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MADAGASCAR CONSERVATION & DEVELOPMENT

INVESTING FOR A SUSTAINABLE NATURAL ENVIRONMENT FOR FUTURE GENERATIONS OF HUMANS, ANIMALS AND PLANTS OF MADAGASCAR

IN THIS ISSUE

TABLE OF CONTENTS

ÉDITORIAL

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Une année internationale des forêts, est-ce bien utile ?

Pas de souci, chers lectrices et chers lecteurs : la période morose que nous vivons sur les plans économique et social appelle des démarches marquées par l'espoir et par la conviction que les générations futures seront suffisamment clairvoyantes pour assurer la conservation de l'un des biens les plus précieux de l'humanité : les forêts. Une année internationale qui leur est consacrée peut y contribuer.

Il faut conserver les forêts. Il faut conserver les forêts pour les biens et les services qu'elles fournissent à l'humanité. Ces mots surgissent tout naturellement sous ma plume : c'est bien pour l'homme qu'elles doivent être protégées.

Loin de moi l'intention de distiller des conseils, d'affirmer par exemple que la sylviculture plus ou moins multifonctionnelle telle que pratiquée assez généralement en Europe devrait servir d'exemple dans les pays qui vivent au jour le jour la déforestation et la dégradation de leurs massifs forestiers. Je préfère tenter de comprendre pourquoi, à Madagascar, les forêts sont actuellement soumises à des pressions aussi considérables. Mais aussi pourquoi et comment, en France par exemple, le taux de boisement est passé de 18 % au début du XX^{e} siècle à 30 % à l'orée du XXI^{e} siècle. Tout comme, en Suisse, la couverture forestière a augmenté de 17 % environ au milieu du XIX^{e} siècle à 31 % aujourd'hui. En Europe, les forêts ont été au cours du temps fortement mises à contribution par l'Homme en raison des défrichements opérés pour gagner des terres cultivables et d'un usage domestique, agricole et pastoral répandu (ramassage systématique de la litière, pâturage en forêt, collecte intensive de bois de feu, notamment). En Suisse, d'importantes inondations et de grands glissements de terrain, dans la première moitié du XIX^{e} siècle, ont marqué les esprits et mis en évidence le rôle protecteur des forêts. L'État fédéral réagit alors en prenant des mesures drastiques pour restaurer et accroître le capital forestier. Les forêts de montagne furent placées sous la haute surveillance de l'État et des moyens dégagés pour promouvoir le reboisement. Il faut cependant noter que sans l'importation de charbon et d'engrais en provenance des pays voisins, qui réduisit rapidement la pression exercée par l'agriculture sur les forêts, un tel renouveau n'eût pas été possible. De cette évolution positive, qui concerne pratiquement tous les pays d'Europe, il est possible de tirer au moins deux enseignements. D'une part que les forestiers, qui ont l'habitude de planifier leurs activités à long terme, savent aussi scruter le passé pour comprendre les raisons d'une situation actuelle dont ils sont les héritiers. D'autre part que l'état des forêts, dans une grande mesure, dépend de l'interaction avec l'homme. Ce dernier constat est d'actualité, tout particulièrement en zone tropicale, où le rythme de destruction des forêts est d'environ 10 millions d'hectares par année – en léger fléchissement par rapport aux précédentes périodes de mesure, selon la FAO.

La forêt est défrichée pour satisfaire la demande de bois de feu et de charbon de bois et pour gagner des terres cultivables et des pâturages. On défriche aussi pour l'agriculture

Défrichement de la forêt dense sèche pour l'agriculture industrielle, région de Morondava (photo Jean-Pierre Sorg)

industrielle, la mise en place d'infrastructures, l'industrialisation et l'urbanisation. Dans les régions tropicales, l'agriculture est en cause dans la grande majorité des cas. En Afrique subsaharienne, en Asie du Sud - Est, dans les régions montagneuses d'Amérique latine, on sait que des « petits paysans » défrichent la forêt naturelle ou les formations secondaires en pratiquant l'agriculture itinérante avec ou sans brûlis. Les substances nutritives contenues dans la végétation sont périodiquement mobilisées au profit de cultures vivrières. C'est largement ce qui se passe à Madagascar. Les paysans malgaches, de l'Est ou de l'Ouest, détruisent-ils la forêt pour leur bon plaisir ? La réponse, bien entendu, est négative. Les défrichements sont nécessaires en raison des faibles rendements agricoles, du coût des engrais, de l'insécurité des droits d'usage, de la faiblesse de la vulgarisation en zone rurale et forestière. Dans la plus grande partie des cas, la forêt est détruite pour satisfaire des besoins élémentaires et pour assurer la survie des populations rurales. Cependant, on défriche aussi parce que les pouvoirs publics encouragent les cultures de rente destinées à l'exportation. Il est facile d'en conclure que l'agriculteur est l'ennemi de la forêt, un constat qui se prête fort opportunément à ouvrir des colloques universitaires ou à formuler des questions d'examens. Est-ce bien exact ? Les forestiers du monde entier sont attachés à leurs forêts, mais ils ne peuvent ignorer les véritables raisons qui expliquent les grands défrichements de ces dernières décennies. Ils savent que la concurrence entre protection des forêts et agriculture est bien réelle et que l'agriculture industrielle constitue un concurrent redoutable, aux raisonnements et aux arguments essentiellement financiers. La compréhension du problème est toutefois différente en ce qui concerne l'agriculture itinérante, dont le moteur est économique et social.

