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## Sea turtles support sustainable livelihoods at Ostional, Costa Rica

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**Abstract** Ostional in Costa Rica is the second largest nesting site of the olive ridley sea turtle *Lepidochelys olivacea*, which is categorized as Vulnerable on the IUCN Red List. In Ostional the local community helps maintain the nesting site and collects olive ridley eggs for consumption and trade within Costa Rica. Since its inception in 1987, the egg harvesting project has integrated sea turtle conservation with community development. We assessed the current status of this project in terms of community awareness, dependency, involvement and perceptions, using a household survey and semi-structured interviews with key informants. We also compared some of our findings with those of previous studies at the site, finding that the project has fewer dependents, primary livelihood activities have shifted towards tourism and hospitality, and respondents are more aware about environmental conservation and stewardship. We map outcomes of the project with the sustainable livelihoods framework, and suggest that further capacity building for research and tourism could contribute towards sustaining the turtle population, local livelihoods, and the community-based conservation institution.

**Keywords** Community-based conservation, Costa Rica, legal wildlife trade, natural resource management, Ostional, sea turtles, sustainable livelihoods.

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### Introduction

Sea turtles have been accorded protection by national and intergovernmental legislation since the 1970s (NOAA, 2014), but illegal and unsustainable take of sea turtles continues, mainly for food (Frazier et al., 2007). Over 80% of sea turtle nesting sites occur in developing nations, and only 25% of these sites are in protected areas (Mazaris et al., 2014), with sea turtles a valuable yet vulnerable source of food in coastal communities. For example, indigenous natives of Torres Strait, Australia hunt legally for sea turtle meat (Watkin Lui et al., 2016), reducing their expenditure on meat by  $\geq 70\%$  (Delisle, 2012). Few places in the world allow the use of any sea turtle product, however, and, where legal, consumption and trade is restricted to rural communities adjoining nesting beaches (Supplementary Table 1). Sea turtle conservation is often effected by protective measures and sometimes by sustainable use, but both approaches have their advantages and disadvantages. Communities are dissuaded from sea turtle consumption through alternative livelihoods, such as Brazil's Projeto TAMAR-IBAMA (Marcovaldi et al., 2005), Costa Rica's Tortuguero National Park (Meletis & Harrison, 2010), and Colombia's Proyecto Help Colombia (Monterrosa &

Palomino, 2012). Performance payment programmes incentivise reporting sea turtle nests in Kenya, Malaysia (Ferraro & Gjertsen, 2009), Tanzania, Indonesia (Gjertsen & Niesten, 2010), El Salvador (Liles et al., 2015) and Nicaragua (Madrigal-Ballesteros & Jurado, 2017). Numerous community-based sea turtle conservation projects operate at nesting sites around the world, fostering responsibility towards the environment, and strengthening local economies (Marcovaldi et al., 2005). However, many face problems encompassing incompatible alternative livelihoods, indiscriminate tourism (Honey, 2008), inequitable benefit distribution, and socio-cultural or political conflict (Campbell, 2007; Meletis & Campbell, 2009; Panda & Sridhar, 2012; Aguilar-González et al., 2014). Conversely, in parts of Central America, although use is permitted for local sustenance only, sea turtle products may be illegally traded commercially nationally (Humber et al., 2014) and internationally (Rice & Moore, 2008). Communities harvesting eggs often cannot recover the costs of the labour of extraction and beach management through local informal trade (Hope, 2002), and thus institutional failure to regulate markets results in overexploitation and illegal trade.

In general, the conflict of interest between conservation and development agendas results in inevitable compromises in the effectiveness of integrated interventions (Chan et al., 2007). Projects such as CAMPFIRE (Zimbabwe) and ADMARE (Zambia) have had limited success in achieving their multiple goals of wildlife conservation, stakeholder engagement, revenue generation, and development, as a result of high dependence on external funding, poor local participation, non-devolved management rights, and elite capture of project revenues and benefits (Marks, 2000; Taylor, 2009; Lyons, 2013). Community-based conservation, however, explicitly integrates development goals, aiming to optimize resource exploitation towards sustainable outcomes (Roe et al., 2009), and has been shown to influence normative behaviour, apply local values and knowledge to achieve conservation goals, and reduce management and enforcement costs, while building capacity to adapt to global change through networks of trust and collaboration (Andrade & Rhodes, 2012; Challender & MacMillan, 2014; Frey & Berkes, 2014; Salerno et al., 2015). There is a dearth of rigorous monitoring and reporting on the outcomes of community-based conservation, and many attribute project failures to this gap in knowledge (DeGeorges & Reilly, 2009; Margoluis et al., 2009; Brooks et al., 2013; Gardner et al., 2013; Rees et al., 2016).

At Ostional on the Pacific coast of Costa Rica there are monthly mass nestings (arribadas) of olive ridley *Lepidochelys olivacea* sea turtles, which the local community exploits by extracting eggs for consumption and sale. In contrast to restricted non-commercial use of sea turtle eggs, the egg harvesting project at Ostional is the only source for a legal nationwide supply chain of sea turtle eggs. Given the general emphasis on protectionist conservation (Child, 2013), this consumption-based model makes Ostional a unique and controversial conservation project (Pritchard, 2007). Based on the community-based conservation model, the project began in 1987, and contributes to both sea turtle conservation (Ballesteros et al., 2000; Valverde et al., 2012) and rural development (Campbell, 1998; Hope, 2002; Campbell et al., 2007). Hope (2002) expressed concerns over the compatibility of harvesting and ecotourism, Campbell et al. (2007) found that the community perceived increasing tourism and reduced egg demand as challenges to the project.

