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Research Article

Conservation status of manatee (*Trichechus senegalensis* Link 1795) in Lower Sanaga Basin, Cameroon: An ethnobiological assessment.

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Abstract
An ethnobiological survey of 174 local resource users was conducted in the Lower Sanaga Basin to assess the current conservation status of West African manatee (*Trichechus senegalensis*, Link 1795) within lakes, rivers, and coast (including mangroves, estuaries and lagoons). Using a multistage sampling design with semi-structured interviews, the study asked three main questions: (i) are manatees still present in Lower Sanaga Basin? (ii) If present, how are their numbers evolving with time? (iii) What are the main threats facing the manatee? Each of these questions led to the formulation and formal testing of a scientific hypothesis. The study outcome is as follows: (i)60% of respondents sighted manatees at least once a month, regardless of habitat type (rivers, lakes, or coast) and seasons (dry, rainy, or both); (ii) depending on habitat type, 69 to 100% of respondents perceived the trend in manatee numbers as either constant or increasing; the increasing trend was ascribed to low kill incidence (due either to increased awareness or lack of adequate equipment) and to high reproduction rate; and (iii) catches (directed or incidental) and habitat degradation (pollution) ranked in decreasing order as perceived threats to manatees. The catch incidence is threefold larger on lakes than in rivers and more adult manatees are caught than juveniles. Pollution occurs in several places by fishing enterprises, industrial plantations and individuals. The perceived incidence of boat collisions is presently negligible compared to catches and habitat degradation. A twelve-point strategy is set forth for improving manatee conservation in the study area.

Key words: *Trichechus senegalensis*, habitat degradation, illegal killing, incidental catches, traditional ecological knowledge.

Résumé:
Une enquête réalisée auprès de 174 pêcheurs dans le basin inférieur de la Sanaga à l'aide d'un échantillonnage multi degré avec entretiens semi structurés a permis d'évaluer l'état actuel de conservation du lamantin de l'Afrique de l'ouest (*Trichechus senegalensis*, Link 1795) dans les lacs, rivières, et zones côtières (incluant mangroves, estuaires et lagons). L'étude a examiné trois questions principales: (i) le lamantin est-il encore présent dans le basin inférieur de la Sanaga? (ii) Si oui, comment évolue son abondance avec le temps? (iii) Quelles en sont les principales menaces de conservation? Chaque question a fait l'objet d'un test formel d'hypothèse scientifique. Les résultats de l'étude se présentent ainsi : (i) 60% des enquêtés observent le lamantin au moins une fois par mois sans distinction du type de l'habitat (rivières, lacs, ou zones côtières) ni même de saison (sèche, pluvieuse, ou les deux); (ii) suivant le type d'habitat considéré, 69 à 100% des répondants perçoivent une tendance constante ou croissante du nombre des lamantins ; la tendance à la hausse serait liée à une faible incidence du braconnage (suite à une meilleure prise de conscience ou faute d' un matériel inapproprié à la chasse) et à un taux de reproduction élevé ; et (iii) les captures (intentionnelles ou accidentelles) et la dégradation de l'habitat (pollution) sont perçues dans cet ordre d'importance comme les menaces les plus sérieuses. L'incidence de capture est trois fois plus élevée sur les lacs que dans les rivières et concerne davantage les individus adultes que les jeunes. La pollution observée à plusieurs endroits est le fait de compagnies de pêche asiatiques, des plantations industrielles et des personnes isolées. La collision des lamantins avec des embarcations est actuellement une perception négligeable comparée aux captures et la dégradation de l'habitat. Une stratégie en douze points est proposée pour l'amélioration de la conservation du lamantin dans la zone d'étude.

Mots clés: *Trichechus senegalensis,* dégradation de l'habitat, braconnage, captures accidentelles, connaissance écologique traditionnelle.

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Introduction

Manatees are aquatic mammals belonging to the Order Sirenia and Family Trichechidae. They comprise three extant species: the West African manatee (*Trichechus senegalensis*) along the African Atlantic coast from southern Mauritania to central Angola and the interior countries of Niger, Mali and Chad; the Amazonian manatee (*T. inunguis*) in the Amazon basin, and the West Indian manatee (*T. manatus*) of the tropical American seas, coasts, and rivers. The latter species is subdivided into Florida (*T. m. latirostris*) and Antillean (*T. m. manatus*) subspecies [1-2].

The whole Sirenia order, including dugongs (*Dugong dugon* the only representative of the Dugondidae family), is classed as vulnerable in the IUCN Red List [2-4]. Since March 2013, all three manatee species have been up-listed from appendix II to appendix I of the Convention on the International Trade in Endangered Species of Wild Fauna and Flora –CITES. Indeed sirenians face similar threats throughout their range. These threats include excessive kills, whether directed (as with subsistence and commercial hunting) or incidental (through watercraft collision and entanglement in fishing equipment), habitat loss (due to encroachment such as urbanisation, construction of dams, and deforestation but also receding water levels), and habitat degradation (due to chemical and sound pollution) [2-12].

Consequently, manatees are experiencing a decline in their population numbers, with the West African manatee facing a higher though uneven risk of extirpation throughout its distribution area. More specifically, by IUCN assessment there are fewer than 10,000 manatees in West Africa of which 30% or more are highly likely to vanish within ninety years [4]. In developing countries, efforts to conserve sirenians and their habitats are currently hindered by data paucity [4, 8, 10, 13], due to technical and financial constraints of monitoring a cryptic, mildly social species in rather inaccessible habitats.