Les remèdes doivent donc être identifiés dans les domaines économique et social. Sans améliorations de la productivité agricole, sans de meilleures garanties des droits d'usage ou de propriété, sans formation, sans participation des petits paysans aux gains escomptés des services de la forêt, sans promotion d'autres sources d'énergie, il ne saurait y avoir de protection efficiente des massifs forestiers. Les préoccupations environnementales, pourtant absolument justifiées, à l'exemple de Madagascar, de même que l'émergence de la foresterie du carbone n'y changeront pas grand-chose si le petit paysan n'y trouve pas son compte. Les formes de gestion contractuelle des forêts vont dans le bon sens, mais leur mise en œuvre généralisée n'est pas simple. Ne faudrait-il pas songer à une communalisation de la propriété forestière, à la généralisation des services forestiers communaux, à la délivrance des permis de coupe et des droits d'usage par les autorités communales ? L'État pourrait alors concentrer ses tâches et ses moyens, assurer la haute surveillance des forêts, la gestion des aires protégées, le développement de la formation et de la vulgarisation. Actuellement à Madagascar, de vastes étendues de forêts sont victimes de l'exploitation abusive qui est faite du bois de rose, expression qui désigne quelques espèces de palissandres. Dans la logique qui prévaut ci-dessus, on peut voir un épiphénomène – porté à son paroxysme – d'une économie de chasse et de cueillette. Les prélèvements effectués en forêt par les villageois riverains pour couvrir leurs besoins quotidiens ne sont pas, en général, véritablement dommageables aux écosystèmes. Ils le deviennent dès lors que des incitations économiques faussent les règles coutumières et encouragent l'illégalité. C'est le cas du bois de rose. Dans une telle situation, il n'y a guère que l'État pour rétablir la légalité.

Oui, une année internationale des forêts est utile. Le nombre et parfois l'ampleur des manifestations qui ont jalonné l'année 2011 dans le monde entier en témoignent. À long terme cependant, particulièrement dans les régions tropicales, la réhabilitation des forêts et le renouveau de la foresterie exigeront de plus grands efforts pour assurer une participation effective des citoyennes et des citoyens à l'aménagement et à la gestion des ressources forestières. C'est un grand défi pour les États, dont les autorités sont invitées à voir au-delà des forêts et à se pencher sérieusement sur la situation de l'agriculture. Ainsi, l'interface Homme-forêt deviendra un véritable partenariat et la forêt restera un bien précieux de l'humanité.

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EDITORIAL

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Conservation through payments for an ecosystem service?

In his Spotlights for the present issue of Madagascar Conservation & Development, Miguel Pedrono argues that captive propagation of tortoises is but one component of a variety of activities that can contribute to species and habitat conservation. This raises the general question on how conservation could possibly be achieved in the absence of strict conservation regulations that are implemented by a powerful government. The simple answer is: it can not as long as the benefits of bushmeat hunting, trade of natural resources or conversion of "original" habitats into "productive land" exceed the benefits of conservation from the same area. This is not just a problem of countries with poor development indices, but a general problem, such as in Germany, where the conservation progress of the last few decades is largely being ruined by the agricultural conversion of fallow land into maize monocultures. If one of the riches countries on earth is unable to withstand the temptations of making more money out of a piece of land than giving it back to nature, how can we expect any person who lives on subsistence activities to leave a piece of land alone if he can get more money out of it by using it? The high flying discussion and argumentation of "ecosystem functions" and "ecosystem services" are being ridiculed by the developments in the industrialized nations.