In this study we hypothesise that there has been no significant change in levels of dependence on the egg harvesting project, other livelihood activities, awareness levels, and community perceptions over 1998-2016. Where this hypothesis is rejected, we use the most significant change method (Wilder & Walpole, 2008) to explain differences in the context of social change, using qualitative evidence from the community and key informants. Parameters for evaluation include the current economic significance of the egg harvesting project, community perspectives, awareness of and involvement in conservation, and economic

valuation of the nesting beach. Some of the data collected are consistent with previous studies at this site (Campbell, 1998; Hope, 2002; Campbell et al., 2007), to facilitate temporal comparisons. Changes thus identified through qualitative and quantitative analyses are mapped as outcomes of community-based conservation (Smutylo, 2005). Rather than describe outcomes as positive, negative or circumstantial (Levine, 2014), we identify interactions between community-based conservation and livelihoods with respect to the sustainable livelihoods framework (DFID, 1999). We also quantify the value of sea turtles to the community through participatory economic valuation (Schreckenberg et al., 2010), using a willingness to accept exercise.

## Study area

Founded in 1902, the community of Ostional (Fig. 1) depended primarily on agriculture and animal husbandry in its early years. Livestock was allowed to feed on sea turtle eggs, and humans would take them for consumption and trade. The egg harvesting project was conceived as a means to promote rational egg use, Ostional Wildlife Refuge was established in 1983, and the first legal harvest was in 1987 (Campbell, 1998). The Refuge is a Combined Property Refuge, jointly owned by the state and the community. The egg harvest is authorized by the Ministerio di Ambiente y Energia (MINAE; Ministry of Environment and Energy) through the Sistema Nacional de Areas de Conservacion (SINAC; National System of Conservation Areas), hereafter MINAE/SINAC, and the egg trade by the Instituto Costarricense de Pesca y Acuicultura (Costa Rican Institute for Fisheries and Aquaculture). Extraction of eggs is justified by the observation that nests laid at the beginning of an arribada are often destroyed by the females arriving to nest later (but see Pritchard, 2007; Valverde et al., 2012). The distribution system comprises registered distributors and resellers, government-issued permits and licenses, and specific packaging to trade eggs throughout the country (Almengor et al., 2001). There are c. 60 direct buyers, and two appointed distributors from the community transport eggs for sale to six national locations. Selling prices of eggs can be twice or thrice the original price (ADIO, pers. comm.).

The local community (including the egg harvesting project) is governed by a democratic body, the Asociación de Desarrollo Integral de Ostional (ADIO; Association for Integrated Development of Ostional), formed in 1984. Funds from the project have helped the Association build a health and nutrition centre, high school, multipurpose community centre and tourism kiosk, and in securing an electricity supply (Campbell, 1998). The human population at Ostional has increased, and entire families depend on the egg harvesting project for food and income. Economic dependence on the egg harvesting project ranged from 30% of households in 1980 to 70% in 1995 (Campbell, 1998), and 32% in 2000 (Hope, 2002). Although many members of the community are now engaged in lucrative service-based employment in neighbouring areas, voluntary participation in activities and decision-making motivates individuals to comply with and contribute to the egg harvesting project (Madrigal-Ballesteros et al., 2013). The population of sea turtles at Ostional has remained relatively stable (Ballesteros et al., 2000; Valverde et al., 2012), with an average of c. 11 arribadas annually, a nesting population of 200,000–500,000 females, a harvest rate of nearly 4% of all clutches laid, and destruction of 48% of eggs by subsequent nesting females and of 8% of clutches by dogs (Orrego, 2014).

## Methods

A household survey was conducted in June 2016 using questionnaires. Responses collected in person by MS were recorded using the *Open Data Kit* (KoBo Toolbox, 2016). Paper questionnaires were used where respondents chose to complete the survey themselves. Closed

questions determined respondents' demographics, and multiple choice questions assessed awareness about the egg harvesting project and trade in sea turtle eggs. Likert scale questions examined residents' perceptions on the cultural, economic, and ecological status of sea turtles, the egg harvesting project, and the community of Ostional.

Open-ended questions were used to elicit (1) perceptions on the advantages and disadvantages of the egg harvesting project, (2) awareness of reasons for and measures by which sea turtles are protected, and (3) perceptions on the positive and negative aspects of, and changes in, life in Ostional over 1998-2016. Of these questions, (1) and (2) were similar to those of Campbell (1998) and Campbell et al. (2007) in that respondents were asked to list three or more answers, not necessarily in order. The most significant change method solicits anecdotal evidence from stakeholders that may not be directly linked to research-specific questions, but could potentially explain drivers of change: open-ended questions on respondent perceptions of changes in the community (3) sought to link statistical differences to social transformation. Anecdotal information from the survey was triangulated through interviews with authoritative key informants, and compared with existing literature.

A willingness to accept exercise was used for participatory economic valuation of the main nesting beach at Ostional. The questionnaire proposed a scenario in which access to the beach was denied and any kind of use of sea turtles was prohibited. Respondents were asked to gauge potential effects of this scenario on ADIO (which depends on funds from the eggs), the beach, employment and recreation, food security, sea turtles and tourism, as positive, negative or neither. They were then asked whether their household would be affected by these changes, whether they would accept compensatory payment for negative impacts and, if so, the magnitude of compensation they would expect. We acknowledge that open-ended valuation questions risk protest and strategic answers (Desbureaux & Brimont, 2015).