In the case of the African manatee, the focus of this paper, only a few accounts are available [6, 9, 14-15] in contrast to other manatee species which are vigorously studied (see reviews in [13, 16-17]). In fact the dissertation of the late Akoi Kouadio [9] is as of this writing the only comprehensive work on the West African manatee. This dearth of data makes it difficult to review the conservation status of manatees objectively [4]. The recourse to ethnobiological surveys that combine (semi-) structured interviews [18] with participatory, informal approaches [19-20] can help overcome this obstacle.

Ethnobiology examines the intricacies of knowledge, perception, and cognition of the environment (structure and functions) as entwined culturally with behaviours and practices. This approach can contribute significantly towards biodiversity conservation and sustainable resource management [21-24] through the unveiling of (i) observational knowledge of nature, (ii) practice involved in resource use activities, and (iii) belief about the relation of people to nature [25]. Thus, ecologists are now increasingly using questionnaires or social surveys to collect data (see, e.g., [26]). They may find in a methodological review [27-28] a stepping stone to an in-depth treatment [29] dealing with the challenges of survey design and analysis.

We set out to assess the trend in manatee numbers, occurrence patterns, and conservation threats from the perspective of local resource users. Accordingly, we asked the following three questions concerning the conservation status of manatee in the study area: (i) are manatees still present in Lower Sanaga Basin? (ii) If present, how are their numbers evolving with time? (iii) What are the main threats facing the manatee? Each of these questions led to the formulation and formal testing of a scientific hypothesis. First, because the study area has long been known to hold an important population of manatees [6, 14-15] we expected manatees to be still present there. Second, manatee killings have been reported to occur locally at rather low rates —because of inadequate equipment and little relish for manatee meat rather than fear of law [15], and given the low urbanisation of the area we predicted that the numbers of manatee had remained constant or experienced some increase. Third, consistent with a large body of evidence available on all sirenians (see, e.g., [2, 6, 8-12]) we anticipated that catches, pollution, and habitat encroachment (but not boat strikes) would represent the main threats to manatees in the study area. These conjectures were all borne out with some added context specifics, leading to a number of recommendations for improved assessment approaches and conservation efforts.

Methods

Study area

This study was conducted concurrently with another independent work [30]; both focus on manatee conservation and are somewhat overlapping. Their context is sketched below relatively to human and biophysical milieus, and conservation efforts.

Physical Milieu

The study was in the Lower Basin of River Sanaga in the Littoral Region of Cameroon, West Africa. It took place against the backdrop of the upgrading of Lake Ossa and Douala-Edea Wildlife Reserves (LOWR and DEWR) into national parks, i.e., from category IV to category II in IUCN classification of protected areas. Lake Ossa Wildlife Reserve, LOWR (3° 45’-3° 52’N, 9° 45’-10° 4’ E, ca. 4,000 ha) is bounded by Edea town to the north and industrial plantations to the south. Douala-Edea Wildlife Reserve, DEWR (3° 14’-3°50’ N, 9°34’-10°03’ E, ca. 160,000 ha) is located in the coastal plain, stretching from the Atlantic coast over a distance of 100 km maximum [31] (see Fig. 1). Both reserves are entirely within a sedimentary, low plain (< 60 m) crossed by rivers and swamps. The main hydrologic components are as follows: Lake Tissongo plus Rivers Sanaga, Kwakwa, Wouri, Lofe, Mvia (in DEWR); Lake Ossa, Lake Mboli, plus some smaller, interconnected lakes (in LOWR). The climate is both maritime and equatorial, with 24–29°C monthly average temperature and 3,000–4,000 mm yearly average rainfall.

