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REPORT

Experiences from harvest-driven conservation: Management of Amazonian river turtles as a common-pool resource

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Abstract Understanding what causes variability in the outcomes of common-pool resources management and governance has important policy implications for biodiversity conservation, in particular for the conservation of wild plants and animals subject to harvest. We report an exploratory study focusing on Amazonian river turtles as a common-pool resource under harvest-driven conservation and management efforts in Peru. Based on document analysis, literature review and a series of interviews, we describe the management program as a social process and identify the most important governance and management outcomes achieved (increased turtle abundance and benefits for harvesters, harvester formalization), factors hindering and facilitating the program implementation (four natural and three societal factors), and key governance actions behind the program outcomes (awareness and capacity building, crafting and enforcing rules). We then highlight the existing knowledge gaps and the needs and possible means to address particular risks related to turtle management on a harvest-driven setting.

Keywords Co-governance · Co-management · Egg relocation · Pacaya Samiria · Peru · *Podocnemis unifilis*

INTRODUCTION

The harvest of wild living organisms takes place all over the globe, targeting a very diverse set of species in all sorts of natural and societal settings. Many harvested wild species are typical common-pool resources (CPR) and become subject to overexploitation (Salo et al. 2014, p. 305). Over the last few decades, considerable progress has been made in research aiming to understand the causes of variability in the outcomes of CPR management and governance (Ostrom 1990; Agrawal 2014). Most research on CPRs has, however, focused on a quite limited set of resources. The book *Governing the Commons* (Ostrom 1990) largely set the foundations for CPR theory, building on empirical case studies of pastures, forestry, irrigation, and fisheries.

Two decades later, the focus of CPR research remained on exactly these same resource types. Among the 91 studies included in a review article by Cox et al. (2010), only five focused on some other type of resource than these. Except for fisheries, the harvest of wild living organisms has received relatively little attention by CPR researchers. Focusing more CPR research on cases of harvested wild plants and animals could have important policy implications for biodiversity conservation while enhancing the benefits from these resources. This would also contribute to the development of CPR theory in general.

Agrawal (2002), in a synthesis of the current state of knowledge about CPR governance and management, listed 35 "critical enabling conditions for sustainability of the commons", but also noted a crucial weakness of such lists, namely that they give the impression that a certain variable always has the same effect, whereas, in reality, the direction and magnitude of the effect of one variable may depend on the state of another/other variable(s).

The terms *management* and *governance* are often used in the CPR literature without presenting a clear distinction between them. This is unfortunate, because optimizing the outcomes from a particular resource stock often requires

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separate strategies for two inherently distinct challenges. One challenge is to maintain, or improve, the status of the resource stock by either refraining from harvest (partly or entirely) or by actively manipulating the resource (e.g. planting/stocking, removing competitors, or providing food/nutrients). This is what Salo et al. (2014, p. 281) called *management,* and it should be noted that this, in principle, can be carried out by one single human being, in the case of a single owner and no externalities. When more than one resource user is involved, or when there are externalities, however, also another challenge is involved, namely to make humans behave in certain desired way(s). This desired behavior may involve, e.g., carrying out specific management actions or arranging harvest-related decision-making, costs and benefits in specific ways. The art of making people behave in these specific ways is what constitutes *governance* (Salo et al. 2014, p. 296). This distinction is important because successful governance alone is never a sufficient, albeit often a necessary, condition for management success. For example, if there are misunderstandings or insufficient knowledge about the functioning of the resource system, management failures may result even if institutions for collective action are successfully crafted and the intended management practices implemented (Moxnes 2004).

In the present paper, we focus on the harvest-driven conservation and management of the yellow spotted river turtle (*Podocnemis unifilis*), known as *taricaya* in Peruvian Amazonia, listed as vulnerable by the International Union for Conservation of Nature (IUCN 2017). Adult river turtles as well as their eggs have been important for the nutrition, culture, and economy of Amazonian peoples since ancient times, but unfortunately stocks declined sharply in the 19th and 20th centuries due to human actions (Bates 1863, p. 437; Smith 1979; Alho 1985; Thorbjarnarson et al. 2000; Townsend et al. 2004; Caputo et al. 2005). Lately, however, various measures have been taken in response to this decline, such as protecting adult turtles and nests from harvest, relocating turtles or their eggs, as well as controlling the trade and transport of turtle products (Soini 1998; Fachín-Terán and von Mülhen 2003; Townsend et al. 2004; Caputo et al. 2005; Mogollones et al. 2010; Miorando et al. 2013). In some cases, such measures aim at strict protection, whereas in other cases, the purpose is sustainable harvest, based on the use of turtle products as a factor motivating local people to participate in conservation efforts.