For the survey we opportunistically selected one adult respondent per household; i.e. any one consenting adult member of a household (regardless of age, gender, status) present at the time. In addition to the survey, 14 key informants were interviewed, from amongst ADIO (5), MINAE/SINAC (1), researchers (5), and tourist guides (3). Key informant categories were identified initially from the literature, and subsequently from observations, but the number of informants per category was determined by availability. The survey questionnaire and interview guide are provided in Supplementary material 1–2. Qualitative data was coded and classified by emergent themes. Statistics were calculated with *R v. 3.2.3* (R Core Team, 2015).

Where compatible, the data collected were compared to data from previous studies at Ostional (Campbell, 1998; Hope, 2002; Campbell et al., 2007) using  $\chi^2$  tests (when  $\geq 80\%$  of expected frequencies were  $\geq 5$ ). Our use of  $\chi^2$  tests violates the assumption that the populations surveyed are independent. However, although there is a significant difference between our sample and those of previous studies in the proportions of members and non-members of the project surveyed, demographic attributes are similar across study samples. Thus, differences are more likely a reflection of the samples rather than of the population. Significant differences and changes were mapped onto a matrix, following the sustainable livelihoods framework. The first axis maps changes in (1) the vulnerability context (2) the five capitals (financial, human, natural, physical, social), (3) institutional linkages and policy processes, and (4) livelihood outcomes, and the second axis maps achievements and challenges. Areas for improvement could thus be identified and future options suggested.

## Results

A total of 63 households were surveyed, 42% of all 150 households in Ostional. A majority (62%) of respondents were educated to primary school level, with fewer having completed

high school (22%), having no educational qualification (10%) or diplomas (6%). About half (48%) of the respondents had lived in Ostional all their lives, and 76% had previously participated in a survey. Females (51%) and males (49%) were almost equally represented, and mean respondent age was 43 years. Of the 243 individuals recorded, 50% were working members (mean 2 per household). Although the egg harvesting project was the largest contributor livelihoods overall, only five households (8%) were entirely dependent on it, 14 (22%) combined the project with other activities to maintain household income, and 70% received no income from the project (×Table 1). Mean monthly household income was CRC 323,275 (USD 599, GBP 409, at 2016 rates). Household income of members and non-members of the project was not significantly different ( $t = 1.0461$ ,  $P = 0.3023$ ).

*Awareness and perceptions* The majority (90%) of respondents were aware of the egg harvesting project, although fewer (78%) were familiar with ADIO. Although 34% of the respondents believed the population of sea turtles at Ostional had remained stable, opinion was divided over the population having decreased (27%) and increased (26%), and 13% responded ‘can’t say’. Involvement with the egg harvesting project or lack thereof did not manifest in a significant difference in opinions on the sea turtle population ( $\chi^2 = 2.6439$ ,  $P = 0.2666$ ), the local community, and its administration/governance ( $\chi^2 = 1.6613$ ,

$P = 0.9958$ ; ×Fig. 2). The tranquillity, community and environment emerged as the best things about Ostional, and problems of accessibility, coordination and government aid were identified as the worst things (×Table 2). On why turtles are protected (×Fig. 3), an example response was “We care for the turtles. They are the people’s pets.”

*Egg use and trade* Of the 89% of respondents who were aware of the uses of sea turtle eggs, 26% only knew about uses, whereas 63% actually used them. Respondents mentioned medicinal properties such as revitalization, and curing headaches, weakness, dengue, dementia and anaemia, and also high protein and vitamin content. Respondents reported cultural significance in the practice of gifting eggs between families, and the annual egg festival during which traditional delicacies are made using turtle eggs (×Fig. 4).

Approximately 66% of the respondents stated they were aware of the overall working of the sea turtle egg trade but only 10% of the respondents reported their households legally trading eggs. Although the majority of respondents (52) stated that only olive ridley eggs from Ostional are used and traded legally in Costa Rica, a few mentioned the use of green sea turtle ( $n = 2$ ), hawksbill ( $n = 4$ ), leatherback ( $n = 4$ ) and loggerhead ( $n = 1$ ) eggs in other parts of Costa Rica. About 65% of the respondents were aware of at least one or more means of identifying eggs harvested legally from Ostional (by packaging, permits or receipts).

*Trade-offs* In the willingness to accept exercise (×Fig. 5) the perceived impact of a ban on access to the turtles and the beach was negative. There was no significant difference between egg harvesting project members and non-members in assessment of impacts ( $\chi^2 = 3.9092$ ,  $P = 0.689$ ). In the event of such a ban, 43% ( $n = 27$ ) of those surveyed said their households would be affected. Of these, 10% ( $n = 6$ ) said they would accept payment as compensation, and only three respondents declared the magnitude of compensation they would expect, ranging from USD 400 per month to a one-off payment of USD 1 million. Respondents whose households would be affected but refused to accept compensation ( $n = 21$ ) cited strong reasons for rejecting the scenario. It is widely believed that the egg harvesting project has helped enhance the nesting habitat by oxygenating the sand and clearing excessive organic matter, and many respondents stated they cherished their turtle-related activities and would not give them up for money.

*The egg harvesting project* The survey reported a total of 78 members in 37 (59%) households (×Table 3). ADIO has c. 200 members, 25% of which are senior citizens who receive an income from the project, through ADIO, but are not required to work (ADIO, pers. comm.). Improved conservation and living outcomes were seen as benefits of the egg harvesting project, and egg smuggling and social and ecological malpractice were cited as drawbacks (×Table 4).