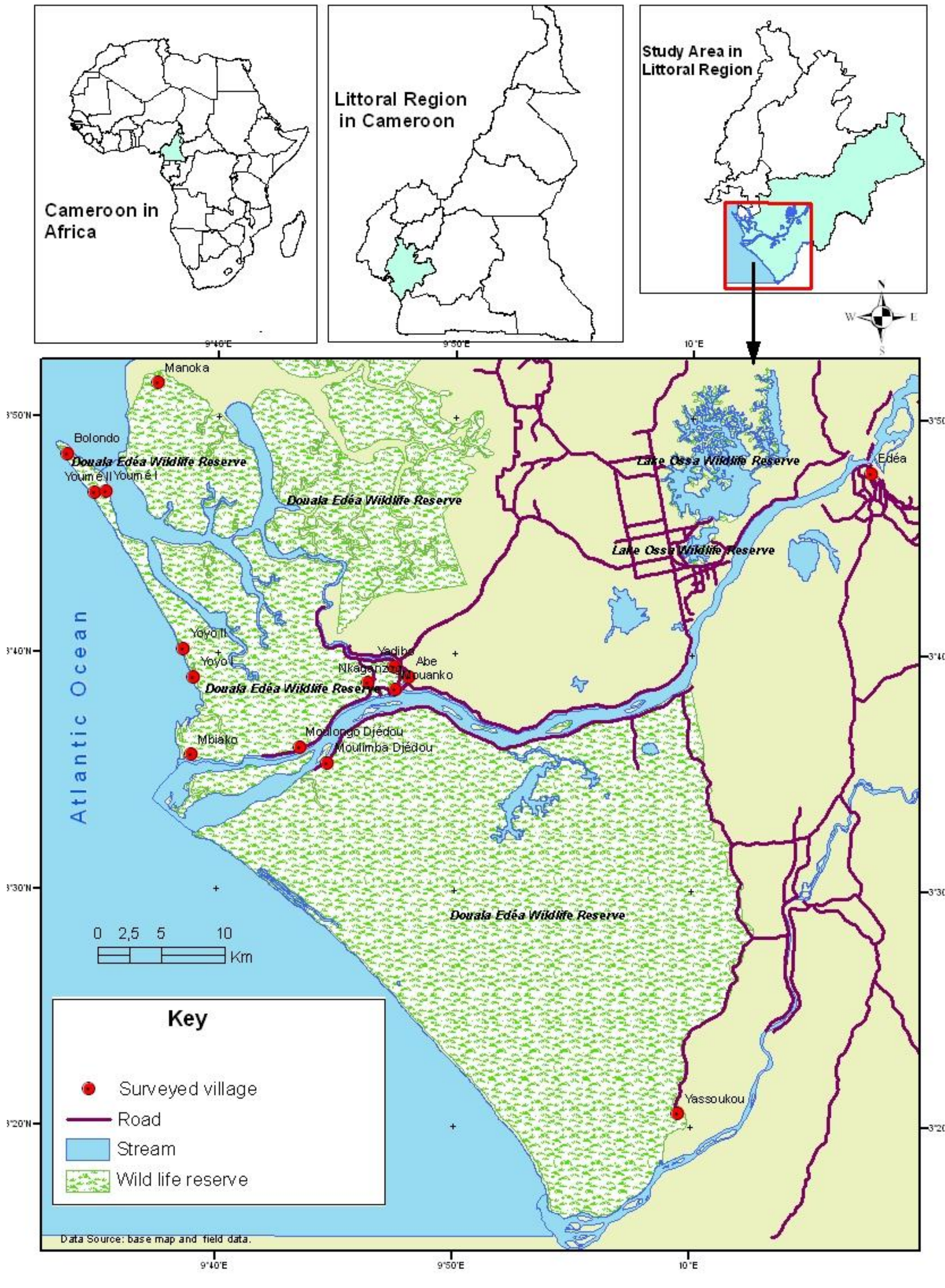

Fig. 1: Map of the study area

Biota

Five main vegetation types occur in the study area [31-32]: (i) mangroves (only in the DEWR) feature *Rhizophora* spp. (true mangroves) and *Avicennia* spp. (grey mangrove); (ii) swamp forests have as dominant species *Raphia* spp (raffia palm), *Mitragyna stipulosa* (African linden), and members of Zingeberaceae family; (iii) lowlands mixed primary rain forests include, amongst others, *Lophira alata* (ironwood), *Saccoglotis gabonensis* (bitterbark tree), and members of Caesalpiniaceae family; (iv) secondary forests are recognizable by *Musanga cecropiodes* (umbrella tree), *Trema orientalis* (charcoal tree), *Lophira alata* (ironwood), *Anthocleistas* spp. (forest fever tree) and *Chromolaena* spp. (Siam weed); finally (v) aquatic and semi-aquatic vegetations of rivers and lakes are composed of many species, of which the following are part of the manatee's diet: *Phragmite* sp. (common reed), *Vossia cuspidate* (hippo grass), *Ludwigia leptocarpa* (Anglestem waterprimrose), *Ceratophyllum demersum* (hornwort), *Calamus* sp. (sweet flag), *Drypteris* sp. (inedible fern root), and *Rhizophora racemosa* (red mangrove) (Takoukam Kamla, unpublished data).

The biotic diversity of land and aquatic vertebrate species is high; a quick review of major taxons is as follows. (i) Mammals include *Trichechus senegalensis* (African manatee), *Loxodonta africana cyclotis* (forest elephants), *Potamochoerus larvatus* (bush pig), several African forest primates – e.g., *Cercopitecus nictitans* (putty-nosed Mangabey), *Colobus satanas* (Colobus monkey), *Cercopitecus pogonias grayi* and *Pan troglodytes* (Chimpanzees) and antelopes, viz., *Tragelaphus euryceros* (forest antelopes), *Tragelaphus spekii* (sitatungas). (ii) Birds: more than 35 bird species grouped into 22 families are found locally, be they resident or migratory, including the protected *Pteronetta hartlaubii* (winged duck) and *Psittacus erithacus* (African grey Parrot) [33]. (iii) Fishes include several species, of which the commonest are *Arius* spp., *Lutjanus endecanthus* (carp) and *Scomberromorus* spp. (iv) Reptile species found locally include: *Crocodylus niloticus* (Nile crocodile), *Ostelamus tetraspis* (pygmy crocodile), *Varanus* sp. (monitor lizards), as well as serpents, fresh water turtles, and land tortoises [31,34].

Human context

About 23,000 people live in the LOWR (2005 estimate). Yakalak and Ndonga tribesmen were first to settle there in the 18th century; several other ethnic groups (Ndonga, Pongo, Malimba, Bassa, Yambassa, Toupouri, Bamileke) are also present. Fishing, sand dredging, and subsistence farming are the main occupations. An extended agro-industrial corporation (rubber and oil palm) is a source of stable employment and cause for environmental concern. The DEWR is populated by more than 8,000 people (2005 estimate), including immigrant fishers from Nigeria, Benin, and Ghana (along the Atlantic coastline), while long established Bakoko and Malimba ethnic groups form large settlements along the boundary rivers (notably Sanaga). These populations engage in the same activities as above, plus oyster fishing, in the Sanaga River.

Conservation Context

Created respectively in 1932 and 1948 by the French colonial administration [31], the DEWR and LOWR are now under the responsibility of the Ministry of Forests and Wildlife (MINFOF). A conservator heads each reserve, assisted with a few guards (precisely thirteen in each reserve). The conservation legal framework includes (i) international agreements to which Cameroon is party (CITES, RAMSAR, CMS, and CBD, amongst others), (ii) Law No. 94/01 of 20 January 1994, (iii)

Decree No. 95/466/PM of 20 July 1995 and (iv) Order No. 0648/MINFOF of 18 December 2006. The main function of the Law is to classify species in three levels of protection: class A (totally protected; e.g., manatee, chimpanzee, and Colobus monkey); class B (protected; e.g., elephant, buffalo *Syncerus caffer*, and kob *Kobus kob*) and class C (partially protected; e.g., patas monkey *Erythrocebus patas*, Grimm's duiker *Cephalophus grimmia*). Decrees are regular updates of this classification (for details see [35]).