The large number of turtles and people involved in the Peruvian management program imply that its impacts are potentially high, yet the program remains understudied and deficiently documented. For example, in 2014 there were 41 management groups in the Pacaya Samiria National Reserve alone that collected 967 877 eggs from 27 833 nests, and released 487 080 hatchlings (Torres Vásquez 2015, p. 54). The absence of pre-intervention field inventory data unfortunately makes it impossible to unequivocally compare turtle populations prior to and after the initiation of the management action in Peru. This problem is common for many cases of river turtle conservation with only few reports presenting systematic monitoring of management outcomes (e.g. Townsend et al. 2004; Miorando et al. 2013). In our case, the management outcomes have been studied only occasionally (Álvarez 1998) and systematic monitoring is unfortunately not in place or is only based on data on turtles handled in the management program (Torres Vásquez 2015, p. 106). However, anecdotal evidence indicating an important population recovery is overwhelming enough to merit investigations into the social processes leading to such purported success, and analyzing them in relation to existing CPR theory.

The present study is an exploratory work whose main motivation is to document and critically discuss the Peruvian taricaya management program, and relate it to existing CPR theory. On this basis, we identify (1) the most important specific governance and management outcomes achieved, (2) factors hindering and facilitating the program implementation, and (3) key governance actions behind the program outcomes. We then highlight the existing knowledge gaps and the needs and possible means to address particular risks related to turtle management on a harvest-driven basis.

MATERIALS AND METHODS

Study area

The Pacaya Samiria National Reserve (Fig. 1) in Peruvian Amazonia was created in 1968, and the reserve today covers 20 800 km^2 (Dourojeanni 2009, p. 483) of humid tropical rainforest with an average temperature of 26.2 °C and annual precipitation of about 2000–3000 mm (Bayley et al. 1992). There are 92 villages with a total of about 24 000 persons living inside the reserve, mostly near its perimeter—leaving the central areas practically uninhabited. There are 116 villages with 68 000 inhabitants in the 10–20 km wide buffer zone (SERNANP 2011b). Agriculture, hunting, and fishing along with timber and nontimber forest product harvest are the most important components of the local economy. Trade with nearby towns and the cities of Iquitos, Pucallpa, and Yurimaguas depends on river transport. Reserve land is state owned, with use rights granted to the local population for subsistence and commercial resource harvest (this latter requiring an approved management plan; Gockel and Gray 2009, 2011). The reserve is administered by the government through the