*Temporal changes* The degrees of household dependence on the egg harvesting project found in this study are different ( $\chi^2 = 70.245$ ,  $P = <0.001$ ) from the previously reported distribution of 32% direct dependency on egg commerce, 56% mixed income, and 12% from other activities (Hope, 2002). The project generates CRC 2,025 million (USD 3,750,000, GBP 2,563,300) annually. Of this, 70% is distributed to members as salaries, and 30% is used to cover costs and invest in community infrastructure (ADIO, pers. comm.). The government no longer shares profits from the trade. This is a change from the previously reported distribution of 40% of the profits going to the government, 30% to the workers, and 30% for community projects (Cornelius, 1985; Campbell, 1998). A bag of 200 eggs is priced at CRC 13,000 (USD 24, GBP 17), and smaller bags of 10 eggs are priced at CRC 700 (USD 1.4, GBP 0.9). The price has not changed significantly since 1998 ( $t = 2.7452$ ,  $P = 0.07103$ ). Anyone residing in Ostional for longer than 6 months is eligible to become a member of ADIO (ADIO, pers. comm.). The residency requirement was previously 5 years, to limit dependency on the egg harvesting project (Campbell, 1998). Other differences with previous studies include a greater proportion of project non-member respondents in our study, a shift towards a service economy, and changed perceptions and awareness about the project (×Table 5).

*Stakeholder engagement* Interviews with key informants revealed previously undocumented information on the roles of stakeholders in the functioning of the Ostional Wildlife Refuge. An inter-institutional committee meets every month at Ostional to discuss the management of the Refuge (F. Bolanos, pers. comm.). Representatives of the Universidad de Costa Rica (University of Costa Rica, UCR), MINAE/SINAC and ADIO are integral to the committee, and tourist guides, fishers and civic associations, and NGOs from neighbouring villages and towns participate regularly. There are two groups of tourist guides, one within ADIO and a private local association, each comprising 15 guides (J. Rosales, pers. comm.). The guides are trained by the biologist at ADIO or UCR, and they conduct 30–45 minute tours around sea turtles and the egg harvesting project. Direct tourism in Ostional is limited to arribadas, mostly during the dry season (November–March). MINAE/SINAC runs an international volunteer programme that contributes substantial funds towards management of the Refuge (J. Pablo, pers. comm.). Volunteers spend 14 days at the field station, assisting with beach cleaning and collecting data. They are hosted by 17 designated families within the community, thus contributing to the community economy. ADIO also uses domestic volunteers to patrol and clean the beach (ADIO, pers. comm.).

## Discussion

The Ostional community has been managing the sea turtle egg harvest with technical support (Pritchard, 1984; Cornelius, 1985), and this community-based conservation project is an example of successfully integrated conservation and development. We found no significant difference between the incomes or perceptions of associates and non-members of the egg harvesting project, awareness of sea turtle ecology, legislation and conservation is widespread, and the project's outcomes are viewed favourably regardless of respondent involvement (Table 5), indicating not only equitable distribution of benefits but also shared responsibilities. The importance of devolved management rights and equity has been emphasized in the literature on natural resource governance (Ostrom, 2010; Twinamatsiko et al., 2014; Büscher et al., 2016; Oldekop et al., 2016), and our case study in Ostional corroborates this.

We propose that the stakeholders develop research and monitoring capacity, which will augment food security, curb poaching, and generate alternative livelihoods, in turn addressing challenges of vulnerability and natural, social and financial capital. Similarly, developing responsible, value-added tourism will build capacity and infrastructure in addition to creating jobs and controlled clientele for eggs, ultimately contributing to financial, physical and human capital and linkages and policy (×Fig. 6).

One of the main criticisms of the egg harvesting project is that it facilitates a nationwide market for eggs illegally extracted outside Ostional (Table 4). The project's distribution system aims to supply the entire country, but it targets commercial hubs, overlooking rural communities where a strong demand for eggs exists (R. Arauz, pers. comm.). These rural communities then illegally collect eggs from solitary nesting beaches for their own use and trade. Thus, although the egg harvesting project fulfils all criteria of the theory of change framework for community response to illegal wildlife trade (Biggs et al. 2017), the supply chain has loopholes that allow illegal wildlife trade to thrive. This reinforces the suggestion that poverty alleviation and law enforcement are not necessarily sufficient to curb illegal wildlife trade, which operates in complex networks on multiple scales (Duffy et al., 2015). Illegal sale of eggs purporting to be from the egg harvesting project is currently being investigated using genetics and tracking devices (H. Pheasey, pers. comm.). Addressing demand (Mason et al., 2012; Challender & MacMillan, 2014) and understanding the motives of perpetrators are also crucial for controlling illegal wildlife trade (von Essen et al., 2014; Harrison et al., 2015).