At the initial stage of our investigation (2009), two environmental NGO's, WTG (Watershed Task Group) and CWCS (Cameroon Wildlife Conservation Society) were active in LOWR and DEWR, respectively. They promoted sustainable resource use among local populations through (i) awareness raising, (ii) environmental education, (iii) collective action and (iv) training (on farming, fish processing, livestock rearing, and ecotourism) [34]).

Research methods used, including survey design, data collection, hypothesis formulation, and statistical data analysis.

Survey Design

Because a sampling list was lacking for the vast, remote, and scarcely accessible swampy area, we used a multistage survey design [29] in three steps. First, the study area was stratified into three major types of manatee habitats: lakes (including Ossa and Tissongo), rivers (including Kwakwa, Sanaga, and Dipombe), and coast (including mangroves, estuaries and lagoons). Second, a different number of villages were randomly drawn from each habitat type: 10 in lakes, 38 in rivers and 19 in coast. Third, a random sample of resource users was drawn from each of the villages selected within habitat types. The total sample size of 174 was apportioned as follows: 63 in lakes, 49 in rivers and 62 in coast. The surveyed resource users included 84% fishers and bivalve gatherers and 16% fish smokers and farmers, but no attempt was made to identify manatee hunters (see further in discussion).

Data Collection

After due preliminary test, the questionnaires were administered during structured interviews that alternated multiple-choice and open-ended questions. These items were conveniently grouped into the following thematic sections: (i) respondent profile, (ii) knowledge and perception of manatee, (iii) attitude towards conservation, (iv) human use of manatee (and its habitat), and (v) appraisal of conservation action (see Table 1 for an outline). The research team included a junior researcher (HCA) and a field assistant, but not an interpreter since the researcher had a good command of French, English, and Pidgin English. The present paper focuses on the trend in manatee numbers, sighting patterns and threats to manatee. The examination of other aspects has been deferred until another occasion.

Table 1: Synopsis of the survey questionnaire, showing item and answer types arranged by sections (I, respondent profile; II, manatee sighting frequency and context; III, human use of manatee (and its habitat); IV, local perception and attitude concerning manatee and its conservation; and V, efficiency of current conservation action).

Section	Questions	Answers
I	Sex, age, ethnic group, village?	M, F; <20, 20-40, 40-60, >60; various answers
	Main occupation?	Fisher, hunter, trader, farmer, wood cutter, oyster gatherer, fish smoker, other (specify)
II	Ever sighted a manatee? How often?	Yes, no, no answer; Frequently, occasionally
	Time (in months) since last sighting; where?	1, 2-6, 7-12, > 12; various locations
	Sighting context: at what distance?	1-5 m, 5-10 m, 15-20 m;
	Season?	rainy season, dry season, all seasons;
	Time of the day?	morning, afternoon, evening, night, anytime;
	From which platform?	on shore, in canoe, other
	Trend in manatee numbers in last five years; cause?	Increase, decrease, constant, no opinion; various reasons
III	Ever caught or seen someone caught a manatee? Tools used? Monthly frequency?	Yes, no; Fishing nets, pointed spears, other (specify); Once, twice, thrice or more, rare
	Is waste dumped into or near water? Who does the dumping? What kind of waste?	Yes, no, no opinion; various answers
	Any manure/fertilizer used around water?	Various answers
IV	Is manatee conservation important? Why?	Yes, no, no opinion; various reasons;
	Is manatee a cause of disturbance to you and other humans? How?	Yes, no, no opinion; harms people, eats food crop, dirties water, other (specify)
	Any manatee-related culture? Please, describe	Yes, no, no opinion; various answers
	Is manatee a useful species? How?	Yes, no, no opinion; meat, sale, medicine (which part), oil (which part), cleans water, other (specify)
	Should manatee be hunted? Why	Yes, no, no opinion; various reasons
V	Aware of the law against manatee capture? Sanctions against offenders?	Yes, no, don't know; Beaten up, locked up, fined, nothing is done, other (specify)
	Is the law respected? Why not?	Yes, no, don't know; various reasons
	Aware of any conservation bodies? Give benefit/inconvenience related to their presence	Yes, no, don't know; various answers
	Ever participated in sensitization talk, event or campaign? Who organized talk/event?	Yes, no; various answers;
	Was this talk/event of any importance to you? Why?	Yes, no, don't know; various reasons

Research Hypotheses

Based on past scientific evidence in the study area [6, 14-15] and elsewhere [8-12], we set up the following (null) hypotheses relatively to research questions 1-3 posed in the introduction:

- $H_0^{(1)}$: Manatees are still present in Lower Sanaga Basin;
- $H_0^{(2)}$: Manatee numbers are either constant or increasing in Lower Sanaga Basin;
- $H_0^{(3)}$: Catches (whether targeted or incidental), habitat loss, and/or degradation are, in decreasing order of importance, the most serious threats facing manatees in Lower Sanaga Basin.

The empirical evidence for testing the above hypotheses comes from sections two (hypotheses 1 and 2) and four (hypothesis 3) of the questionnaire. Further, each hypothesis can be viewed as composite in the sense that its testing involved the joint consideration of several items in the corresponding questionnaire section, whether under a single statistical test or through several statistical tests.