The problem uniting rich and poor countries alike simply is, that "ecosystem functions and services" of a pristine area are of value primarily on a global level (clean air, global evaporation and precipitation, CO_2 storage), while it is of little value to a farmer who is struggling to survive today. For agricultural land, the reverse is true. Madagascar's land tortoises could be turned into one of the rare examples where it pays more to keep the natural forest intact than turning it into a manioc field, if only the people were allowed to use the land without some of the restrictions imposed upon them by conservation regulations. The radiated tortoise is listed as Critically Endangered and thus can not be traded legally. Yet, illegal trade is substantial. One tortoise sells for about 200 € in Asian and about 4,000 € in the European pet markets (Todd 2011), with an estimated number of about 45,000 animals taken from the wild and traded annually (O'Brien et al. 2003). According to a survey by in 2011 (SuLaMa 2011), about two pirogues with 50 – 80 tortoises each, leave from the coast of a small community west of Tsimanampetsotsa National Park per week. The local revenue from these animals collected for the pet trade is next to nothing.

Scaphiophryne gottlebei (photo: Harald Schütz). The international trade with herps holds substantial economic profits but would be difficult to control. In contrast to amphibians and other reptiles, tortoises could be marked individually and followed through the market chain from the forest of origin to their final destination.

If the trade of these (and possibly other) tortoises would be legalized, these tortoises would offer a unique opportunity to generate income from the natural forest for the local communities. Each community could be allowed to sell a defined number of tortoises that is proportional to the community forest area. The animals could be sold through some controlling organization (such as Madagascar National Parks, NGO or a "Social enterprise", i.e., an organization that applies business strategies within a non-profit framework) directly to the international pet trade at a price that avoids the risks and dumping price of the illegal market chain. The trade of tortoises could be controlled more easily than the trade of smaller reptiles and amphibians which also have a high potential to generate income for the local communities (Raselimanana 2003). In contrast to the smaller species, ivory or rosewood, each tortoise taken from the forest could be marked for life with an implanted transponder, i.e. a microchip with a unique number that can be read with a scanner like the barcode in a supermarket. Transponder numbers can be assigned to be used by specific villages, registered and even displayed on the internet so that the trade is fully transparent for everybody and can be checked even by the final customer. This could provide sustained income for the local communities that maintain their forest. Each tortoise could be sold for a fairly high price as legal marketing would avoid various middlemen. In comparison, one hectare of cleared forest yields between 2 and 20 oxcarts of manioc with a harvest declining rapidly over the years. One oxcart of manioc sells for about 11 €. Thus, a sustained revenue of about 100 € per hectare derived from forest tortoises, could exceed the income from agriculture.

The questions that remain are on how revenue from the tortoises would be distributed within the community and how sabotage from villages without forests could be avoided. This may be a major hurdle, but the tortoise trade could set an example for an "ecosystem service" of the dry spiny forest that pays for the conservation of this ecosystem by itself rather than by funding for conservation outcomes defined by people in other countries (Ferraro and Kiss 2002) and possibly subject to political or institutional uncertainties.

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REFERENCES

Ferraro, P. J. and Kiss, A. 2002. Direct payments to conserve biodiversity. Science 298: 1718–1719. (doi:10.1126/science.1078104)

O'Brien, S., Emahalala, E. R., Beard, V., Rakotondrainy, R. M., Reid, A., Raharisoa, V. and Coulson, T. 2003. Decline of the Madagascar radiated tortoise *Geochelone radiata* due to overexploitation. Oryx 37, 3: 338–343. (doi:10.1017/S0030605303000590)

Pedrono, M. 2011. Wasted efforts: why captivity is not the best way to conserve species. Madagascar Conservation & Development 6, 2 : 57–59. (doi:10.4314/mcd.v6i2.3)

Raselimanana, A. P. 2003 Trade in reptiles and amphibians. In: The Natural History of Madagascar. S. M. Goodman and J. P. Benstead (eds.), pp 1564–1568. The University of Chicago Press, Chicago.

SuLaMa 2011. Diagnostic participatif de la gestion des ressources naturelles sur le plateau Mahafaly. Unpublished report. (http://www.sulama.de downloaded 20/11/2011)

Todd, M. 2011. Trade in Malagasy reptiles and amphibians in Thailand. TRAFFIC Southeast Asia, Petaling Jaya, Selangor, Malaysia. (http://www.traffic.org/species-reports/traffic_species_reptiles30.pdf downloaded 20/11/2011)

SPOTLIGHTS

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Wasted efforts: why captivity is not the best way to conserve species

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ABSTRACT

Conservation strategies of Malagasy turtles and tortoises are based principally on the captive-breeding of these species, with the ultimate aim of their possible reintroduction in the wild. Given the current precarious conservation status of endemic Malagasy turtle and tortoise species, it is clear that this approach has been a failure. Instead of being used to complement *in situ* approaches for a number of years captive-breeding efforts have been used as an alternative. It is essential to develop conservation strategies for these species based on empirical data, and not only on the subjective vision of NGOs with a strong interest in *ex situ* conservation approaches. It is only by fighting the causes of decline of Malagasy chelonian species in the wild that they will be able to be saved.