Interviewees and survey respondents expressed concerns over the lack of interest in the egg harvesting project among Ostional's youth. Madrigal-Ballesteros et al. (2013) also found that younger respondents were less likely to comply with the community code of conduct (ADIO, 2017) and activities of the project. This highlights the need to engage more local youths in community-based conservation in Ostional. Beach patrolling and law enforcement, research, monitoring, and tourism management are potential avenues to recruit youths, and to teach skills that could be used beyond the project (Fig. 6). Although the UCR, MINAE/SINAC, and ADIO are all involved in research and monitoring of the beach and the sea turtle population, differences in their approaches hinder research collaboration. The previous lack of data has led to questioning of the project's sustainability and credibility (Valverde, 1999; R. Arauz, pers. comm.). Currently, only five individuals from the community are involved in facilitating research and monitoring, with visiting researchers and volunteers occasionally contributing (J. Quiros-Rosales, pers. comm.). Claims that the egg harvest benefits turtle nests by cleaning and oxygenating the sand have been validated (Bézy et al., 2015). However, there is a need to estimate sustainable harvest rates (R. Valverde, pers. comm.). Skill-building in research techniques and improved monitoring could help secure the turtle population and



the food supply for those who depend on turtle eggs (Fig. 6), while also providing an opportunity for the community to host formal training programmes.

Despite tourism and hospitality contributing considerably to Ostional's economy, most of these livelihoods are linked to general beach tourism in neighbouring communities. The community honours a strict protocol (ADIO, 2017) regulating access to the beach during arribadas, but there are no gates, guards or checkpoints to ensure compliance. This facilitates violations of the protocol by tourists, and is a concern in light of plans for ecotourism development at Ostional (ADIO, pers. comm.; J. Rosales, pers. comm.). Although locally adopted codes demonstrate moral commitment to sustainability (Walker & Hawkins, 2013), these need to tie into wider regulatory frameworks and best practices to maintain compliance to promote visitor compliance. Costa Rica is a reputable tourist destination with certification for sustainable and biodiversity-linked ecotourism (Honey, 2008; UNEP, 2013), and, with careful consideration for the local context, this could be implemented at Ostional. Existing tourism could be improved by training guides to communicate values of conservation and sustainability to tourists (Walker & Weiler, 2016). We propose that increase in tourist volumes and pressure can be met by a diversified portfolio of natural and cultural recreational activities such as hiking trails and food tasting. Investing in tourism (Fig. 6) would generate employment, improve existing facilities and road connectivity (Table 2), and enhance capacity and involvement of youths.

Although consumption of wildlife has low acceptability in industrial societies (Schally, 2011), examples such as the egg harvesting project demonstrate that controlled and legalized use of wildlife resources can incentivize and fulfil conservation priorities. Socioeconomic benefits from resource use have yielded positive conservation outcomes globally (Oldekop et al., 2016). Respondents in this study considered sea turtles and the arribada phenomenon a unique aspect of their community identity and heritage. Their unwillingness to accept a fortress conservation scenario resonates with global evidence on the merits of inclusive conservation (Twinamatsiko et al., 2014; Büscher et al., 2016; Biggs et al., 2017). As economic and dietary dependence on the egg harvesting project dwindles, this intrinsic value of the turtles for the community will be a key for perpetuating this community-based conservation project, either through consumption or other activities.

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### **Author contributions**

MS: executed the study; DM: provided guidance on design and presentation.

### **Ethical standards**

This study adhered to the code of ethics endorsed by the Economic and Social Research Council and the American Anthropological Association.

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### **Biographical sketches**

MALLIKA SARDESHPANDE is interested in use-based conservation and economic incentivization. DOUGLAS MACMILLAN focuses on the economic dimensions of environmental change, biodiversity conservation, and livelihoods, with expertise in ecosystem valuation, decision-analysis and large carnivore conflict.

TABLE 1 Distribution of livelihood activities at Ostional (Fig. 1) across the 63 surveyed households.

Livelihood activities	% *(n)
Egg Harvesting Project	30% (19)
Services (personal, e.g. carer, & technical, e.g. electrician)	24% (15)
Secondary production (artisan, construction, manufacturing)	22% (14)
Hospitality (homestays, housekeeping, restaurants)	19% (12)
Primary production (Agriculture, animal husbandry, fishing)	13% (8)
Tourism (guides, publicity)	11% (7)
Government (police, teaching, conservation)	11% (7)
Pensioners	10% (6)
Trade (household items and estate)	8% (5)

\*Percentages do not add up to 100 as households engaged in more than one livelihood activity.

TABLE 2 Frequently cited advantages and disadvantages of, and changes in, Ostional (Fig. 1) across the 63 surveyed households. Words in brackets are examples of each category; figures in brackets denote percentage of respondents citing these.

Rank*	Advantages	Disadvantages	Changes
1 (%)	Tranquillity (65)	Poor accessibility & infrastructure (56)	Improved infrastructure (37)
2 (%)	Community (birthplace, friendly) (52)	Lack of community coordination (30)	Increased population (25)
3 (%)	Environment (beauty, purity, refuge) (51)	Lack of government support (19)	Improved standard of living (22)
4 (%)	Sea turtles & ocean (arribada, beach, conservation, fishing) (33 each)	Limited development & opportunities (14)	More & diverse employment opportunities (21)
5 (%)	Activities & work (egg harvesting project, employment, hospitality, tourism) (33)	Other (drugs, mosquitos) (14)	Better education (19)

\*Percentages do not add up to 100 as respondents gave 0–3 answers in no order of priority.



TABLE 3 Activities of the egg harvesting project and members engaged. Members are a percentage of 243 individuals recorded in 63 households; this row could be deleted for clarity. Percentages are calculated from a total member sample size of 78 individuals in 37 households.

Project associates*	Individuals	Households
% members (n)	32 (78)	59 (37)
% egg harvest (n)	68 (53)	44 (28)
% beach-keeping (n)	7 (5)	8 (5)
% tourist guide (n)	10 (8)	11 (7)
% administration (n)	6 (5)	6 (4)
% senior members (n)	9 (7)	6 (4)

\*Percentages do not add up to 100 as members engaged in more than one activity in the egg harvesting project.