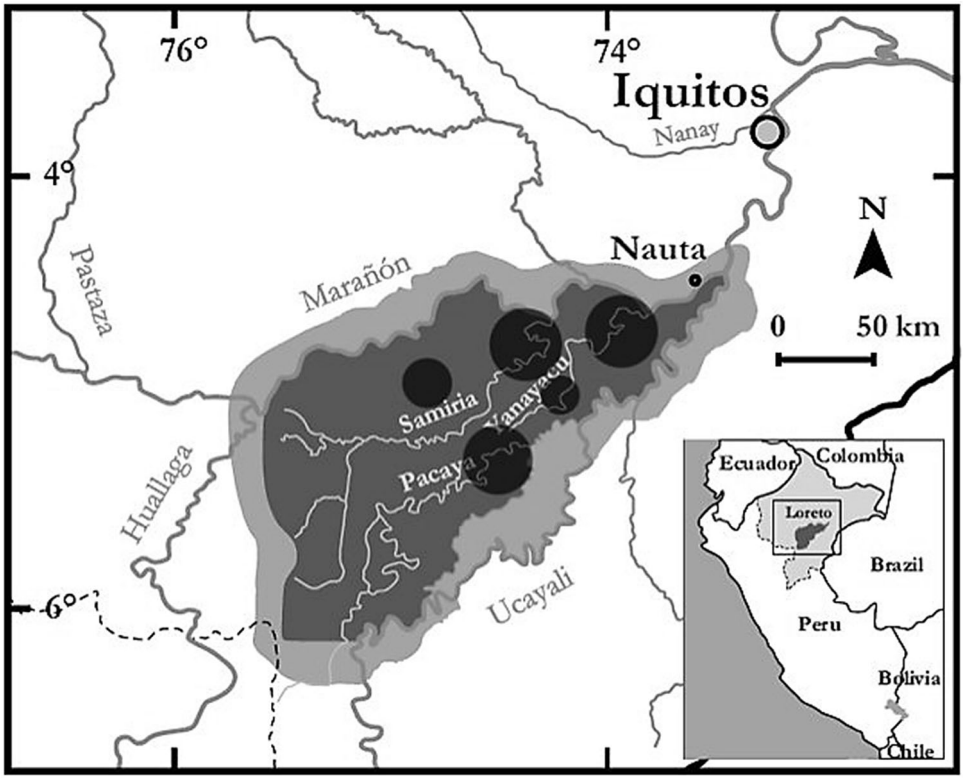

Fig. 1 Map of the study area. The area shaded darker gray is the Pacaya Samiria National Reserve. It is surrounded by a buffer zone, shaded lighter gray. The areas where the management work was done during the fieldwork are shown in the map as dark circles

National Protected Areas Service (Servicio Nacional de Áreas Naturales Protegidas por el Estado, SERNANP).

Although, on paper, the harvest of turtle eggs and capture of adult turtles were banned in the area in 1902, no serious enforcement efforts were made for many decades (Bergman 1990, cited by Vásquez and Tovar 2009). Turtle hunting and egg collection were therefore widespread and unrestricted when the reserve was established. In the 1980s, reports estimate that 70% of all the turtle eggs laid along the rivers Pacaya and Samiria were collected and by the early 1990s, less than 10% of the nests of taricayas in the whole reserve stayed unaffected (Soini 1980, 1986, 1992). From the mid-1980s, however, small-scale experiments of egg relocation were implemented, eggs being collected and reburied on elevated sand platforms, protected from humans, natural predators, and flooding. Hatchlings were then released back into their natural environment (Soini 1986).

In 1991, a pilot project for egg relocation and hatchling release was initiated in three riverine communities in the buffer zone (Soini 1996). Based on these experiences, in 1994, the reserve administration and a Peruvian non-governmental conservation organization (NGO), Pro Naturaleza, along with other organizations, started a program involving local turtle management groups. Although in 2005 there were still only seven groups, their number then started to increase and by 2010, there were 32 groups from 13 communities, with about 350 members in total (SERNANP 2010a, b, c, 2011a, b). Additionally, a number of unofficial groups participated in the management activities in agreement with the reserve administration. Most of the groups have been formed by an initiative of the reserve administration or Pro Naturaleza, although there are also cases where the initiative has come from local inhabitants. The reserve administration determines the location and extent of the management area for each group.

The management work involves construction of "artificial beaches" with protective fencing (Fig. 2), surveillance of natural nesting beaches during nesting season, collection of eggs from natural nests and transportation, and rebury of eggs to the artificial beaches. The reserve guards are responsible for controlling illegal resource extraction in the reserve but the management groups also actively take part in the surveillance, particularly during the nesting season. During incubation (60–90 days), the artificial beaches are weeded and protected against theft and predation (Soini 1998). Between 60 and 89% of the relocated eggs hatch (SERNANP 2010a, b, c, 2011b). Hatchlings are released to their natural environment, preferably in the same location where the eggs were collected.

Fig. 2 Artificial beaches, such as this one in Santa Elena on the Pacaya watershed area, are used by the management groups to protect and incubate the nests collected. Photo: Juana Galeano, Reserva Nacional Pacaya Samiria—SERNANP

The labor of the management group members has always been unpaid. Initially, the reserve staff and Pro Naturaleza provided training, gasoline, and staple foods during the management activities but as of today material support has basically ceased. The direct benefit for the management group members is that they are allowed to use part of the collected eggs and reared hatchlings for own consumption and sale (Fig. 3). The eggs are mostly sold as a delicacy for consumers in nearby cities and the hatchlings to export companies with main market in Asia.

The reserve administration consults Pro Naturaleza and the management groups and sets a target number of eggs that should be collected by each management group. This *minimum* number of eggs to be collected is used in the management system to determine another minimum number, namely that of eggs to be relocated. Internally, each such minimum number is called a *cuota*. This terminology is potentially confusing, as the standard meaning of the term "quota" in natural resource management contexts is not a minimum, but instead a *maximum* limit on extraction. Therefore we here use the term "target" for these minimum limits.