RÉSUMÉ

Les stratégies de conservation des tortues malgaches reposent principalement sur l'élevage en captivité de ces espèces, en vue de leur possible réintroduction dans la nature. Force est de constater que cette approche a conduit à un échec, au regard du statut actuel, particulièrement précaire, des tortues endémiques malgaches. Au lieu d'appuyer les efforts de conservation *in situ* comme il se doit, l'élevage en captivité s'est substitué à eux, et ce depuis de nombreuses années. Il est désormais essentiel d'élaborer les stratégies de conservation de ces espèces sur la base de données empiriques, et non plus sur la seule vision subjective d'ONGs présentant un fort intérêt pour l'approche *ex situ*. C'est seulement en combattant les causes du déclin des tortues malgaches qu'il sera possible d'assurer leur survie.

MALAGASY TORTOISES EMBARK IN THE ARK

In Madagascar, most species-oriented conservation projects have focused on either tortoises or lemurs. However, the conservation approaches developed for these two groups are very different even though the factors threatening their survival in the wild are quite similar. Most conservation projects developed for Malagasy lemurs are focused on protection of wild populations and critical habitats, whereas conservation efforts for chelonians are focused on captive-breeding. In captive-breeding efforts, a few individuals extracted from wild populations, or already captive individuals, are bred in captivity to produce so called 'assurance colonies', both in-country and overseas (e.g., Seal 1986, Soulé et al. 1986, Tudge 1992). Historically, this has been the approach for four threatened Malagasy chelonians: the ploughshare tortoise (*Astrochelys yniphora*, Figure 1) by Juvik et al. (1982) and implemented by the Durrell Wildlife Conservation Trust (DWCT) since 1986; the Madagascar side-necked turtle (*Erymnochelys madagascariensis)* by Kuchling (1997) and also implemented by DWCT since 1998; and the radiated tortoise (*Astrochelys radiata)* and the spider tortoise (*Pyxis arachnoides)* implemented by the Station d'Observation et de Protection des Tortues et de leurs Milieux (SOPTOM) since 2002. Additional 'assurance colonies' have been established by members of the Turtle Survival Alliance (TSA) in US and Europe for most of these species during the same period.

Catalysed by the commencement of activities by TSA and the Turtle Conservancy (TC) in Madagascar, and by an IUCN/SSC workshop in Antananarivo in January 2008 and followed by two additional workshops on the same subject at a TSA meeting in Florida in 2010 and in Mahajanga in September 2011, interest in conservation projects for Malagasy tortoises has spiked dramatically in recent years. The workshops have had important implications for the trajectory of conservation activities: the main output of this series of workshops was the development of Conservation Strategies and Action Plans with a dominant *ex situ* component.

FIGURE 1: Female ploughshare tortoise (*Astrochelys yniphora)* in Baly Bay National Park. By Miguel Pedrono

AN UTTER WASTE OF CONSERVATION RESOURCES

The buzz of recent activity could lead one to believe that Malagasy chelonians are now in a more secure position than most other groups of vertebrates in Madagascar. Unfortunately this is not the case. In fact, despite the long history of several of these conservation programs and the recent high profile workshops, Malagasy tortoise and turtle populations have never been in such jeopardy. All the endemic chelonians were even classified as 'Critically Endangered' on the IUCN Red List following the Antananarivo workshop in January 2008 (although such an extreme categorisation is certainly exaggerated for several species, Pedrono In prep.). Why? I believe that both the past and current generation of conservation projects focus too strongly on captive rather than on wild populations and that this approach has been totally ineffective. Considerable experience has shown that the most effective conservation strategies for tortoises and turtles target conservation of reproductive adults in the wild (e.g., Frazer 1992, Congdon et al. 1994). There is little sense in treating the symptoms but not the underlying causes of the decline of tortoise and turtle populations. I believe that the potential benefits of *ex situ* initiatives – including fostering public support and funding for the protection of chelonians – are outweighed by the fact that such approaches divert attention and resources from efforts to conserve wild populations that still have a chance to recover. Think of what could have been done with money wasted in overly expensive captive-breeding projects for *in situ* conservation and restoration efforts. Captive-breeding and reintroduction also have the potential to decrease genetic variability within species, to transmit exogenous pathogens to wild populations, and are done without any notion of the particular species' minimum viable population size (Snyder et al. 1996). Thus, *ex situ* conservation options should never be implemented as a priority over *in situ* approaches; rather they should be used to supplement them as demonstrated in the case of the ploughshare tortoise (*Astrochelys yniphora*). Modelling of wild and captive populations of ploughshare tortoise has clearly demonstrated that its long term survival depends essentially of the conservation of wild adults, but provided they are conserved, the release of captive-bred juveniles to the wild can contribute to boost the overall species recovery (Pedrono et al. 2004). Captive-breeding *per se* has limited utility for conservation that is only worthwhile under certain specific scenarios, i.e. when captive-breeding has a high probability of changing the extinction risk of species. Even the world's leading zoos who once touted the 'Ark Paradigm' to compensate for the loss of biodiversity in the wild, now largely acknowledge its limitations (Lees and Wilcken 2009).