Statistical Data Analysis

All statistical analyses were run under version 2.2.1 of software R [36], mainly to examine associations between variables through the log-linear modelling of contingency tables. Bearing a similarity with ANOVA, this technique applies to count frequencies with the same requirements as Pearson's chi square test:(i) the observed cell frequencies are all independent and (ii) the expected cell frequencies are sufficiently high (five or more) (see, e.g., [37]).

To gain a better understanding of manatee occurrence patterns, the frequencies of reported sightings were cross-tabulated by Time of day (TOD; morning, afternoon, night, and anytime), Season (dry, rainy, or both), and Habitat (coast, lakes, and rivers). The mosaic plot for this three-way classification reveals a significant seasonal effect in addition to a strong association between TOD and Habitat on sighting frequencies (Fig.2). Therefore TOD x Habitat interaction should appear in any candidate Poisson model envisaged for this three-dimensional table, leaving for consideration only half of the eight models possible (excluding the saturated model). The contending models were assessed relatively to their goodness-of-fit using AIC (Akaike's Information Criteria) and LRT (Likelihood Ratio Test) criteria. In the interim, however, the anticipated model formally read thus (see, [37]): $\log(\mu_{ijk}) = \lambda + \lambda_i^S + \lambda_j^H + \lambda_k^{TOD} + \lambda_{jk}^{H \cdot TOD}$ where μ_{ijk} is the expected sighting frequency in cell (i,j,k); λ is the overall effect; $\lambda_i^S, \lambda_j^H, \lambda_k^{TOD}$ are respectively the marginal effect of season i (i=1,2, 3), habitat j (j=1,2,3) and time of day k (k=1,2,3,4); and $\lambda_{jk}^{H \cdot TOD}$ are two-factor interaction (or association) effects of habitat and time of day.

The precision appended to parameter estimates $\hat{\theta}$ (be they coefficients of log-linear model or percentage of respondents) always refers to the 95% confidence limits; when it does refer to the standard error, it will be clearly stated as such. Thus a two-sided test of the null hypothesis $H_0 : \theta = \theta_0$ can be achieved at 5% probability level by checking whether the 95% confidence interval contains the hypothesised value θ_0 or, alternatively, whether in absolute value the quantity $(\hat{\theta} - \theta_0)/\mathrm{stder}(\hat{\theta})$ (which is a normal deviate under reasonably met conditions) is larger than 1.96. In the case of two-way tables, the Pearson's chi square statistic X^2 would be quoted insofar as all expected frequencies are larger than one and no more than 20% of them are below five [38], or else preference would be given to the large sample chi square statistic G^2.

Two correlated items were: (i) how often manatees were sighted, frequently or occasionally, and (ii) how long ago was the last sighting, on the ordinal time scale: < 1 month, 2-6 months, 7-12 months, and > 12 months, later transformed into discrete values: 1, 4, 9, and 14 months. Asking questions that are causally linked protects against biased responses. The first item, henceforth called Frequency, served as a classificatory factor, along with Habitat and Season. More precisely, we used it to classify respondents into two groups, according to whether they claimed to sight manatees frequently or only occasionally. The second item provided the number of months elapsed since the last manatee sighting. For each factorial combination of habitat, season and frequency, the median number of months was determined and used as a response variable in a three-way, additive ANOVA. The empirical cumulative distribution of time elapsed was plotted for each level of a statistically significant factor. For fixed percentile and factor level, the corresponding number of months is read directly off the plot. This data-based approach was adopted because, under our current knowledge of manatees in Lower Sanaga Basin, it would have been subjective to propose a predefined time period for frequent and occasional manatee sightings.

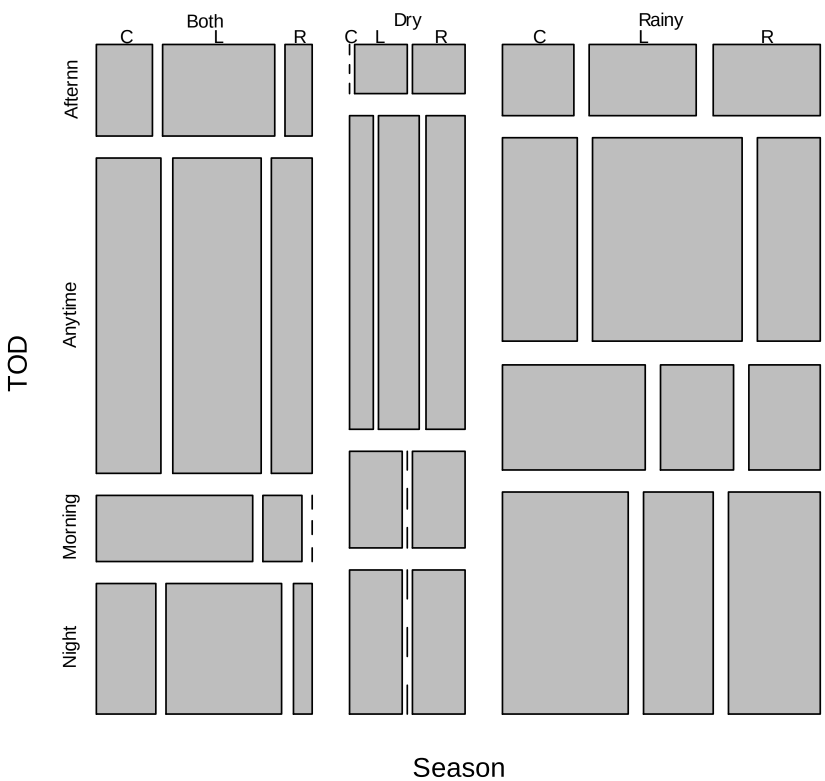

Fig. 2: Mosaic plot of the three-way classification table of sighting frequencies by season, time of day (TOD), and habitat.

