we were conducting. In addition, all participants were guaranteed strict confidentiality and assured that their identity was not being recorded (they did not provide their names). Once they were given this information, each poacher we selected chose whether or not they wanted to be interviewed. All interviews were conducted in the poacher's home community to make them feel more at ease.

The interviews were conducted using a semi-structured questionnaire including control questions to maintain consistency (e.g., questions 9 and 28, or 20 and 32, Supplementary data). All questions were open-ended in order to obtain the most detailed information as possible and the interviewer collected information from respondents in a relaxed but guided manner. We followed the approximate order of the questionnaire, but allowed participants to bring up topics and elaborate as much as they wished. In general, interviews lasted approximately 1 h but varied based on responses to individual questions.

The in-depth interviews were designed to: (1) address the complexity of feelings (Dunn 2000; Winchester 2000) on such a sensitive topic; and (2) allow for a more detailed description of views than a traditional survey (Kitchen and Tate 2000; see also Campbell 2002). In-depth interviews with specialists are employed when individuals have specific insights into, as well as some level of influence on, a particular issue (Lindsay 1997; Campbell 2002). Therefore we selected participants based on their level of sea turtle poaching expertise. Our semi-structured interview design (see Supplementary Data) was divided into four sections to: (1) estimate the relevance of poaching with respect to socioeconomic factors; (2) obtain a detailed description of poaching rates, black market prices, and distribution networks; (3) understand poachers' perceptions of law enforcement and severity of penalties; and (4) highlight factors that might motivate an individual to engage in poaching. We identified common thematic trends and areas of agreement and disagreement. Descriptive narratives (representative respondent quotes) are presented in Supplementary Data.

We acknowledge that our sample size is small and, therefore, not intended to be representative of all sea turtle poachers in BCS. Nevertheless, sea turtle poaching in BCS is an extremely sensitive topic to discuss with outsiders and identifying well-known, reliable sea turtle poachers who were willing to speak candidly about their illegal activities proved very difficult. Additionally, considerable time, expense, and travel preparation were required to access remote areas often lacking basic infrastructure.

Cost-benefit Model Sumaila *et al.* (2006) proposed a model to estimate net benefits from engaging in illegal, unregulated, or unreported (IUU) fishing. The model assumes that a fisher will decide to engage in IUU fishing, weighing five factors: (1) benefit from the illegal activity; (2) probability of being detected and the level of law enforcement and regulations; (3) penalty faced by the fisher if detected and caught; (4) cost of avoidance of detection and/or capture; and (5) fishers' moral and social standing in society and how it may be affected by IUU activities.

Following Sumaila *et al.* (2006) we define net benefit (NB) as:

$$\mathbf{NB} = \mathbf{f}(\mathbf{h}(\mathbf{A}, \mathbf{e}, \mathbf{x}), \theta(\mathbf{e}, \mathbf{A}, \mathbf{R}), \mathbf{F}, \mathbf{m}(\mathbf{e}), \mathbf{s}(\mathbf{e})) \quad (1)$$

where h is the catch from illegal fishing; e represents the illegal fishing inputs (cost of avoidance activities); x is the biomass of fish available; A denotes the level of avoidance activity; R is the set of regulations in place; θ is the probability of detection; F is the penalty a violator faces when caught; and m and s denote the individual's moral and social standing. Moral and social costs (Kuperan and Sutinen 1998; Charles *et al.* 1999; Sutinen and Kuperan 1999) were not considered because most BCS residents do not presently perceive the illegal sea turtle fishery in a negative way. Thus, the Eq. 1 can be adjusted as follows:

$$\mathbf{NB} = [\mathbf{ph}(\mathbf{A}, \mathbf{e}, \mathbf{x}) - \mathbf{T}(\mathbf{e}, \mathbf{A})] - \theta(\mathbf{e}, \mathbf{A}, \mathbf{R})\mathbf{F} \quad (2)$$

where p denotes the unit price and $T(e, A)$ represents the total cost of illegal fishing (cost of avoidance activities and cost of illegal fishing inputs).