The reserve administration also sets a limit on the number of hatchlings that may be sold. This limit is expressed as a percentage from the total number of eggs collected. The rest of the hatchlings must be released. The percentages of the different uses of eggs and hatchlings depend on how long each group has participated in the management, increasing the benefits over time. Although there are various ecological and bio-economic models available in the literature (e.g. Milner-Gulland and Akçakaya 2001; Salo et al. 2014, Ch. 13–15), no such model is explicitly used for setting the targets for egg collection and the quota for use and sale of eggs and hatchlings. Each management group is in charge of recording the number of eggs and hatchlings in each step of their management procedure on a data form. This is facilitated and surveilled by the reserve administration (SERNANP 2011a).

Fig. 3 These taricaya eggs have been identified as unviable for incubation by the management group members in the Cocha Yarina, Pacaya watershed. They are preserved with salt and sold for human consumption. Photo: María Isabel Torres Vásquez, Pro Naturaleza

Data collection

We develop our case based on interviews with locals and professionals involved in the management activities, and a review of grey literature related to the management program. The first author spent a total of 7 weeks in the study area between March and July 2011, collecting reports, manuals, management plans and administrative documents, and conducting 43 semi-structured interviews.

The interviewees were chosen to represent the variety of actors directly involved in the management program. We wanted to qualitatively explore the perceptions of the local managers and therefore choose to interview the local members of 16 management groups from two different management areas (see Fig. 1). The professionals interviewed included all the persons we could find with direct involvement in the program (i.e. SERNANP and Pro Naturaleza employees as well as researchers from the Iquitos-based Peruvian Amazon Research Institute [IIAP]). Out of 48 interviewees, 37 were management group members and 11 were professionals. Among the former group, 10 were leaders of their respective groups. Only two interviewees were females, reflecting existing male-dominance in the management groups as well as among the professionals. The age of interviewees ranged from approximately 20 to 70 years old, and was fairly evenly distributed over this age span.

Most interviews were conducted individually, but three of them were held with groups of two to three interviewees. Initially, 12 of the interviews with management group members were conducted in the presence of reserve staff, but as this may affect the responses of the interviewees, the rest of the interviews were conducted in the absence of staff members. The interviews were conducted using a list of questions and topics to be dealt with as guidance (Interviews Scheme S1 is available as supplementary material). The interviews addressed six broad themes: importance of the resource; local participation; impacts of

management; restrictions, rules, and trust; taricaya migration habits; and the future. The semi-structured and open-ended character of the interviews implied that interviewees were encouraged to talk freely about whatever they felt was important.

Interviews were conducted in Spanish, the mother tongue of all the interviewees. Notes were taken and the interviews were recorded. The interview responses were subjected to a qualitative content analysis, in which they were coded and extracts relocated to spreadsheets for analysis. We do not present full quantitative analysis of the interview data because of the exploratory nature of the study but, in the results section, we present the main outcomes that the interviewees saw as resulting from the governance and management actions taken. Then, we similarly present the most important natural and societal factors that, according to the interviewees, either had hindered or facilitated the governance and management actions. Finally, we present the actions that the interviewees pointed out as the most important for the outcomes to be achieved.

RESULTS

Governance and management outcomes

The most important outcomes of the turtle management program are that turtle stocks have increased, that the benefits acquired through turtle harvest have increased, and that illegal harvesters have become legally recognized managers.

Outcome 1: Increased resource stock

There is no time series of reliable, independent, and comprehensive turtle population surveys, but all available information indicates that the scarce turtle populations reported in the past have increased considerably (e.g. Torres Vásquez 2015). The interviewees on site and among the professionals invariably noted that the amount of eggs available for extraction and number of observations of adult turtles have increased. Similar local perceptions have been previously noted by Gockel and Gray (2009, 2011). Furthermore, the Peruvian scientific authority for the CITES confirms that the current extraction does not threaten the species (MINAM 2014).

> "At the beaches where 20 taricayas used to lay their eggs, now 100 lay eggs. This is why it is said that it [the number of taricayas] has increased."—Male, ~40 years, management group member.

Outcome 2: Increased benefits

Interviewees from groups who had managed taricayas for several years generally indicated that they now harvested more taricaya eggs than before, partly due to more investment (time and participants) in management work and partly due to the fact that more eggs were available. Interviewees from groups that had started management recently stated that they had observed how other groups increased their harvest, and expected to be able to do the same in near future. In addition, hatchling trade and the help from Pro Naturaleza in negotiating better prices further added to the increased benefits from turtle products.