CONSERVATION STRATEGIES SHOULD BE BASED ON EMPIRICAL EVIDENCE

The bias in allocation of conservation efforts for chelonians in Madagascar may result from the relative ease with which these species adapt to captivity and to reintroduction in the wild. This is not the case for lemurs, for which the stress induced by capture, transport, release procedures and social disturbance appear much more important, resulting in low reintroduction success (Britt et al. 2004). However, I don't believe that just because we can – we should. That is, this conservation option should not be prioritized over others just because tortoises and turtles are easy to breed in captivity and to reintroduce in the wild. This is especially true because such approaches have globally proven to be unsuccessful in reaching their ultimate objective: the continued existence of wild populations of chelonians in their natural habitat (Dodd and Seigel 1991, Frazer 1992). My main contention is that for optimal allocation of conservation efforts between wild and captive populations, decisions must be based on empirical evidence and not on the subjective judgement of those with a vested interest in *ex situ* conservation efforts over other types of conservation options. None of the breeding programs developed for chelonians in Madagascar to date have been based on quantitative analyses, but on the personal judgement of the concerned turtle hobbyists and related private NGOs. Although the 'assurance colonies' are generally presented as one component of these Action Plans for chelonian conservation, in reality, these captive-breeding projects are the cornerstones of these Action Plans. Such an approach appears to derive from the belief that there is a single miracle cure to the multiple problems that affect the diverse species addressed in the Action Plans, and perhaps the ease of demonstrating 'successful outcomes' in captive-bred populations; a must for any NGO that needs to demonstrate efficient use of donor funds.

POSING THE RIGHT QUESTION

The TSA, for example, was created by, and is funded almost exclusively by zoo professionals and avid turtle hobbyists who seek to play an important role in the conservation efforts of their favourite species. The fact TSA has emerged as a conservation organization does not necessarily steer them towards the fundamental question in species recovery: "Which management option will be the most effective to save a species?" Instead there is a propensity to commence from a basis of "How can captive-breeding programs be integrated into species conservation strategies?" It is therefore understandable that they are prone to orient chelonian conservation strategies towards *ex situ* approaches as they align most closely with the expressed mission and areas of expertise of this group. This is how TSA and SOPTOM decided to invest in the expansion of the facilities for 'assurance colonies' of radiated tortoises (*Astrochelys radiata)* and spider tortoises (*Pyxis arachnoides)* in southern Madagascar (Ogle and Hudson 2008). It was anticipated that tortoises confiscated from the international trade and captive-bred individuals could be used to supplement wild populations to a self-sustaining level, or to re-establish these species in parts of their former range. Despite the fact that wild populations of these species are in severe decline (O'Brien et al. 2003, Walker 2010), the justification for captive-breeding as a viable conservation measure is questionable at best, given the remaining large populations of both of these species in the wild (several million individuals of each species, Pedrono 2008). Conservation efforts should rather focus on effective measures to control the poaching of adult radiated and spider tortoises. And if those most closely involved in chelonian conservation don't believe that such a change is worthwhile let's put the question another way – would creation of 'assurance colonies' of endangered North-American or European tortoise and turtle species in Madagascar be acceptable to turtle hobbyists?

FIGHTING THE CAUSES OF THE PROBLEM

Countries such as South Africa and India have successfully controlled the poaching of highly valued species – such as the African elephant and tigers – for the international trade in exotic species, and it should not be impossible for Madagascar to do the same for its tortoises and turtles, especially with the high levels of support of NGOs that have expressed their enthusiasm to play a leading role in their conservation. Some of these NGOs have already started to reorient their actions toward the preservation of wild populations particularly through financial support to antipoaching initiatives. My hope is that these approaches will soon overtake the old-fashioned ideas that focus on the repatriation of confiscated tortoises, rescue centers, and captive-breeding projects. Independent evaluation of existing projects and increased use of scientific analyses to forecast conservation project impacts may help to foster such a switch.