Model Assumptions Sea turtle fishing has been strictly forbidden in Mexico since 1990 (DOF 1990). Thus, we assumed that the value of θ is different from 0 and can be up to 1. We considered all illegal fishing activities unprofitable if the daily net benefit was less than the average daily salary of legal fishers in BCS (NB=$11.93 USD) (Secretaría para el Trabajo y la Prevision Social, STPS December 2007). Law enforcement is assumed to have only two components (Milner-Gulland and Leader-Williams 1992): a composite probability of detection and the penalty imposed. This measure includes the probabilities of being detected, the probability of being arrested after detection, and the probability and severity of sentencing after capture. Whereas indications of probability of being detected were obtained through interviews with illegal fishers, data on capture and sentencing rates were obtained from the Mexican department of environmental crimes (Procuraduria Federal para la Protección del Medio Ambiente, PROFEPA) and the Attorney General's office in BCS (Procuraduria General de la Republica, PGR). We used all the cases recorded by both institutions from 1995 to June 2008; however, the probability of being captured is likely an underestimate because officers sometimes receive bribes from illegal fishers and/or their relatives (Delgado and Nichols 2005; Senko *et al.* 2011; Authors pers. obs.).

Parameter Estimates The total daily catch from illegal fishery (h) was calculated in kilograms (kg). However, in three cases the response was given in number of animals. Consequently, we converted the number of animals into

kg using 30 kg / turtle, which denotes the average weight of each sea turtle captured in BCS (Mancini and Koch 2009). The price (p) was expressed in USD/kg. We considered only the prices paid by the middleman or customer on the beach, which represents what fishers ultimately receive. The cost of illegal fishing (e) includes the daily cost of fuel (as reported in the interviews) and equipment (e.g., boat, motor, net) maintenance. A fishing-net for sea turtles is valued at US$660 and can last for at least 2 years with minimum maintenance (Jesus Lucero, pers. comm.). This represents a daily cost of US$1. Cost for engine maintenance varies substantially depending on the type and age of the motor. Usually boats, known locally as *pangas*, are 8 m fishing skiffs with 75–300 hp outboard motors. We considered the average cost reported during interviews, which was US$2,453 per year (~US$7 per day). We did not include fixed costs (e.g., boat and outboard motor) because fishers also use these during their legal fishing activities. The daily cost of avoidance activities (A) includes the cost of extra fuel to escape in case of detection and bribes in case of capture. Although each respondent reported the daily cost of fuel, only two specified the actual amount of bribes they paid. Thus, we used the mean bribe value for each case as most of the interviewees mentioned bribes as the most frequent way to avoid being arrested (US$1,472) (Table 1). Estimates of composite detection probability were obtained through quantifying the probabilities of: (1) being detected; (2) being arrested; and (3) being sentenced. The probability of being detected (θ) was calculated at each site by comparing the average weekly presence of inspectors from PROFEPA and the number of days per week that fishers catch turtles. This probability is likely an overestimate of the actual value because it implies that, when inspectors are present, all illegal fishers are detected. The probability of being arrested (a) was estimated based on official data from PROFEPA: of 39 people detected while fishing illegally or transporting sea turtle products, only 13 were actually arrested (21%). The probability of being sentenced once arrested was calculated based on official sentences imposed from 1995 to present (n=9, 69%).

The maximum possible penalty as stipulated in the law consists of 9 years of jail and a fine of up to 150,000 MXN (US$11,038, US$1=13.5 MXN) (Codigo Penal Federal 1996). Based on nine sentences reported by the Attorney General of BCS (PGR, pers. comm.), an average fine of US $2,519 and an average incarceration penalty of 405 days have been imposed since 1995 (n=9). To calculate the fine (F) in monetary terms, we converted the prison sentence into USD using the standard conversion method based on the loss of earnings while in prison (Becker 1968; Sesnowitz 1972). For this conversion, we used the average daily salary of BCS fishers, which was estimated at US $11.93, as reported by the Mexican Secretary for Work and Social Security (Secretaría para el Trabajo y la Prevision Social, STPS December 2007). Using this conversion factor, the maximum penalty was calculated at US $50,213, while average imposed penalty was calculated at US$7,349 (which represents a proportion of 15% of the maximum penalty).