The percentage targets for hatchling release have decreased over time, and instead an increased percentage of eggs and hatchlings have been destined for sale. The data recorded indicates that, in absolute terms, there has been an increase both in the number of released hatchlings (Fig. 4) and the hatchlings and eggs sold or consumed, the latter having increased from less than 7000 in 1994 to more than 330 000 in 2009 (SERNANP 2010a, b, c, 2011b). Although the number of hatchlings and eggs sold or consumed *per group* has increased from less than 7000 in 1994 to more than 10 000 in 2009, the total volume of consumption and trade has grown particularly due to the increase in the number of people involved in the management and also because of an increase in the spatial extent of management areas. The contribution of the guards involved in management work and the unofficial groups is not included in these figures but has been estimated to be around one-fourth of the total number of released hatchlings, (SERNANP 2011a).

Although the local resource users do not hold full property rights in relation to the turtles, they do possess specific rights that secure them the (exclusive) use of the resource, at least in the presence of external help in the forms like surveillance and enforcement by the reserve staff. Material assistance was modest from the beginning, and the most important external aid has been and still is immaterial help: training, assistance with legal requirements (including permissions to fish inside the reserve while working in management activities), and helping to establish commercial ties.

> "[…] benefits such as income and food in order to survive. Every year we gain more benefits. That is what we are after and that is why we do a good job."—Male, ~50 years, management group leader.

Outcome 3: Illegals become managers

Harvest of adult taricayas as well as eggs was illegal, but in practice unrestricted, before management activities began.

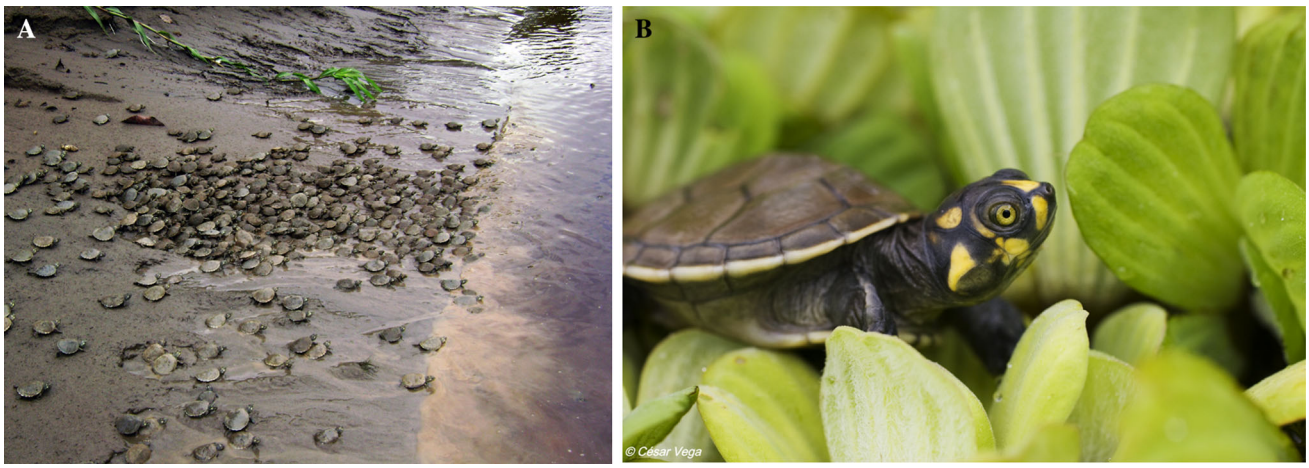

Fig. 4 **a** Reared hatchlings being released to their natural environment in the Pacaya watershed area. Photo: Juana Galeano, Reserva Nacional Pacaya Samiria—SERNANP. **b** Taricaya hatchling on pistia (*Pistia stratiotes*) leaves in the Pacaya-Samiria National Reserve. Photo: César Vega, Pro Naturaleza

Many management group members are today such "ex-illegals" and although some people refuse to participate in the management groups and continue with illegal extraction, this has become relatively uncommon.

> "Now there are very few illegals because most [of the ex-illegals] are in the groups. They have noticed that being illegal is not good."—Male, ~60 years, management group member.

Negative outcomes

Interviewees did not mention any negative outcomes of the governance and management actions, and some explicitly rejected that any would exist. There were, however, some indications that there may have been also negative or at least disappointing experiences. There has been quite a high turnover rate of the members of the management groups, as many have quit and other new ones have entered. Reasons for the high turnover remain unknown to us.