Results

Sighting Frequency and Patterns

The proportion of respondents who declared ever sighting a manatee did not differ significantly between habitats (G^2=4.91, 2 df, P=0.0857) nor from 0.99 as a whole (X^2=2.674, 1 df, P = 0.102). Further, the ratio of frequent to occasional sightings varied thus: 15:10 in coast, 21:18 on Lake Ossa, 6: 1 on Lake Tissongo, 17:10 on River Sanaga, 4:3 on River Dipombe, 1:4 on River Kwakwa and 4:5 in other sites. These samples did not differ significantly (G^2=6.781, 6 df, P= 0.342), meaning that the overall ratio is 3:2 or equivalently 60% of respondents at 5% probability level. The same percentage holds for seasons: the recorded ratios were 20:13 for all seasons, 11:5 in dry season and 33: 29 in rainy season, which differed neither between seasons (X^2=1.4227, 2 df, P=0.491) nor from 3:2 as a whole (X^2= 2.306, 1 df, P=0.1288). Thus, three out of five respondents (mostly fishers) declared sighting manatees frequently, regardless of habitat type or seasons.

The ANOVA revealed that only the frequency factor had a significant effect on the median number of months elapsed since the last manatee sighting (P=0.02828). Accordingly, Fig. 3 profiles the cumulative distribution: the median values are one and four months respectively for frequent and occasional sightings. Other deciles can be read directly off that plot: four months would be needed to sight a manatee with a probability of 0.8, under frequent encounters, as opposed to 14 months, when encounters are occasional.

Table 2: Selection of the best Poisson model adjusted to sighting frequencies cross-tabulated by season (S), habitat (H) and time of day (TOD). The selection criteria used are AIC (Akaike's Information Criteria) and LRT (Log-likelihood Ratio Test).

Model	Type of association	AIC	Residual Deviance	d.f.	LRT χ^2(d.f.)
$S + H \cdot TOD$	Block independence	154.0	25.77	22	
$S \cdot H + H \cdot TOD$	Partial independence	154.1	17.87	18	7.90 (4 d.f.) NS
$S \cdot TOD + H \cdot TOD$	Partial independence	159.2	18.98	16	-1.10 (2 d.f.) NS
$S \cdot H + S \cdot TOD + H \cdot TOD$	Uniform association	159.5	11.28	12	7.69 (4 d.f.) NS

The sighting platform associated strongly with habitat type (G^2= 21.655, 2 df, P=0.0). Indeed, sightings on rivers were all from canoe whereas in coast and lakes every fourth sighting was made from the shoreline (P=0.92). Furthermore, most of the sightings occurred at close range, i.e., within 5m (129 cases out of 154).

Table 2 compares the four contending models based on two criteria: AIC (Akaike's Information Criteria) and LRT (Log-likelihood Ratio Test). Though performing equally as well as the anticipated model, Season + Habitat x TOD, the model Season x Habitat + Habitat x TOD was not selected as it involved more parameters. The estimated model and parameters model bear out the visual impression from the mosaic plot. Indeed, the marginal effects (with standard errors) of rainy and dry seasons are respectively larger (0.391± 0.191) and smaller (-0.610 ± 0.249) than zero at 5% probability level, whereas the marginal effect of "both seasons" (0.281± 0.514) is not significant. The increases in manatee sightings are significant at night (1.447± 0.556), borderline in the morning (1.099± 0.577) and not significant in the afternoon (0.281± 0.514). This pattern does not hold with equal strength everywhere, however. Indeed, night sightings tend to be less frequent on lakes (-1.042± 0.719) than on rivers (-0.572± 0.770) and morning sightings on lakes are even fewer (-1.792±0.842). These statistical estimations bear out visual impressions from the mosaic plot.

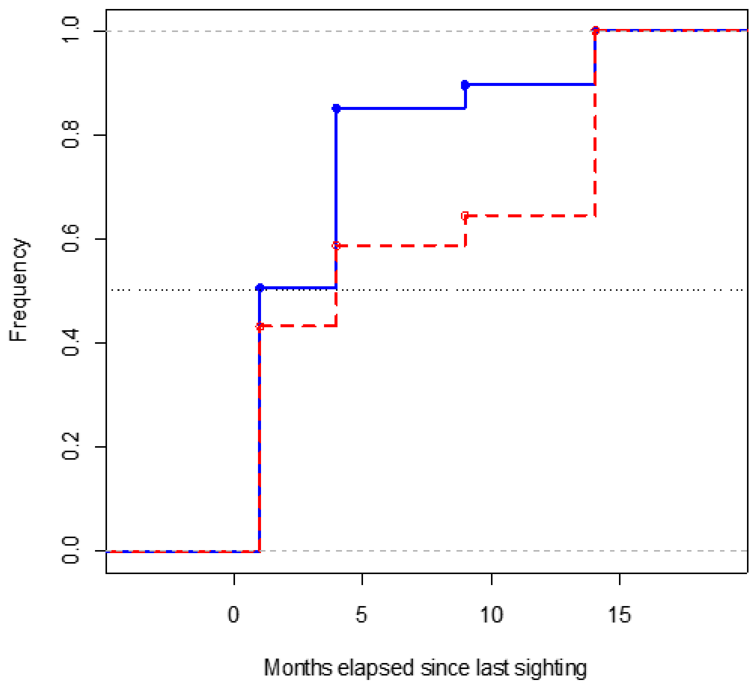

Fig. 3. Quantiles of the distribution of time elapsed (in months) since last manatee sighting, whence the median values (reference horizontal line) are one and four months respectively for frequent sightings (solid line) and occasional sightings (dashed line).