Results

Interviews with Poachers Respondents were all male, ranged in age from 28–60, and all but one was born in their current community. When not poaching sea turtles, six (75%) fished for finfish and two (25%) fished for shellfish. All but one fisher sold sea turtles to a middleman, with the one exception being the eldest of the interviewees, and most sea turtles either remained in the community or were exported to other cities in Baja California, Mexico (Table 1). Based on reported daily capture rates and mean number of fishing days per year, we estimated that the five poachers who still actively hunted sea turtles removed approximately 6,640 animals annually. The majority of turtles killed consisted of East Pacific greens (65%), followed by olive ridleys (25%), and loggerheads (10%) (Table 2). This represents a mean annual capture of 1,328 turtles per fisher or group of fishers (see below).

Illegal fishers were classified into two categories: chronic and occasional poachers. In the case of chronic poachers (n=6, 75%), illegal fishing represents the primary activity and thus their predominant source of family income. In two cases, sea turtles were not the main target species. Chronic poachers were organized into structured groups, with each group containing three to eight individuals with a well-defined leader. These fishers owned boats equipped with powerful outboard motors, which improved their chances of escape if/when detected. Their catch is usually sold to a middleman who is typically in charge of transporting the meat to its final destination (Mancini and Koch 2009). Occasional poachers (n=2, 25%) were those fishers who targeted sea turtles to generate supplementary income. These poachers were not organized and each boat crew (usually two people) worked independently with artisanal 'panga' style fishing boats. Their decision to catch sea turtles depended largely on the demand from dealers or trusted customers, as well as the presence of sea turtles at their local fishing grounds.

Factors that emerged for illegal poaching included: high profitability (n=8, 100%); lack of law enforcement and ease of escape or bribery (n=8, 100%); family tradition (n=5, 63%); strong identification as a fisher (e.g., "I'm a fisher; it's all I know; it's what I do") (n=4, 50%); solo

Table 1 Characteristics and summary of answers by illegal fishers interviewed in BCS, Mexico

	F 1	F 2[a]	F 3[a]	F 4[a]	F 5	F 6	F 7	F 8
Age	48	38	55	45	33	28	29	60
Sex	Male	Male	Male	Male	Male	Male	Male	Male
Years living in the community	Born in the community.	Born in the community.	Born in the community.	Born in the community.	Born in the community.	Born in the community.	Born in the community.	More than 40 years.
Economic dependants	4	None.	None.	2	3	4	2	4
Education	Primary school	Primary school	Primary school	Primary school	University (1st year)	High school	High school	Primary school
Main fishery products	Finfish	Finfish	Finfish	Finfish	Lobsters, shrimps, abalone (illegally).	Lobsters, shrimps, abalone (illegally).	Finfish	Finfish
Most used fishing gear	Nets, harpoons	Nets, harpoons	Nets	Nets	Nets and diving.	Nets and diving.	Nets.	Nets
Technique used for sea turtles	Nets, harpoons	Nets, harpoons	Nets	Nets	Nets.	Nets.	Nets.	Nets.
How long have you been fishing sea turtles?	Since the ban in 1990 (18 years and continuing)	From 1990 to 2005 (15 years)	From 1990 to 2003 (13 years)	From 1990 to 2003 (13 years)	For the past 5 to 8 years and continuing	For the past 5 years but not continuously and continuing	From 2003 to 2007 (4 years)	Since the ban in 1990 (18 years and continuing)
How many days per week do you fish?	4 day per week	6 days per week.	6 days per week.	6 days per week.	4 days per week.	4 days per week.	5 days per week.	6 days per week.
Do you sell directly the product or do you have a middleman?	I sell the product to a middleman.	I sell the product to a middleman.	I sell the product to a middleman.	I sell the product to a middleman.	I sell to trusted people only. I don't know if it is for personal consumption or for sale.	I sell the product to a middleman.	I sell the product to a middleman.	I sell the product directly to customers.
Where is the product transported mainly?	Tijuana and Ensenada.	The community and the Northern Baja.	Tijuana.	Tijuana and USA.	Ciudad. Constitucion (BCS).	I am not sure.	Los Cabos, La Paz.	The community and around.
Why did you choose this activity?	I can earn a lot of many with a relatively low effort.	I learnt from my father.	I learnt from my father and there is no other activity that allows you to make so much money for such a less effort.	I learnt from my father.	I can earn a lot of many with a relatively low effort.	I can earn a lot of many with a relatively low effort.	I can earn a lot of many with a relatively low effort.	I can earn a lot of many with a relatively low effort.
Are there any other job opportunities?	Not in the regular fishery.	I think there are other job opportunities in the community, but not in the fishery.	Not so well paid.	I am not sure.	I think there are other job opportunities in the community, but not in the fishery.	I think there are other job opportunities in the community, but no one is so well paid.	Yes, there are other opportunities.	Not so well paid.
Where do most of the illegal fishers come from?	They are from the community.	They are from the community.	They are from the community.	They are from the community.	Sonora, Nayarit	They are from the community.	They are from the community.	They are from the community and from Sonora.
Do they have other activities?	They are mostly fishers.	They are mostly fishers.	They are mostly fishers.	They are mostly fishers.	They are mostly fishers.	They have no other activity.	They are mostly fishers.	They are mostly fishers.
How many times have you been detected?	Many	Many	Many	Many	Many	Many	Never	Few
How many times have you been arrested?	1	2	Many	Many	Never	3	Never	Never
How many times did you avoid detection and/or being arrested?	Many	Many	Many	Many	Many	Many	Never	Many
How did you avoid being detected or arrested?	Escaping, bribing	Escaping, bribing	Bribing	Bribing	Escaping	Escaping, bribing	/	Escaping, bribing
Have you ever been sentenced?	Never	Once	Once	Never	Never	Once	/	Never