Factors hindering and facilitating the program implementation

We identified four natural and three societal factors that were particularly important as either hindering or facilitating the implementation of the program (Table 1). Each one of these items is treated with further detail below. It is noteworthy that as time passes a specific factor could be seen either as a hindrance or as a facilitator depending on the development of the situation.

Natural factor 1: Spatiotemporal aggregation during critical life phase

The main reason why the taricayas are so susceptible to overharvest is their habit of nesting in large numbers in limited and predictable areas (the beaches) during relatively short periods of time (most of the eggs are laid within a period of about 1 month). This allows humans to harvest, with little effort, most of the reproductive females

Table 1 Pre-existing natural and societal factors that either constituted hindrances, facilitated successful management or both, depending on the moment of time

	Hindering	Facilitating
Natural factors		
N1. Spatiotemporal aggregation during critical life phase	X	X
N2. Easily observable resource	X	X
N3. High natural resource abundance		X
N4. Biological potential for rapid resource growth		X
Societal factors		
S1. Lack of awareness among local resource users	X	
S2. Lack of enforcement of existing legal restrictions	X	
S3. High value of products (eggs and hatchlings)	X	X

as well as their offspring. This aggregation, however, also opened a feasible management option, as it facilitated surveillance of harvest. In addition, the aggregation also implied that eggs could be collected and relocated with relatively little effort, facilitating surveillance even further and, in addition, reducing egg mortality from natural causes.

> "The illegals will rob the eggs if they are not relocated in the artificial beaches."—Male, ~30 years, management group leader.

Natural factor 2: Easily observable resource

The conspicuous habits of the taricayas when nesting make them easy targets for egg collection and hunting, and therefore highly susceptible to overharvest. This initially enabled excessive exploitation but later the same habits instead facilitated management activities. Adult turtles can be readily observed when sunbathing (Fig. 5), and also the number of nests is a good indicator of abundance. Thus, it was easy for local people to observe the increased abundance of turtles.

> "[Taricayas] can be seen in the river banks and lagoons sunbathing. There are all the different sizes."—Male ~60 years, management group member.

Natural factor 3: High natural resource abundance

One reason behind the perceived management success was that among the locals there was a historical reminiscence of a very high abundance of taricayas in the past. This historical memory could entail that the local people perceive it possible to have a greater resource stock.

> "Now taricayas have almost recovered. There is almost the same number [of taricayas] as before, when there were a lot.—Male, ~60 years, management group member.

Fig. 5 Adult taricayas are easy to observe while sunbathing. This, and their habit of concentrating in large numbers lay eggs on riverside beaches exposed by descending rivers makes them easy prey for hunters and harvesters—but also facilitates management. Photo: César Vega, Pro Naturaleza

Natural factor 4: Biological potential for rapid resource growth

Many interviewees mentioned that what motivated them to engage in turtle management was that they had heard, or observed themselves, that in areas where management activities had taken place, the abundance of taricayas had increased substantially in just a few years. This was possible because of the large number of eggs laid annually given the species a potential for relatively rapid population growth.

> […] people organized and started to collect and rebury the eggs […] After three to four years the taricayas already appeared.—Male, ~50 years, management group member.

Societal factor 1: Lack of awareness among local resource users

Several interviewees representing the management groups stated that local resource users had been ignorant of the idea that a resource could run out due to overharvest. This is somewhat contrary to the statements about the past abundance of taricayas mentioned above, and such statements could possibly be influenced by the discourses of reserve staff and NGOs working in the area. This said, the unawareness about the potential to increase the resource stock through effective management techniques is nevertheless too strong a point made by the informants to be disregarded. This lack of awareness was tackled by Pro Naturaleza and the other organizations by training the management groups. Their experiences were then disseminated to people in other communities by the word of mouth and direct observation revealing the impacts of the management actions.

> "Before we just used everything as much as possible but now we know we should wait."—Female, ~40 years, management group member.

Societal factor 2: Lack of enforcement of existing legal restrictions

Although harvest of taricaya eggs was prohibited, this ban was not enforced, such that local people as well as reserve guards who in past openly engaged in unrestricted exploitation and trade with taricayas and their eggs rarely received any punishment.

> "[…] before entered 50 canoes [of illegals], now there are few that go unnoticed […] most are in the [management] groups."—Male, ~50 years, management group member.