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REFERENCES

Britt, A., Welch, C., Katz, A., Iambana, B., Porton, I., Junge, R., Crawford, G., Williams, C. and Haring., D. 2004. The re-stocking of captive-bred ruffed lemurs (*Varecia variegata variegata*) into the Betampona Reserve, Madagascar: Methodology and recommendations. Biodiversity and Conservation 13, 3: 635–657. (doi:10.1023/B:BIOC.0000009497.24917.ae)

Congdon, J. D., Dunham, A. E. and Van Loben Sels, R. C. 1994. Demographics of common snapping turtles (*Chelydra serpentina*): Implications for conservation and management of long-lived organisms. American Zoologist 34, 3: 397–408. (doi:10.1093/icb/34.3.397)

Dodd, C. K. and Seigel, R. A. 1991. Relocation, repatriation, and translocation of amphibians and reptiles: Are they conservation strategies that work? Herpetologica 47, 3: 336–350.

Frazer, N. B. 1992. Sea turtle conservation and halfway technology. Conservation Biology 6, 2: 179–184. (doi:10.1046/j.1523-1739.1992.620179.x)

Juvik, J. O., Andrianarivo, A. J., Blanc, C. P. and Bour, R. 1982. Revised species recovery plan for the endangered Madagascar angulated tortoise (*Geochelone = Astrochelys yniphora*). Unpublished proposal to the Department of Water and Forests of Madagascar and the World Wildlife Fund.

Kuchling, G. 1997. Captive propagation of *Erymnochelys madagascariensis* and a tortoise and turtle exhibit at Ampijoroa. Unpublished report to Conservation International and Jersey Wildlife Preservation Trust.

Lees, C. M. and Wilcken, J. 2009. Sustaining the Ark: The challenges faced by zoos in maintaining viable populations. International Zoo Yearbook 43, 1: 6–18. (doi:10.1111/j.1748-1090.2008.00066.x)

O'Brien, S., Emahalala, E. R., Beard, V., Rakotondrainy, R. M., Reid, A., Raharisoa, V. and Coulson, T. 2003. Decline of the Madagascar radiated tortoise *Geochelone radiata* due to overexploitation. Oryx 37, 3: 338–343. (doi:10.1017/S0030605303000590)

Ogle, M. and Hudson, R. 2008. Supporting efforts to protect Madagascar's endemic tortoises – TSA launches new program. Turtle Survival Alliance Newsletter, August 2008: 36–39.

Pedrono, M. 2008. The Tortoises and Turtles of Madagascar. Natural History Publications (Borneo). Kota Kinabalu, Sabah, Malaysia.

Pedrono, M., Smith, L. L., Clobert, J., Massot, M. and Sarrazin, F. 2004. Wild-captive metapopulation viability analysis. Biological Conservation 119, 4: 463–473. (doi:10.1016/j.biocon.2004.01.007)

Seal, U. S. 1986. Goals of captive propagation programmes for the conservation of endangered species. International Zoo Yearbook 24, 1: 174–179. (doi:10.1111/j.1748-1090.1985.tb02535.x)

Snyder, N. F. R., Derrickson, S. R., Beissinger, S. R., Wiley, J. W., Smith, T. B., Toone, W. D. and Miller, B. 1996. Limitations of captive breeding in endangered species recovery. Conservation Biology 10, 2: 338–348. (doi:10.1046/j.1523-1739.1996.10020338.x)

Soulé, M., Gilpin, M., Conway, W. and Foose, T. 1986. The millennium ark: How long a voyage, how many staterooms, how many passengers? Zoo Biology 5, 2: 101–113. (doi:10.1002/zoo.1430050205)

Tudge, C. 1992. Last Animals at the Zoo: How Mass Extinction Can Be Stopped. Island Press, Washington, D.C.

Walker, R. C. J. 2010. The decline of the critically endangered northern Madagascar spider tortoise (*Pyxis arachnoides brygooi*). Herpetologica 66, 4: 411–417. (doi:10.1655/09-047.1)

ARTICLE

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Participatory assessment of the Toliara Bay reef fishery, southwest Madagascar