Table 1 (continued)

	F 1	F 2[a]	F 3[a]	F 4[a]	F 5	F 6	F 7	F 8
What was your sentence?	/	2y. jail	6mo. jail	/	/	Equipment confiscated	/	/
What is the probability of being detected?	Low[b]	Very low	Very low	Very low	Low	Low	Very low	Very low
What is the probability of being arrested after detection?	Low[b]	Very low	Low	Low	Low	Medium	Low	Low

[a] Indicates fishers that stopped poaching at least 2 years ago.

[b] Probability of being detected and arrested increasing due to the presence of Mexican Navy.

fisher lacking support of a cooperative (n=3, 38%); disbelief that sea turtles were actually endangered or declining (n=2, 25%); preponderance of transient fishers in their fishing area (n=2, 25%); lack of other skills or jobs (n=1, 13%); innate right to take from the ocean (n=1, 13%); less finfish in their fishing area (n=1, 13%); and difficulty obtaining new permits (n=1, 13%) (Table 3). Factors that contributed, or had the potential to contribute to fishers stopping poaching included: prison (n=3, 38%); sympathy for turtles (n=2, 25%); and setting a good example for their children (n=2, 25%) (Table 3).

Cost-benefit Model Daily costs and revenues generated from illegal sea turtle hunting in BCS are reported in Table 4. The total cost/expected revenue ratio of illegal fishing shows whether or not sea turtle poaching is profitable: a value≥1 implies that this activity is not profitable. From the interviews and official data from PROFEPA and PGR, we obtained: (1) a 21% probability of being captured if they are detected (from 1995 to present); (2) a 69% probability of being sentenced; (3) a severity of sentencing representing 15% of the maximum penalty; and (4) a maximum fine of US$50,213. Thus, poaching appears to be unprofitable for only two interviewees (Table 4), with a total cost/expected revenue ratio of 1.20 and 2.44 for these two individuals. In the other cases, the ratio is <1, implying that this illegal activity is highly profitable.

Discussion

Although our sample size is too small to be representative of all illegal poachers in BCS, we believe our baseline study gives a good overview of a topic that is both highly sensitive and difficult to assess. Our results suggest that the most prevalent drivers for poaching are direct economic benefits, lack of law enforcement and ease of escape from or bribery of authorities, and strong family tradition. In order to reduce poaching it will be necessary to better enforce existing environmental laws, reduce social acceptance of sea turtle hunting, educate fishers on why sea turtles are ecologically important and vulnerable, and show them direct economic benefits from non-consumptive use of sea turtles.

