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Demonstrating decline of an iconic species under sustained indigenous harvest – The pig-nosed turtle (*Carettochelys insculpta*) in Papua New Guinea

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ABSTRACT

Papua New Guinea has astonishing biological and cultural diversity which, coupled with a strong community reliance on the land and its biota for subsistence, add complexity to monitoring and conservation and in particular, the demonstration of declines in wildlife populations. Many species of concern are long-lived which provides additional challenges for conservation. We provide, for the first time, concrete evidence of a substantive decline in populations of the pig-nosed turtle (*Carettochelys insculpta*); an important source of protein for local communities. Our study combined matched village and market surveys separated by 30 years, trends in nesting female size, and assessment of levels and efficacy of harvest, each of which was an essential ingredient to making a definitive assessment of population trends. Opportunities for an effective response by local communities to these declines needs to consider both conservation and fisheries perspectives because local communities consider the turtle a food resource, whereas the broader global community views it as a high priority for conservation. Our study in the Kikori region is representative of harvest regimes in most rivers within the range of the species in Papua New Guinea, and provides lessons for conservation of many other wildlife species subject to harvest.

1. Introduction

Papua New Guinea (PNG) is one of 17 megadiverse countries that account for 70% of global biodiversity (Mittermeier et al., 1997). The biodiversity of many of these nations is under threat, particularly in tropical countries that allow and encourage aggressive mining, forestry and agricultural practices driven by immediate financial imperatives rather than longer term sustainable economic considerations (Laurance et al., 2001; Sodhi et al., 2004). Papua New Guinea has remarkable species diversity and high levels of endemism. Its biodiversity is of international concern, and attracts considerable conservation funding in support of government initiatives to prevent overexploitation of their biological assets (Connell, 1997).

Charting a path to a sustainable future is complicated by the equally astonishing cultural diversity of the Papuan human population, many of whom still live traditional lives in villages distributed through the New Guinea highlands and coastal plains (Foley, 1986). This cultural diversity coupled with a strong community reliance on the land and its biota for subsistence, presents a number of challenges for monitoring and managing wildlife populations. Wildlife management is complicated by a shift from subsistence to a cash economy, increasing human population size and the introduction of modern fishing and hunting techniques (Bennett and Robinson, 2000). These changes can intensify the pressures placed on natural resources (Dudgeon et al., 2006; Groombridge and Wright 1982; Rosser and Mainka, 2002) and the outcome is often the decline and extinction of wildlife populations.

Exploitation of long-lived species brings additional problems for conservation management (Marsh et al., 2004; Romero et al., 2002). They generally exhibit slow growth and late maturity. Reproduction is usually characterized by low fecundity (e.g. large cetaceans) or variable and infrequent recruitment (e.g. sea turtles) (Musick, 1999). These characteristics make long-lived species particularly vulnerable to excessive adult mortality (Broderick et al., 2006; Frazer, 1992, but see also Fordham et al., 2007, 2009). Furthermore, the impact of exploitation younger life stages and trends toward population collapse may be masked because absence of recruitment can be concealed by the presence of long-lived senescing adults. Declines may progress for many years before it is detected and overcome (Browne and Hecnar, 2007; Musick, 1999).

Long-lived animals are important sources of protein for indigenous communities and have been for many centuries (Milner-Gulland and Bennett, 2003; Smith, 1979). The pig-nosed turtle (*Carettochelys insculpta*), an iconic species from the Kikori region, is no exception (Georges et al., 2008a). It is of conservation

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concern because it is the sole survivor of a once widespread family (Carettochelyidae), because it has a restricted distribution, and because it is subject to intense harvest pressure (Groombridge and Wright, 1982). It is one of many chelonian species of international concern (Rhodin et al., 2011).

Highly prized as food, these turtles are caught and their eggs are collected for consumption by local villagers or trade in local markets (Georges et al., 2008a). Local villagers harvest *C. insculpta* eggs with close to 90% efficiency (Pauza, 2003). Growth in human populations, a greater propensity for villages to establish on riverbanks since tribal warfare ceased, and the introduction of new technologies, particularly outboard motors, have brought added pressure to turtle populations in recent decades. This has led to the widespread view that populations of *C. insculpta* have suffered severe population declines (Georges et al., 2008b; Groombridge and Wright, 1982; Pauza, 2003). There is however, remarkably little direct evidence of these declines, and what there is remains unpublished. The International Union for Conservation of Nature (IUCN) listing of the species as vulnerable (IUCN, 2009) rests largely on a precautionary approach to evaluation of its status. This uncertainty has in turn led to reduced commitment to act to conserve the pig-nosed turtle despite its international profile as a distinctive relic species.