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ABSTRACT

In order to ensure the sustainable management of reef fisheries, it is necessary to obtain data about the impacts of these fisheries on both fish resources and the ecosystems that sustain them. Ecosystem-based surveys provide such information, but are difficult to implement because of high technical, financial and human resource requirements. In this regard participatory assessment methods have the potential to increase the amount of data collected at low cost, while taking advantage of local traditional ecological knowledge. In order to investigate the reef fishery of Toliara Bay, southwest Madagascar, we used participatory fish survey and interview data collected on site. These methods included: (i) monitoring of catch landings over six months by wholesale fish merchants, (ii) household surveys of fishing catch and effort, and fish consumption conducted by school children, and (iii) semi-structured interviews of reef users. The landings of 1,586 fishing trips were sampled between September 2006 and February 2007, 326 households were surveyed by trained school children in January 2007, and 70 reef users were interviewed in July/August 2006. Data collected by participants were compiled and compared to reference values when available, allowing an assessment of the sustainability of the reef fishery. The results of this study confirm the unsustainable nature of resource exploitation and underline the need for rapid management responses in order to reverse this trend. It also highlights the great potential of participatory assessment methods for gathering large amounts of relevant information on the status and evolution of the ecosystem upon which the fishery depends, while promoting education and awareness about the conservation and sustainable use of natural resources.

RÉSUMÉ

Bien que les pêcheries récifales ne contribuent que marginalement aux captures de pêche mondiales, elles restent une source majeure de revenus et de protéines pour des millions de personnes, en particulier dans les pays en voie de développement. Afin de s'assurer de la bonne gestion de ces pêcheries, il est nécessaire de disposer d'informations sur l'état des ressources et des écosystèmes dont elles dépendent. Mener de telles études est d'autant plus compliqué que les pêcheries en milieu corallien portent sur un large éventail de stocks et d'espèces de poissons, concernent de nombreux pêcheurs et supposent diverses méthodes de captures, et empruntent un grand nombre de canaux de distribution. De plus, ces pêcheries sont souvent considérées de moindre valeur par les gouvernements qui leur octroient donc peu de moyens humains et financiers. Face à ces problèmes, l'implication de la société civile dans les programmes de suivi, appelé suivi participatif, semble en mesure d'apporter des solutions, d'autant que les suivis participatifs présentent l'avantage d'accroître le nombre de données collectées à moindre coût, tout en profitant des connaissances écologiques empiriques qui sont disponibles localement. Afin d'évaluer la pérennité de la pêcherie récifale de la baie de Toliara dans le sud ouest de Madagascar, des méthodes de suivi participatif ont été expérimentées. Ces méthodes consistent à mettre en œuvre : (i) des suivis des débarquements pendant six mois impliquant des mareyeuses, (ii) des enquêtes auprès des ménages, réalisées par des écoliers préalablement formés, afin de recueillir des informations sur l'effort de pêche, les captures et la consommation de poisons, (iii) des entretiens semi-directifs avec des usagers du milieu marin. Ainsi, entre 2006 et 2007, 1586 sorties de pêche ont été échantillonnées, et 326 ménages et 70 usagers ont fait l'objet d'enquêtes. Les données collectées par les membres de la communauté locale ont été analysées afin d'évaluer la pérennité de la pêcherie dans la baie de Toliara. Les résultats de l'étude confirment une exploitation non pérenne et soulignent la nécessité de mettre en place des mesures de gestion afin d'inverser la tendance de détérioration des écosystèmes de la baie. Il ressort également de cette étude que l'implication de la société civile s'avère être pertinente pour recueillir des informations sur les pêcheries récifales à faible coût. En effet, de part le nombre, la qualité, la variété et la pertinence des informations produites, les suivis participatifs contribuent utilement à l'évaluation des pêcheries récifales. Cette expérience met également en évidence le fort potentiel des suivis participatifs à contribuer au renforcement des connaissances et des capacités des communautés locales dans le domaine de la gestion des ressources marines. Ainsi, face au difficile contexte socio-économique et politique qui prévaut actuellement à Madagascar, cette approche s'avère

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particulièrement prometteuse pour améliorer la gestion des pêcheries traditionnelles grâce à la production d'informations sur ces pêcheries et une plus grande implication des communautés locales dans le processus de gestion.

INTRODUCTION

Although coral reef fisheries account for a small proportion of global fisheries catches (Pauly et al. 2003), these small-scale fisheries are a major source of income and protein for millions of people, especially in developing countries (Sadovy 2005). Coral reef ecosystems are, however, severely degraded worldwide, and overexploitation is one of the major threats they face (Jackson et al. 2001). Fisheries have an impact on the resources targeted and can also cause severe damage to non-target species, habitats, structures and functions in marine ecosystems. There is therefore a critical need to manage fisheries in a way that maximizes individual species yields in the long term while minimizing impacts on ecosystem components, structures and functions, thus securing the sustainability of the fishery. This is the biological objective of a successful fishery, which should also achieve economic efficiency and social objectives (Hilborn 2007). In order to achieve this objective, information is needed on the status of the exploited resources and the ecosystem components that sustain these resources in order to undertake ecosystem-based management (FAO 2003).