Exploitation of immature sea turtles has been shown to substantially limit population recovery (Crouse *et al.* 1987; Crowder *et al.* 1994; Heppell *et al.* 1999; NMFS and USFWS 2007). The estimated removal of approximately 6,640 sea turtles per year (65% East Pacific green, 25% olive ridley, and 10% loggerhead) by only five fishers may, in itself, represent a serious threat to the recovery of at least some of these species, especially since the majority of East Pacific green and loggerhead turtles poached in

Table 2 Estimated number of annual sea turtle captures based on mean daily capture rates and approximate number of working days per year, as reported by five illegal fishers interviewed in BCS, Mexico

	Mean daily sea turtle captures	Working days/year	Mean annual sea turtles captures	Predominant sea turtle species caught
F 1	14	250	3,542	*Chelonia mydas*
F 5	11	50	550	*Chelonia mydas, Caretta caretta*
F 6	4	200	800	*Chelonia mydas, Caretta caretta*
F 7	14	125	1,688	*Lepidochelys olivacea*
F 8	5	14	70	*Chelonia mydas*
Mean	10	128	1,218	
		Total	6,640	

BCS are immature (Koch *et al.* 2006). Although our small sample size is not intended to be representative of all poachers in BCS, these results suggest that even a small number of fishers are capable of poaching a large number of sea turtles. Similarly, Peckham *et al.* (2007) found annual by-catch mortality of endangered Pacific loggerhead turtles from only two small-scale fishing fleets along the Pacific coast of BCS exceeded 1,000 animals.

Not surprisingly, all fishers believed that any benefits derived from poaching sea turtles were worth the risks. Two factors emerged in contributing to this belief: (1) the comparatively greater amount of money that could be earned from poaching sea turtles versus legal fishing for finfish or shellfish; and (2) the lack of law enforcement patrolling coastal foraging areas as well as ease of escape from or bribery of authorities. Although it is considered relatively easy to find a blue-collar job in BCS (authors pers. obs.), none are even remotely close to being as profitable as sea turtle poaching. For example, the average weekly salary of a fisher in BCS is $84 (STP 2007), whereas the average price from poaching a single turtle for our eight poachers was $58. The 1990 moratorium led to an increase in national and international demand for sea turtle products and a simultaneous decrease in supply (Garcia-Martínez and Nichols 2000), which ultimately created a network of well-organized black market circuits that drove prices up considerably. Likewise, all interviewees perceived a low risk of being caught by law enforcement authorities, sometimes even if they were present in the area (Table 1). Even if being caught and arrested is considered the main risk of sea turtle poaching, the interviewees generally felt safe while poaching.

> Of course there's some law enforcement, but most of the time you can easily escape. The inspectors from PROFEPA have small boats they can't catch us, on the other hand the marines are more efficient but most of the time they don't care about turtles. They look for guns and drugs. And sometimes when you get caught you just need to give them some money and there's no problem…—F2

Sea turtles have been utilized in BCS culture over the past 600 years for food, medicine, and decoration (Caldwell 1963; O'Donnell 1974; Olguin-Mena 1990; Clifton *et al.* 1995; Nichols 2003; Mancini and Koch 2009; Senko *et al.* 2009). The Seri Indians, a group indigenous to the region, were the first inhabitants to use sea turtles, both for food and religious ceremonies (Garcia-Martínez and Nichols 2000). Five fishers (63%) mentioned family tradition as a driving factor, indicating that their fathers introduced them to this activity as children and that they had grown up fishing for turtles. When the complete moratorium was declared in 1990, these fishers noted that they simply decided to carry on catching sea turtles.

> I have always lived in this town, for us eating turtle meat was like eating chicken. It was less expensive than the beef meat and it tastes so much better. I am a fisherman, it's a tough work but there's nothing else I can do…F1
>
> I was born here. I learned how to catch turtles using a harpoon with my father and my uncle, they were turtle fishers when it was still legal and then we continued even after. I go out, I am supposed to catch fish but there's no more fish, you have to go further out and you need more and more nets. If I go out to catch turtles 1 day I can make as much money as I would in at least 2 weeks of regular fishery […]. I don't understand, we used to eat tons of turtles every year and now it's illegal. But I know a lot of people who eat them, important people....—F2
>
> I started catching turtles in the lagoon with my father and my grandfather. When the ban was declared, I simply went on doing what I knew. Since [then] I have been catching turtles regularly…—F3

In addition to family tradition, strong identity as a fisher and not belonging to a cooperative also influenced whether or not fishers engaged in poaching. For example, F1 mentioned both factors:

Table 3 Factors driving sea turtle poaching by illegal fishers interviewed in BCS, Mexico