Societal factor 3: High value of products

The high value of taricaya products both in household consumption and as a market commodity has obviously been a major reason for overharvest and the demise of the resource base. Nevertheless, the high value was also a necessary condition for people to engage in the management activities. Therefore, this challenging feature of the resource turned out to be a facilitating condition when the legal use and selling of eggs and hatchlings were made possible, and even more, when prices increased further.

> "[We manage taricayas] because it is a resource that has a good market, very important, greater income than with other resources."—Male, ~30 years, management group member.

Key governance actions reported by the informants

The interviewees presented a high level of agreement on which actions had been important in order to achieve the outcomes mentioned above. All of these actions are of the governance type, i.e., how people are persuaded or otherwise made to behave in a certain way favorable to turtle management.

Action 1: Building awareness and capacity

The most crucial actions undertaken, according to the informants, were the awareness-building events provided by Pro Naturaleza together with the reserve guards. This raised awareness of the negative impacts of uncoordinated resource harvest, and, even more importantly, about the potential benefits of resource management. Similarly, crucial was the training in the management practices, in particular the training on egg relocation and incubation in artificial beaches. All this was particularly important in the initial phase of the management activities by the locals, as later the process became almost self-sustaining: once the management actions of the first local management groups led to perceived results, others soon joined suit. As local people gained experience on egg relocation, they could teach others and depended less on external training. Finally, also capacity building and support related to the commercialization of taricaya hatchlings, which sell at a price 15–20 times that of the eggs, has led to increased economic gains. This creates even stronger motivation for people to participate. It is notable that the local resource users themselves had very little participation in the development of the management techniques primarily developed by external experts.

> "We were told that we would do it [management of taricayas] for ourselves and we could still eat

taricayas and earn money. This made us feel more positive about the management."—Male, ~20 years, management group leader.

Action 2: Crafting and enforcing rules

The previous legal restrictions, draconian on paper but ineffective in real life, were replaced by rules that sought to increase the long-term benefits for the local users. These new rules were also enforced on the ground. More specifically, the authorities (SERNANP) established targets for collected eggs and quota for sold hatchlings based on experts' recommendation, but also consulting the local management groups. Surveillance efforts by the reserve guards increased and were also carried out by the local resource users/managers themselves, with moral and logistic support from SERNANP and Pro Naturaleza.

"Now there are more groups and more reserve guards, thus the reserve is more protected."—Male, ~50 years, management group leader.
"We help the state with our work; we are allied with the guards."—Male, ~30 years, management group member.

DISCUSSION

The most important management outcomes of the program, as perceived by the locals, were the increase of the turtle populations and economic benefits as well as the shift of people from illegal extractors to legal turtle managers. One should bear in mind that our sample of interviewees in this exploratory study was non-random and included only persons that themselves have an interest in turtle management and its future. A longer field study, using a random sample of interviewees and including also people not participating in the program could surely provide a deeper understanding of the situation. In spite of its exploratory character, our study, however, provides some important insights.

The data collected by management groups (e.g. SERNANP 2010a, b, c, 2011a, b) often contains internal inconsistencies, usually of minor importance, but sometimes substantial. There would be much to gain from improved reporting accuracy and the initiation of systematic population surveys using consistent methods yielding data to be comparable over the years (cf. Torres Vásquez 2015, p. 113). Similarly, current procedures of setting targets based on expert judgement could be improved by incorporating also the use of explicit ecological models of resource growth and harvest.

Turtle management programs based on nest transfer have recently been criticized because hatchling sex is determined by incubation temperature. Therefore rearing in artificial beaches could potentially cause a skewed sex ratio, resulting in male-dominated populations sooner or later doomed to collapse. Such programs have therefore been dismissed as "feel-good conservation" causing good public relations but making more harm than good to turtle conservation (Páez et al. 2015). We disagree with such criticism. The management program we studied has been developed based on many experimental studies carried out by professional biologists. Although the only study on the sex ratio of the population based on reproduction in artificial nests that we are aware of revealed a male bias of 1.45:1 (Álvarez 1998), the sex of adult taricayas can be determined in the field at the age of three years and with increasing accuracy as the age increases (Arsenio Calle Córdova, pers. comm.). Thus, if the management program would have been producing only males during almost 30 years, this would have been readily observable in the field long ago—which has not been the case (Arsenio Calle Córdova, pers. comm.).