TABLE 4 Frequently cited advantages and disadvantages of the egg harvesting project (N = 52 respondents). Words in brackets are examples of each category; figures in brackets denote percentage of respondents citing these.

Rank*	Advantages	Disadvantages
1 (%)	Employment & income (56)	Contraband & poaching (29%)
2 (%)	Conservation (wildlife, turtles) (44)	Poor egg harvesting project administration (disputes, discrimination) (27%)
3 (%)	Improved quality of life (development, education) (29)	Inadequate government support (services, staff) (15)
4 (%)	Community benefits (integration, elderly care) (27)	Low hatchling success (depredation, contamination) (15)
5 (%)	Beach management (afforestation, cleaning, vigilance) (25)	Bad collection practices (inconsistent harvesting, overdependence) (15)

& \* Percentages do not add up to 100 as respondents gave 0 to 3 answers in no order of priority.

TABLE 5 Comparisons with previous studies.

[Sardeshpande & MacMillan (2017) is not listed in the reference list (or should it be ‘This study’?)] Certain questions were consistent with/similar to those used in previous studies by Campbell and colleagues. The results from answers to these questions were compared using  $\chi^2$  tests to determine changes in community/sample composition and perceptions over time. Please replace with ‘This study’

Characteristics*	Campbell (1998)	Campbell et al. (2007)	Sardeshpande & MacMillan (2017)	$\chi^2$	P
Sample size (% of population)	N=76 (91)	N=60 (51)	N=63 (42)		
% male	34	47	49	3.7142	0.1561
% female	66	53	51		
Average age (yrs)	38	40	43	0.3141	0.8547
Average residency in Ostional (years)	24	27	31	0.9024	0.6369
% egg harvesting project associate households	92	90	59	29.436	<0.001
% Non-member households	8	10	41		
Average associates per household	2.2		2		
Primary livelihood activities (%)					
Egg harvesting project	70	63	30	46.555	<0.001
Construction	3	25	21		
Tourism & hospitality	7	19	30		
Agriculture & animal husbandry	22		13		
Number of livelihood activities per household (%)					
1	7		67	88.045	<0.001
2	32		22		
3	62		10		
Community perceptions (‘Agree’ %)					
Sea turtles are an important source of income	61	35	86	21.44	<0.001
Egg harvesting project has benefitted the community	63	63	97	81.529	<0.001
Egg harvesting project has benefitted the sea turtles	72	81	87	1.425	0.4904
Sea turtle protection activities identified by respondents					
% hatchlings	79	83	52	7.972	0.0186
% guarding	24	45	29	7.3673	0.0251
% beach cleaning	18	82	22	63.213	<0.001
% protection from predators	17	22	18	0.7368	0.6918
% egg extraction	0	22	14	20.667	<0.001

\*Percentages are calculated based on sample size (N) of respective study.

FIG. 1 Ostional, Costa Rica, showing the location of the main nesting beach and the community.