	High profitability	Lack of law enforcement and ease of escape/ bribery	Family tradition	Strong identify to being a fisher	Solo fisher lacking cooperative support	Disbelief sea turtles were endangered	Preponderance of transient fishers	Lack of other skills or jobs	Innate right to take from ocean	Less finfish in fishing area	Difficulty obtaining new permits
F1	x	x	x	x	x	x		x			
F2[f]	x	x	x	x						x	
F3[f,β]	x	x	x	x							
F4[f,β]	x	x	x								
F5	x	x			x		x				x
F6	x	x		x	x				X		
F7[γ]	x	x									
F8	x	x	x			x	x				
%	100	100	63	50	38	25	25	13	13	13	13

f Prison contributed to fisher stopping illegal poaching

β Sympathy for sea turtles contributed to fisher stopping illegal poaching

γ Setting a good example for their children had the capacity to contribute to fisher stopping illegal poaching

> I am a fisherman, it's tough work but there's nothing else I can do. I usually fish *escama* [finfish] but you have to be out in the boat for hours and sometimes you only get enough to cover the cost of the gasoline. Then you have to take care of the boat and the engine. I am a solo fisherman, I don't have the support of a cooperative. With my harpoon I can easily catch many turtles in 1 day and then I can stop working for the rest of the week....—F1

Two fishers were confused as to how sea turtles could be endangered when they continued to catch them in their nets. For example, F8 states:

> You say turtles are endangered but I have seen a lot and all the fishermen say that there are a lot out there, sometimes they find 10 or more in the net. Are they really endangered?—F8

Senko *et al.* (2011) reported a similar disbelief by fishers that sea turtles in BCS were actually endangered and suggested that more focused education efforts are needed so that fishers understand why sea turtle populations at foraging areas are especially vulnerable to even small-scale fishing pressures. Both fishers who doubted sea turtles were endangered also mentioned family tradition as a reason for continuing poaching. Similar instances in other areas of the world (e.g., Diamond 1991; Milner-Gulland *et al.* 2003; Koch *et al.* 2006) show that it is quite common for people to continue long-standing traditions of hunting animals after the activity is deemed illegal.

Some interviewees also expressed frustration over transient fishers who came from other areas and were not members of their community.

> There are also a lot of illegal fishers coming from Sonora and Nayarit, and no one stops them. They come, take what they want and then leave, so why wouldn't I do the same?—F5

Transient fishers, who often set up fishing camps and fish seasonally, sometimes traveling from several hundred kilometers away, are common in BCS and generally have little or no vested interest in sustainable use of local natural resources (Hastings and Fischer 2001; Young 2001; Senko *et al.* 2011). Senko *et al.* (2011) reported a similar frustration over transient fishers, with local fishers indicating that they presented challenges to community-based sea turtle conservation efforts.

Only chronic and occasional poachers were considered in this study; however, an unknown number of regular fishers in BCS catch sea turtles for their own consumption (Gardner and Nichols 2001; Nichols 2003; Delgado and

Table 4 Cost and benefits of sea turtle illegal fishery for each interviewee based on mean daily catch rates

	Catch (kg)	Price (USD)	Revenue (USD)	Expected revenue (USD)[a]	Variable cost (USD)	θ	Avoidance activity (USD)	Corrected avoidance activity (USD)[b]	Expected fine (USD)[c]	Total cost (USD)	Total cost/ expected revenue
Professional poachers											
Case 1	425	4.42	1876	1764	22	0.06	1486	13	65	101	0.06
Case 2*	488	1.32	646	608	44	0.06	1508	13	65	123	0.20
Case 3*	333	1.03	343	340	44	0.01	1508	2	11	57	0.17
Case 4*	333	1.03	343	340	44	0.01	1508	2	11	57	0.17
Case 5	330	1.25	413	310	44	0.25	1508	55	273	372	1.20
Case 6	120	1.69	203	152	44	0.25	1508	55	273	372	2.44
Occasional poachers											
Case 7	405	2.94	1192	1180	26	0.01	1490	2	11	39	0.03
Case 8	150	1.69	254	244	26	0.04	1490	9	44	78	0.32

[a] Expected revenue=(1-θ)*Revenue. Highlights that the catch is usually confiscated after capture (Sumaila *et al.* 2006)

[b] Reflects that the cost for avoidance activity has to be paid only if detected, caught, and/or sentenced