Assessing the impact of small-scale or artisan fisheries in remote locations of developing countries is extremely necessary because of its value to local economies (Humber et al.,, 2010; Low et al., 2009; Salas et al., 2007; Soykan et al., 2008; Townsend et al., 2005). Nevertheless, few studies have the benefit of long term data (Broderick et al., 2006; Spotila et al., 2000). Furthermore, direct evidence of decline is very difficult to obtain. Indirect evidence through market surveys typically span too few years to be of value, and in any case can underestimate the extent of harvest (Milner-Gulland and Bennett, 2003). To eliminate some of these potential biases, it is necessary to combine market surveys with surveys of households and direct surveys of wildlife populations (Milner-Gulland and Bennett, 2003). Thus, obtaining defensible evidence of decline in complex situations involving both human harvest, altering harvest practice and patterns of consumption and environmental change presents a formidable challenge.

In this paper, we meet this challenge with matched surveys of *C. insculpta* consumption via both market and village over almost 30 years in the Kikori delta, which provide the first evidence of population declines of this iconic species. We compared the nesting female size between the two periods to evaluate the effect of selective harvesting of nesting females. We monitored the nesting survivorship in natural sandbanks to access the level of harvest pressure. Finally, we identify opportunities for an effective community level response to these declines with a view to establishing more sustainable harvest practices for this important food species.

2. Material and methods

2.1. Study site

The Kikori drainage extends from the coastal region and delta to the limestone plains of the Kikori lowlands (Löffler, 1977) in the Gulf Province of Papua New Guinea (Fig. 1). The river system is highly confined within its limestone bed, and meanders and oxbows are absent. The delta is a large alluvial plain below 40 m elevation, dissected by a tributary system of river channels, and formed where thick layers of soils, principally soft silts and clays, have been deposited over the underlying limestone plain. The coast comprises the delta islands exposed to the Gulf of Papua. Wind and wave action creates coastal beaches, sand bars and sand islands in what is a very dynamic system (Enesar Consulting, 2005).

Before interaction with Europeans, the lowland upstream sections of the Kikori River were characterized by a few sparsely-distributed small villages whereas the delta region had many villages each with more than 1000 people (David, 2008). Nowadays, there are 51 villages and fishing camps, from three major language groups, distributed over much of the lowland area. The Rumu language group comprises approximately 700 people living in villages mainly in the limestone plains upstream of the main Kikori Township. The Porome language group comprises approximately 600 people residing in villages of the delta region. The Kerewo language group is the largest, comprising approximately 1500 people whose lands are in the deltas and coastal regions of the Omati and Kikori River systems. Each of these groups is subdivided into networks of clans and lineages with their own territorial estates (Busse et al., 1993).

2.2. Methods

A daily survey of pig-nosed turtle eggs passing through the Kikori (7°24′44.45″S; 144°14′51.78″E) and Sirebi markets (7°12′23 .36″S; 144°14′47.80″E) was conducted during the turtle nesting seasons (September to February) in the years 1980–1981, 1981–1982, 2007–2008, 2008–2009. Only the Kikori market operated in the years 1980–1982. A second market was established at the Sirebi Forestry Camp in 2007 and continued to operate until early 2009. We based the comparisons among years on the Kikori market in 1980–1982 versus the combined totals for both markets in 2007–2009. Data recorders comprised volunteers from local villages, who visited Kikori and Sirebi markets every day of operation and recorded the number of pig-nosed turtle eggs for sale and obtained estimates of counts of eggs that had already been sold. We regularly visited the markets to undertake spot surveys as a cross check on the veracity of the accounts from the recorders.

Two riverine villages (Kopi and Waira) and one coastal village (Dopima) were selected for intensive monitoring of egg and turtle numbers consumed in the 2007–2008 and 2008–2009 nesting seasons. These villages were selected because of comparable data collected there in the nesting season of 1981–1982. Data on household consumption was recorded by volunteer village residents. Four volunteers in Kopi, two in Waira and one in Dopima visited all village families every week to access the number of eggs harvested per day. When shells or live turtles were available, we used a flexible measurement tape to measure the curved carapace length (CCL).

Nest survival rate was recorded for the two most remote nesting areas (Turuvio island and Wau creek sandbank) in the 2007–2008 and 2008–2009 nesting seasons. Data on nest fate were collected by local volunteers and validated by direct survey every month. Nest characteristics (clutch size, egg diameter and hatchling weight) were measured in all years. To ensure comparability of data, only data from nesting females, nests, eggs, and hatchlings from nests laid in the riverine sandbanks in December were used for the *t*-test comparisons between years. Price for the pig-nosed turtle meat and eggs was also recorded from villages and markets.

Data on egg diameter and hatchling weight were averaged by clutch to avoid pseudoreplication arising from lack of independence of eggs within clutches. Statistical tests followed those recommended by Sokal and Rohlf (1981) and were performed using SAS 9.1 or by hand. Chi-square tests were performed on counts of clutches as the independent entities satisfying the underlying multinomial assumptions. Where we had only egg counts, not clutch counts, the number of clutches was estimated by dividing the number of eggs by the average clutch size of 21.3, so that these data could be included in the statistical analyses. We used the difference between the total number of eggs consumed (market and villages) in the 1981–1982 nesting season and the average from