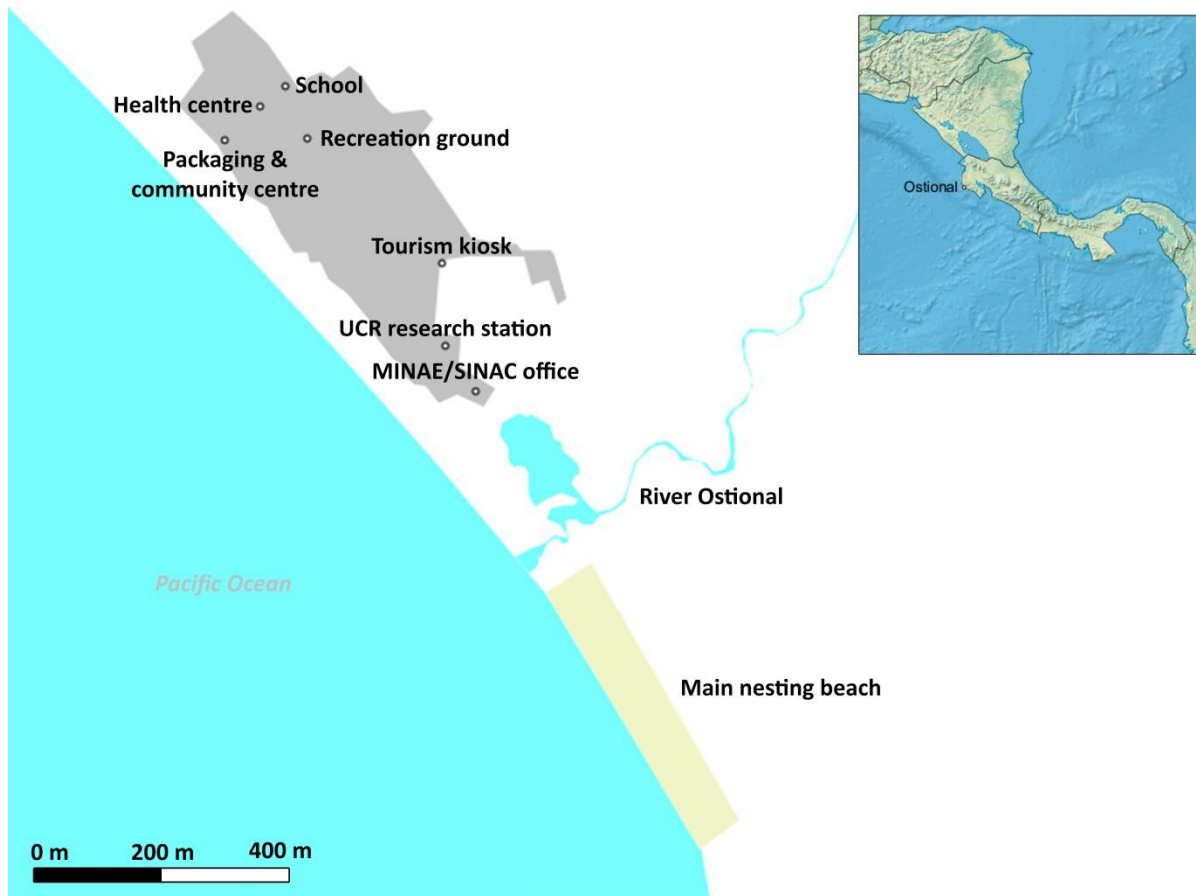


FIG. 2 Perceptions of 63 respondents in Ostional towards the egg harvesting project and related matters, measured using the Likert scale.

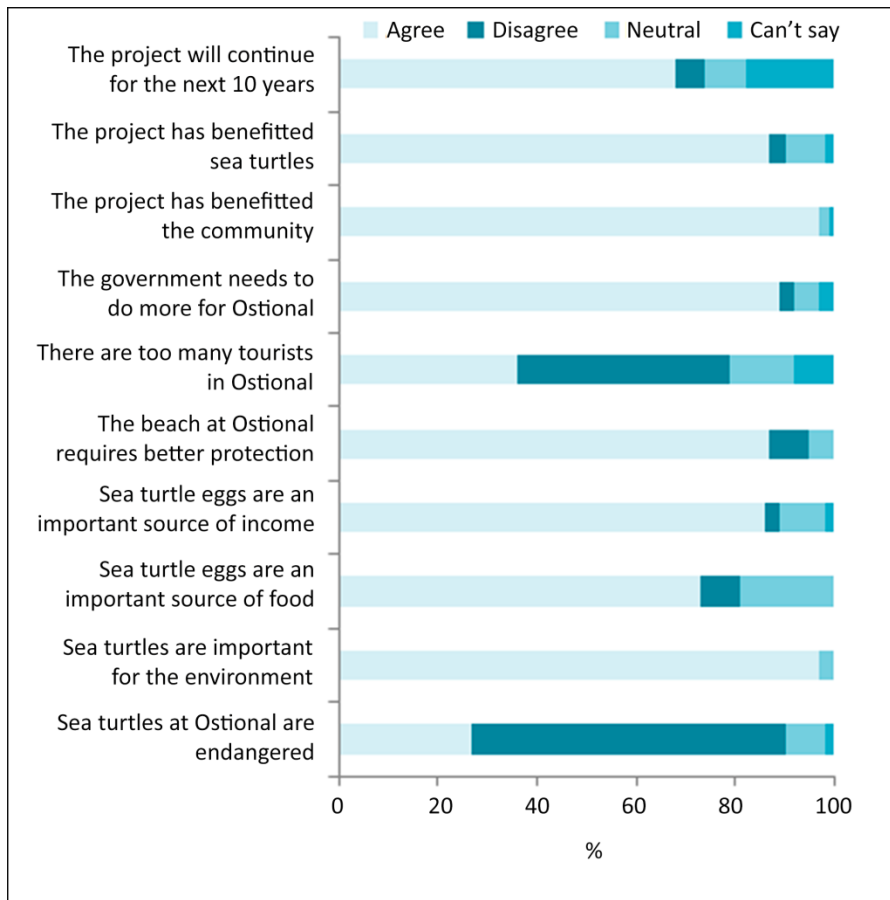


FIG. 3 Reasons cited by 63 respondents for protection of sea turtles. Percentages do not sum to 100 as some respondents cited more than one reason.

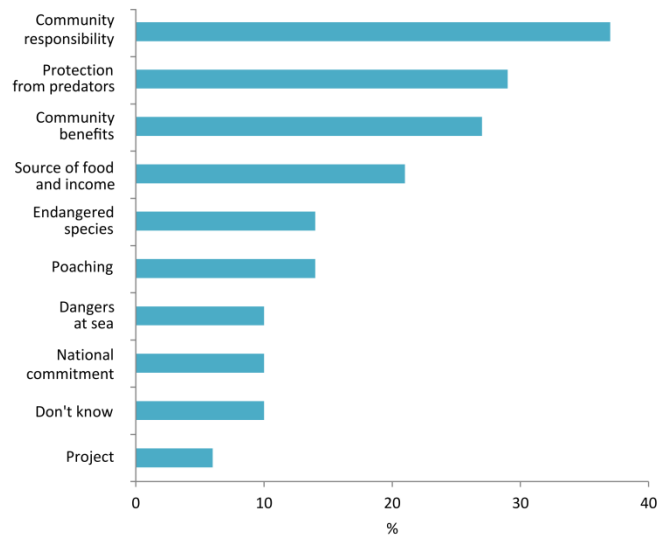


FIG. 4 Uses of sea turtle eggs reported by 63 respondents. Percentages do not sum to 100 as some respondents said they did not know about some uses.