Perceived Trend in Manatee Numbers

Respondents were asked to tell how they perceived the trend in manatee numbers during the past five years. Most of them saw this trend as either increasing or constant throughout the study area: 35 out 51 at the coast, 33 out 45 in lakes within DEWR, all 6 in lakes within LOWR, and all 47 in rivers, notwithstanding the strong significant habitat effect (G^2= 28.350, 3 df, P=0.0). The increasing trend was ascribed to three factors: manatees were no longer killed (81.7±7.9) as a result of increased awareness, or were actually difficult to kill (9.7±6.0), or had a high reproduction rate (8.6±5.7). On the contrary, the decreasing trend was attributed to excessive killing (44.0±19.5), but also to natural factors (36.0±18.8) such as food poisoning (due to a toxic slug), old age, and habitat loss through reduced water level, whereas increased noise level (20.0±15.7) might have played a role in driving away manatees.

Threats to Manatee Conservation

Though habitat loss is an important threat to manatee conservation, it would have been problematic to have respondents discern between its driving factors: deforestation, urbanization, and reduced water level—amongst others. Consequently this study focused on two threats: catches (whether directed or incidental) and habitat degradation (mainly pollution). The percentage of respondents who have ever caught a manatee themselves, or witnessed a third party do so, differed significantly with habitats (G^2= 9.82, 3 df, P=0.020). The significant habitat effect is due to the smaller percentage in rivers (41.7±19.7) compared to coast (78.4±13.3) and lakes (64.4±14.0). Thus the odds of a fisher catching a manatee in the latter two habitats are 3.38 times higher than in the former habitat.

Respondents were further asked to convey the frequency of manatee catches within a one-month period. Here too, the situation in rivers was markedly different from the one prevailing in coast and lakes. Indeed, monthly catches were reported to occur only rarely in rivers (100%). In lakes and coast, however, catches were predominantly rare (51.0±13.7) as against once (21.6±11.3), twice (9.8±8.2) or thrice and more (17.6±10.4) a month.

Manatees were reported to be hunted using either pointed spears (26 cases out of 71), nets (21 cases), and guns (2 cases) or different combinations thereof, the most frequent being nets and pointed spears (13 cases). One instance of toxic chemical use was reported, calling to mind the issue of habitat pollution (to be further elaborated upon below). Finally, 41of 54 cases of reported manatee deaths were reported to be adults only, while the remaining 13 cases involved both adults and calves.

Among the nuisances caused by manatees, 13 respondents out of 174 mentioned boat capsizing. Such incidents are different from boat strikes (or boat hits) *sensu stricto*, however.

Habitat pollution was asserted by 27 respondents out of the 74 who answered. The proportion of reported pollution did not differ significantly either between habitats (G^2= 5.279, 2 df, P= 0.071) or from one third of the sample (X^2= 0.204, 1 df, P>0.60). The respondents indicated polluters as mostly Asian fishing companies (half of the 24 respondents), local industries (4 respondents), and individual fishers (8 respondents). The type of pollutants reported include: by-catch and rotten fish (12 respondents), unspecified toxic chemicals (4 respondents), pesticides (2 respondents), as well as engine oil, metallic and rubber waste (one respondent each). The two reported pesticide pollutions were connected to illegal fishing practice. Finally, a specific questionnaire item concerned fertiliser use for which two positive responses were recorded.

Discussion

Sighting Frequency and Patterns

Manatees were sighted frequently throughout the study area, a finding consistent with that of the concurrent study [30]. Our work quantified the frequency of sightings more precisely. Frequent sightings (by 60% of respondents) occurred with a median time period of one month, compared to four months for occasional sightings (by 40% of respondents), regardless of habitats (lakes, rivers, and coast) and seasons (rainy, dry or both). In other parts of Africa, frequent sightings are considered to occur weekly (Keith Diagne, unpublished data). However, our relatively longer time period estimates may have resulted when recoding the respondents' answers from an ordinal time scale to a discrete time scale that was rather coarse.

African manatees tend to congregate in deep pools in dry seasons [9]. Thus, it can be conjectured that Lake Ossa might serve as a sanctuary for manatees, not only in the dry season [6], but actually year-round, as it is connected to River Sanaga. It was rather unexpected therefore, that the frequency of sightings was not markedly higher in Lake Ossa than in other water bodies. A scrutiny of the sighting context may provide some explanation. First, all sightings in rivers occurred from a canoe, whereas in lakes three fourths of sightings were done from a canoe and one fourth from shorelines. The latter platform allows only a very small fraction of the lake surface area to be observed. Second, manatees feel less secure in shallow water, where their noisy escape is more likely to draw attention, whereas in deepwater they are safe and can stay hidden below the surface [9]. The flight distance of 5 m or less reported by all respondents must therefore be interpreted in the light of this fact.

The fitted log-linear model provided additional insight as well. On one hand, more manatees were sighted in the dry season (perhaps due to the formation of congregations as mentioned earlier) than in the wet season (probably due to an expanded home range through dispersal). Indeed manatees are known to feed in flooded forests [6]. The African manatee feeds mostly at night [9] — though many observances of daytime feeding have been made in Angola, Gabon, and Senegal (Keith Diagne unpublished data) —probably increasing the likelihood of nocturnal sighting. In Lake Ossa, however, more sightings seem to occur in the afternoon, a shift in manatee activity pattern that might have been caused by the fishing pressure on that water body, given that night-time fishing is most common in the area.