[c] Describes how much of the total fine is usually imposed to the poacher once detected, captured, and sentenced

* Indicates fishers that stopped poaching at least 2 years ago

Nichols 2005; Mancini and Koch 2009; Senko *et al.* 2009). For most of the chronic offenders, sea turtle hunting is the main source of family income, although lobsters (*Panulirus* sp.) and abalone (*Haliotis* sp.) are also poached (Bórquez-Reyes *et al.* 2009). By contrast, occasional offenders only catch sea turtles as a means of 'opportunistic' economic gains, and the desire to fulfil the high demand coming from trusted people. Although these two groups act in very disparate ways (the former organized in groups, the latter by themselves), both appear to be driven by similar factors.

In addition to our qualitative results, our model suggests that the primary driver of illegal turtle hunting is direct economic gains. Daily revenues from sea turtle hunting ranged from US$203–$1,836, whereas a fisher obtaining legal marine products can earn approximately US$11.93 per day (STP 2007). Our model reported unprofitable values for only two sea turtle poachers (F5 and F6, Table 4), however both of these fishers indicated that turtles were not their main target species and that they preferred to catch (illegally) abalone and lobster. Although consumption of sea turtle meat may be slightly decreasing amongst the working class (Mancini and Koch 2009), demand for sea turtle meat in BCS remains extremely high and may rise even more given that sea turtle meat is increasingly considered a symbol of wealth and status by high and medium income people (Garcia-Martínez and Nichols 2000; Delgado and Nichols 2005; Mancini and Koch 2009). This surge in demand likely will lead to even higher profits for illegal poachers.

The decision to engage in illegal poaching also depends on a cost-benefit analysis by the fisher, weighing the risk of being caught and possibly arrested versus the economic benefits from poaching (Charles *et al.* 1999; Sumaila *et al.* 2006; Bórquez-Reyes *et al.* 2009). Fisher's general perception is that they probably will not be caught poaching sea turtles by wildlife protection authorities due to the lack of law enforcement at coastal environments. With limited resources available for conservation and the high costs associated with patrolling coastal and offshore habitats (as opposed to mainland nesting beaches), enforcement levels encountering few or no infractions could be prohibitively expensive (Balmford *et al.* 2002). Thus, conservation law enforcement strategies are needed to maximize benefits while minimizing costs (Keane *et al.* 2008). Low-cost solutions include increasing the penalty (Keane *et al.* 2008), but this option is less feasible because the penalty for possessing sea turtle products in Mexico is already extremely high. For example, a 6-month jail sentence proved to be a better deterrent than fines for two fishers from BCS (Nichols and Safina 2004; F. Fisher, pers. comm.). Some studies (e.g., Sutinen and Gauvin 1989; Furlong 1991; Milner-Gulland and Leader-Williams 1992; Leader-Williams and Milner-Gulland 1993) indicate that a higher probability of detection is a more effective deterrent than the actual penalty. This was confirmed by one fisher (F8) who was considering ceasing poaching if there was an increase in the presence of Navy and wildlife inspectors in his fishing area.

Presently there are two reasons why the probability of being detected in BCS remains very low: (1) the limited number of inspectors at coastal environments and the resulting low detection rate; and (2) a conflict of interest

between fisheries inspectors and fishers (e.g., the inspector and fisher are friends or family members) (Nichols 2003). The low detection rate (21%) by conservation inspectors is largely due to: (1) a lack of appropriate equipment (fast boats) to catch poachers; and (2) corruption. In an attempt to obivate both probabilities, inspections are presently being conducted by the Mexican Navy, which is patrolling the coastal waters of BCS with fast boats that are equipped with radar and armed personnel to deter drug trafficking (Authors pers. obs.). This is encouraging, because we know from experience that the Navy will cooperate with federal environmental agencies (e.g., PROFEPA) when asked to investigate illegal fishing or sea turtle poaching (Authors pers. obs.). We have also found that the mere presence of the Navy at one coastal foraging area discouraged illegal gillnet fishing that previously resulted in very high levels of sea turtle by-catch (Authors pers. obs.; Mancini *et al.* in press). Additionally, when elements from different governmental organizations are present there may be less chance that poachers will successfully bribe authorities (Ede 2000).

Interestingly, two fishers expressed sympathy for sea turtles as their primary reason for no longer poaching them.