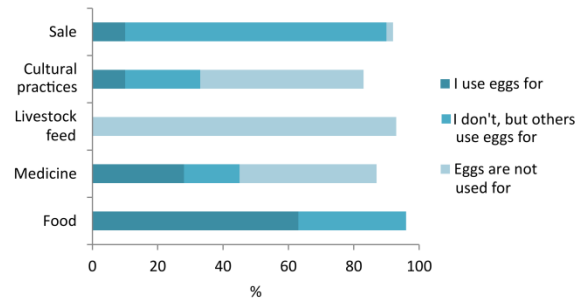


FIG. 5 Perceived potential impacts, from 63 respondents, of a hypothetical ban on the use of sea turtles and the beach at Ostional.

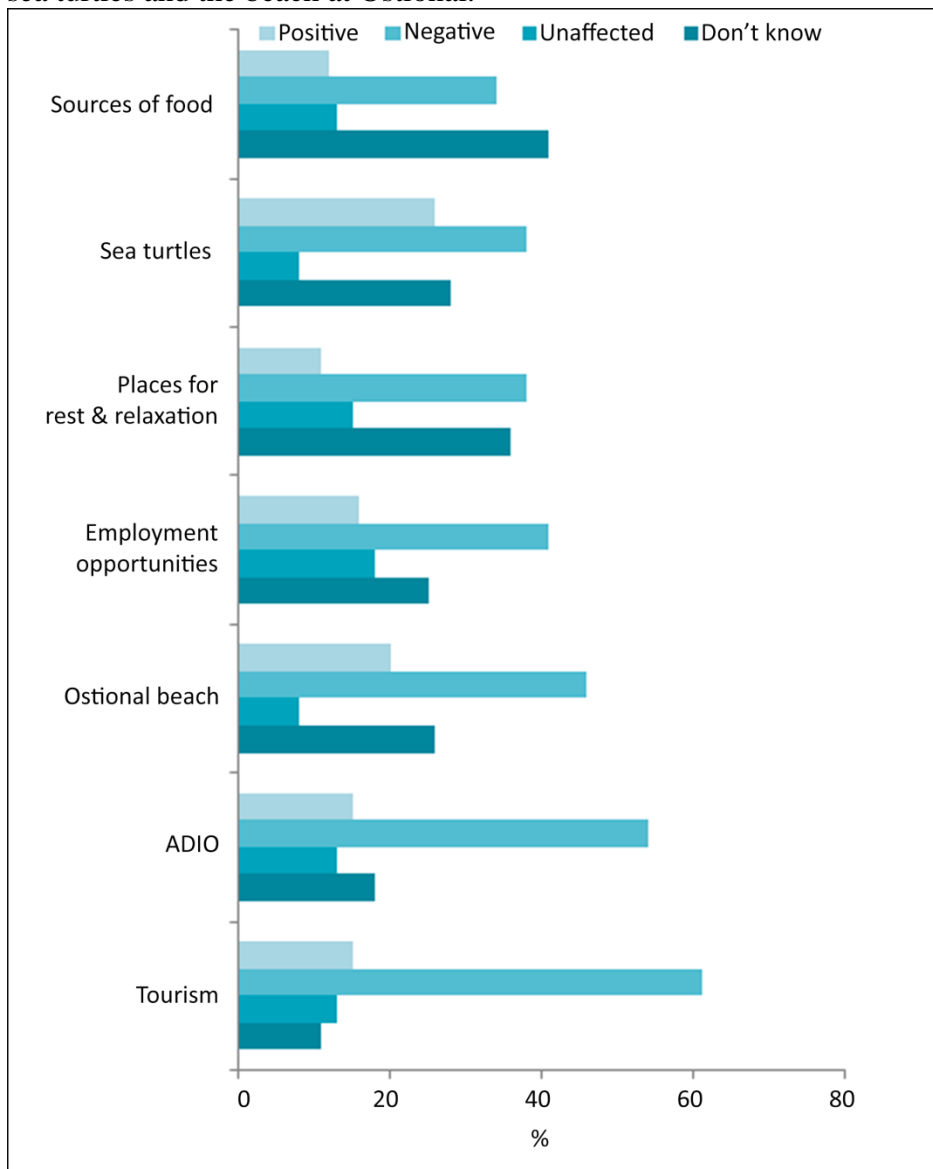




FIG. 6 Outcomes of the egg harvesting project mapped on the Sustainable Livelihoods Framework (DFID, 1999).

Sustainable livelihood criterion	Project outcomes			Recommendations	
	Achievements		Challenges	Scope for improvement	Suggested investment
<b>Vulnerability context</b>	Reduced livelihood seasonality	Economic stability	Harvest rate uncertainty	Food & turtle security	<b>Research &amp; monitoring:</b> better patrolling, estimating sustainable production rates, hosting biologist training programmes
<b>Natural capital</b>	Stable turtle population	Clean well-maintained environment			
<b>Social capital</b>	Increased community solidarity		Intra-community problems	Reduced poaching	
<b>Financial capital</b>	Diversified livelihood avenues	Non-use income from turtles		Alternative livelihoods	
<b>Physical capital</b>	Improved infrastructure		Poor connectivity	Infrastructure & facilities	<b>Tourism:</b> Integrating turtle tours with wildlife reserve & natural attractions, introducing recreation & cultural activities, marketing culinary egg preparations
<b>Human capital</b>	Improved education	Improved but insufficient health services			
<b>Institutional linkages</b>	Collaborations for research, trade, tourism	Multi-stakeholder management of reserve		Capacity building	
<b>Policies &amp; processes</b>	Legalised harvest & trade	Cultural identity	Illegal egg trade	Alternative livelihoods	