The model output would have been much clearer if the recorded percentage of imprecise responses (18% manatee sightings occurring anytime of the day in both seasons) had been lower. It may seem that this vagueness could have been reduced through a restriction of response categories. However, unless it is grounded in well-established facts, such an attempt is tantamount to a leading question with its inherent risk of bias. Other sources of bias include, amongst others, faulty design and analysis, low response rate, cultural differences, misinterpretation by respondents or researchers, distorted translation, memory decay, excessive self-pride, fear of reprisal, and undisclosed community expectations, for which remedies are found in literature [26-29]. Having said this, the fitted model achieved its intended functions: (i) provide a heuristic tool for abstracting the salient attributes of a process, i.e., the pattern of manatee occurrence in relation to habitat types, seasons and time of the day; (ii) help to identify and formulate scientific hypotheses to be tested later.

Perceived Trend in Manatee Numbers

Manatee numbers were perceived to be either increasing or constant (see also [30]). To account for this trend, respondents invoked low mortality due to hunting and high reproduction rate. The latter factor is currently unverifiable, due to a dire lack of data on pregnancy rates and time of births for most sirenian populations worldwide, except for Florida [6, 8]. The killing of manatees, rated as difficult or nonexistent by a majority of respondents, is discussed further below. During the focus group surveys (not reported in this paper), the ever-rising frequency of manatee sighting and number of torn nets were provided as further evidence for the increase in manatee numbers. But this is arguable, since the increasing number of torn nets might well reflect growing fishing pressure or sheer bias from fishers. Nonetheless, the Lower Sanaga Basin has long been known to have a higher manatee concentration [6, 14-15], which our findings seem to corroborate. There are, however, several causes for concern, as we now discuss.

Local Perception of Threats to Manatee Conservation

The study focused on two threats: catches (whether directed or incidental) and habitat degradation (pollution), which ranked in decreasing level of local perception. The catch incidence is threefold larger on lakes, where commercial fishing is concentrated, than in rivers and involves adult manatees more than juveniles. Manatee meat sells openly in nearby cities, mainly Douala and Edéa ([6], Takoukam, pers. comm.), though it is relished only moderately in the study area

[15]. Natives indulge most in the consumption of manatee meat (Che Awah, unpublished data) and, not surprisingly, tend to justify manatee hunting as a customary right. Grigione [15] observed an utterly different situation in Korup, where natives did not appreciate manatee meat and hunting was carried out by Nigerian immigrants. Further, whilst the medicinal use of manatee body parts (oil, skin, and bones) and faecal materials is widespread in West African countries [6], it is almost unknown in the study area. Similarly, in terms of diversity and sophistication, the assortment of hunting tools used locally is modest compared to the variety of technologies available elsewhere in Africa [2, 4, 6]. Rather than fear of law (see also [15]), the above factors might explain why hunting pressure may be much lower in our study area than elsewhere in the distribution range of African manatees. The argument of inappropriate hunting tools set forth by most respondents must be mitigated, however. Indeed, the use of harpoons, nets and guns (mentioned to us) has been effective in hunting manatees in other parts of Africa [2, 6, 9, 26, 39]. To reduce the rate of biased responses, we did not identify manatee hunters, given that manatee killing is illegal. An interview-based survey of marine mammal and sea turtle by-catch in artisanal fisheries elicited voluntary information on direct harvest of manatees, with 290 reported kills in Cameroon alone [26]. Future investigations need to keep up this assessment, as a sound conservation policy must address incidental capture and directed hunting separately, in both its formulation and implementation.

Waste dumping in water bodies is done at several places by individuals and fishing enterprises. Also, industrial and subsistence farms surround these water bodies, often extending right into the shorelines. This situation poses a major risk of pollution from agricultural fertilisers and pesticides. In particular, discarded waste may cause digestive blockage due to the ingestion of foreign objects, whilst a variety of pathogens and contaminants can cause several maladies to manatees [8]. Finally, an increase in the level of ambient noise (due to anthropogenic activities) was linked to the disappearance of manatees from certain areas. Other adaptive responses to (underwater) noise pollution include a shift in the behavioural patterns of manatees such as nocturnal feeding and a change in the proportion of time spent in feeding and milling [12].

Implications for conservation

Recommendations for Improved Assessment and Conservation

Several strategic action plans and notes are widely available to inform manatee conservation efforts in the Lower Sanaga Basin [2, 39-43]. Based upon our findings we suggest twelve key measures that could be implemented in the short to medium term:

- Design a monitoring protocol whereby fishers can contribute data on manatee presence/absence by geographical sector, season, time of day, and boating time;
- Increase law enforcement (i.e., anti-poaching controls, prosecution and deterrent fines) to curb illegal killings and decrease illegal manatee meat trade;
- Regulate fishing effort (number of licensed fishers, fishing periods and gears) to levels that strike a balance between economic needs and conservation constraints;
- Design and implement interactive education programs for school and sensitization campaigns for adults using brochures and pamphlets;
- Identify and focus conservation efforts on key components of manatee habitat systems which include [44-45]: activity centres, dispersal routes, feeding areas, and sanctuaries;

- Encourage fishing companies and adjacent industries to adopt environment-friendly practices as part of market signals for environmental compliance (i.e., eco-labelling, green ratings and certification);
- In accord with the "polluter pays principle", levy taxes from recalcitrant industries to defray the costs of clean-up and decontamination;
- Train local communities and/or strengthen their capacities in the sustainable use of mangrove resources and/or promote alternative revenue-generating activities;
- Regulate or ban ecotourism in sensitive manatee areas, after due assessment of actual and potential negative impacts on the environment;
- Once reliable estimations are available on population numbers and trends, consider allowing a small quota for the ritual harvesting of manatees during cultural revival events such as festivals;
- Train personnel on the rescue and data collection of stranded manatees (live or dead) including life history parameters, body condition, reproduction status, mortality factors;
- Restrict use, types, and/or speed of boats in sensitive manatee areas (see above);

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