We do agree, however, that, in accordance with the precautionary principle (Cooney 2004), it is recommendable to increase efforts to monitor and control incubation temperatures and the resulting sex ratio of hatchlings. These are technical issues that, after all, are quite straightforward to solve (although blood sampling may be costly). Furthermore, whereas we can agree with the designation by Páez et al. (2015) of nest transfer as "feel-good conservation", to us this is not a pejorative term. On the contrary, we believe that conservation success in many cases requires that local people feel good about what they are doing. If handling turtle eggs and hatchlings causes a switch in the minds of people, making them think and act as stewards rather than predators, nothing is wrong about that. Páez et al. (2015) also point out that the most important conservation measure is the protection of adult females. We agree, and it should be noted that the management program described in this article does involve the protection of female adults, a spin-off of that local people got involved in handling eggs and hatchlings—and "felt good" about it.

Our results confirm what was suggested by Agrawal (2002), namely that the direction and magnitude of the effects of one variable on CPR management and governance may vary depending on the state of other variables. We identified three pre-conditions that, in different periods of time, turned from hindrances to facilitating conditions. One such condition was the high value of the taricaya products, initially a major cause of uncoordinated and excessive harvest. However, the high value of the legally harvested goods became a major motivation for local

people to engage in the management activities and adhere to the restrictions set by the authorities. Other such conditions were the spatiotemporal aggregation of taricayas during a critical life phase (nesting on beaches) and the ease of observing the resource (nesting traces and sunbathing adults) initially enabling overexploitation but later, instead, facilitating management, surveillance of harvest, and observation of changes in the resource stock.

To some extent, our results contradict common wisdom about the societal factors influencing the likelihood of successful CPR governance. Whereas strong dependence on the resource is commonly seen as a factor favoring successful CPR governance (Agrawal 2002), the local resource users in our case were not very dependent on the resource before the management action was initiated. On the contrary, the resource stock was so exhausted that harvest levels were low. Moreover, although nowadays the management group members obtain a much larger income from taricaya products than before, they still did not consider themselves very dependent on the resource.

Besides the currently low dependency on turtle products, the level of user demand and the level of articulation with external markets were relatively high, also contrasting with what is suggested to be typical in successful CPR governance and management situations (Agrawal 2002). To the contrary, the taricaya egg is a foodstuff highly appreciated because of its taste and nutritional value, which combined with the existence of an external market demand, is a main motivation for local people to participate in management activities.

In Amazonia, and many other tropical regions, wild plant and animal resources are commonly subject to poorly regulated or unregulated exploitation, such that abundant resource stocks remain only where transportation costs become prohibitively high due to long distances to settlements or transportation routes (e.g. Peres and Lake 2003). Cases of successful CPR governance and sustainable resource use are relatively rare, but there are some such cases described in the literature. One case worth mentioning is the management of pirarucu (*Arapaima* spp.) fisheries in the Mamirauá reserve in central Amazonia, where a collaborative project between fishing communities and an NGO led previously deprived pirarucu populations to increase, thus leading also to increased catches and incomes among the local fishers (Castello et al. 2009).

Whereas the main focus of that study is on how experts can work together with local communities to improve the sustainability of small-scale fisheries, the narrative provided actually replicates much of the findings from our study. In particular, the pirarucu disperses into flooded forests in the wet season and aggregates in lakes during the dry season. It is an air breathing fish, making it easily observable when surfacing to breathe every 5–15 min. This spatiotemporal aggregation and conspicuous behavior initially facilitated overexploitation, but eventually instead facilitated monitoring of the resource stock. On this basis, a quota system was established, restricting fishing to such levels that not only depletion of pirarucu stocks was halted, but also their rapid increase was achieved. The actual management measures differed greatly from our case. In the pirarucu case, management consisted of a harvest quota set on the basis of detailed quantitative field surveys conducted by locals, while in the turtle case the management consists of strict protection of adults in combination with active stock manipulations in order to increase hatching success. In both cases, however, training of local resource users, conducted by external experts, was of crucial importance.

CONCLUSION

The actors involved in the management program reported increased turtle abundance and economic benefits as well as the shift of people from illegal harvest to legal turtle management and harvest. Our case showed that the specific CPR governance and management outcomes were intertwined in complex ways. The high value of the taricaya products, the spatiotemporal aggregation of taricayas during the nesting season and the ease of observing the turtles first hindered the sustainable management of the resource. Later on, however, resulting from awareness-raising, capacity building, and local rule enforcement motivated by increasing benefits, these same factors facilitated CPR management and conservation. We recommend that systematic monitoring of turtle population densities, and of sex ratios, is implemented, and that a combination of carefully documented expert judgment and ecological modeling is incorporated in the target and quota setting processes.

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