> I used to catch turtles and when I couldn't I had people catching them for me. Now I don't eat turtle meat anymore, I am sorry for them (the turtles).—F3

> I used to kill the turtles, but now I wouldn't be able anymore. I'd feel pity for them. While my brother was in jail I heard a lot about protecting sea turtles and why they are important…—F4

Sympathy for turtles may be a result of increased education and outreach efforts (F4). Fishers such as these two may be ideal candidates to initiate non-consumptive use efforts. For example, Troëng and Drews (2004) showed that non-consumptive uses of sea turtles (e.g., ecotourism, voluntourism) usually generate greater income than consumption. In BCS there is increasing emphasis on small-scale sea turtle voluntourism, which appears to be overwhelmingly supported by local residents (Senko *et al.* 2011). Nevertheless, the potential for small-scale voluntourism may not be sufficient to sustain economic growth of coastal communities in the long term and it may not be practical in all communities due to differences in infrastructure and resources (Senko *et al.* 2011). Assuming that an increasing number of small-scale voluntourism or ecotourism projects emerge in BCS, it is important to ensure that at least some direct economic benefits from non-consumptive use of sea turtles go to those who previously used them consumptively. Fishers who previously poached sea turtles might be able to take a lead role in developing these activities because they already possess the necessary equipment (e.g., boats, nets, GPS devices) and ecological knowledge of turtle movements and abundance (Senko *et al.* 2011). Salafsky *et al.* (2001) found that ecotourism ventures utilizing skills and technologies that community members already possess are the most likely to be successful (Senko *et al.* 2011).

Today, sea turtle meat is still consumed regularly in BCS and consumption can be considered a social norm, otherwise known as shared understandings about actions that are obligatory, permitted, or forbidden (Baland and Platteau 1996). Changing social norms is a long and complex process, but moral suasion has been used effectively in small artisanal fisheries in Norway and Newfoundland, where high levels of compliance were achieved despite low levels of formal enforcement (Gezelius 2002, 2004). Possible strategies for reducing social acceptance of sea turtle poaching include educating residents on the ecological importance of sea turtles (e.g., seascape and marine substrate engineers and nutrient transporters) as well as why sea turtle populations in BCS are especially vulnerable to poaching from even a small number of fishers (e.g., slow growth, long lived, late sexual maturity, aggregations of juveniles at foraging areas). An additional strategy for reducing social acceptance may be to educate residents on why sea turtles might be unhealthy to consume. For example, Senko *et al.* (2009) found that residents in BCS overwhelmingly viewed sea turtle meat as a healthy food source even though growing evidence (see Aguirre *et al.* 2006; Fussy *et al.* 2007) suggests that eating sea turtles may be harmful to human health because of biotoxins, environmental contaminants, parasites, bacteria, and dubious processing and transporting of meat via unregulated black market circuits.

We recognize changing community attitudes, knowledge, and behaviors in regard to resources utilization is complex and requires a detailed understanding of the cultural, economic, political, and social fabric (Larson *et al.* 1997; Senko *et al.* 2011). In BCS, changing anti-environmental behaviors that currently threaten sea turtles will continue to be a challenging endeavor as long as people continue to poach and traffic in endangered species despite progressive legal protections and easier access to other more reliable and less risky protein sources. Thus, efforts to change social norms may not be enough; increased law enforcement and alternative economic incentives are also needed (Baland and Platteau 1996). For example, community vigilance has proven useful in deterring illegal fishing and sea turtle poaching in Punta Abreojos, a coastal foraging lagoon in BCS where fishers run their own inspection program through a fishing cooperative to protect their natural resources, with strict penalties for any fisher who is caught poaching even a single sea turtle, including expulsion from the cooperative (Bórquez-Reyes *et al.* 2009;

J. Villavicencio, Punta Abreojos Cooperative pers. comm.). Furthermore, if we manage to implement non-consumptive uses of sea turtles that could bring direct economic benefits to local communities, co-management strategies, intended as "sharing of power and responsibility between the government and local resource users" (Berkes *et al.* 1991), could be used to both overcome the lack of law enforcement by having the community watching over the resource (Campbell *et al.* 2009) and generate jobs and revenues in the form of sea turtle voluntourism or ecotourism activities (Troëng and Drews 2004; Senko *et al.* 2011).

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