Assessing the biological sustainability of reef fisheries is a difficult task for at least five reasons: (i) reef fisheries are complex, relying on a wide variety of target species, gear types, landing areas and distribution routes; (ii) generally, governments do not spend large amounts of money on the management of reef fisheries; (iii) when financial and human resources are scarce, monitoring and evaluation programs are neglected because of their cost and complexity; (iv) ecosystem-based management requires information not only on the status of target species, but also other ecosystem components or processes, with intensive data requirements; (v) there is a lack of historical information on resources and ecosystem status and trends which hinders the interpretation of recently collected data (Zeller et al. 2006).

In the face of such challenges, the involvement of local communities in the assessment of reef fisheries sustainability (participatory assessment) has proved to be useful for several reasons: (i) it increases sampling effort in space and time, making participatory assessment especially effective for broad scale surveys; (ii) it is cost-effective because it usually involves volunteers and takes advantage of their logistical resources; (iii) it takes advantage of the traditional ecological knowledge and skills of resource users (Obura et al. 2002).

This approach could be particularly appropriate for obtaining information on small-scale fisheries in Madagascar. Indeed statistics for these fisheries, which employ about 100,000 fishers in Madagascar, are scarce (Le Manach et al. 2012). Further, these fisheries are often active in remote areas where few research resources are available. The purpose of participatory assessment is to fill information needs by generating a general understanding of the scale, composition and trends of these fisheries, to guide the implementation and assessment of fisheries regulations and management plans. The value of participatory methods in providing such information has been assessed in larger-scale research involving several case studies (Brenier 2009). In this paper, we will discuss the applicability of easy-to-use participatory methods for gaining rapid knowledge of Madagascar's small-scale fisheries at low-cost. For this purpose we tested several participatory methods to assess the biological sustainability of the reef fishery of Toliara Bay in southwest Madagascar. The second objective of the study is to characterize the on-going evolution of the Toliara Bay fishery and its ecological impacts. This fishery was described in 1989/1990 (Laroche and Ramananarivo 1995), and about two decades later we have the opportunity to re-assess the ecological sustainability of the Toliara Bay reef fishery and characterize its evolution.

STUDY SITE. Supporting more than 140,000 inhabitants in the 1990s (Vasseur 1997), Toliara Bay in southwest Madagascar is bordered by the Fiherenana delta to the north and by the Onilahy estuary to the south (Figure 1). This bay encompasses the most diverse coral reef formations of the southwest coast of Madagascar and consists of two barrier reefs (the Grand Récif of Toliara, an 18 km long barrier reef, and Nosy Tafara in the south), two coral banks (Mareana, Ankilibe), three lagoon reefs (Norikazo, Dimadimatse, Beloza) and one fringing reef (Pichon 1978). Mangrove forests occur along the shoreline between the Onilahy and Fiherenana rivers. Two main seasons influence the temporal variability of the area: the austral summer from November to April, a warm season with occasional rains, and the austral winter from May to October, a cold and dry season. The small-scale (or traditional) fishery of Toliara Bay uses only unpowered traditional canoes with a single outrigger and a square sail, and, in most cases, only one of the following three fishing methods: hand-line, gill-net or seine (Laroche and Ramananarivo 1995). In Madagascar the term traditional or small-scale fisheries refers to non-motorized, kinship-based fishing for subsistence or for local markets (Mathew 2002). In Toliara Bay dugout canoes three meters long are usually used by one man practicing line fishing, and dugout canoes four to eight meters long are usually used by two to four men practicing gill-net fishing, or at least three people practicing seine fishing. From north to south there are six main landing sites: the fishing districts of Ambohitsabo/Besakoa, Mahavatse II and Ankiembe/Mahavatse I, and the villages of Ankilibe, Sarodrano and Saint Augustin (Figure 1). About 1,500 subsistence fishers exploit this coastline (Laroche and Ramananarivo 1995). Women and children also practice reef gleaning on foot on the reef flats of Toliara Bay during low tides (Vasseur 1997).

METHODOLOGY

The study of the relevance of participatory methods to reef fisheries assessment was part of a larger research project involving three case studies. At each site, including Toliara Bay, we followed a four-step process. The first step was to test the participatory methods in the field in order to assess their feasibility. The second step of the process dealt with the assessment of the community members' commitment to the monitoring activities. The third step consisted of an assessment of the credibility of the data collected by the community members for each method. The last step involved examining the relevance and usefulness of the data obtained through participatory methods for assessing the state of reef fisheries. In this study we will discuss more specifically the applicability of participatory methods for assessing Madagascar's small-scale fisheries, based on our research in Toliara Bay.

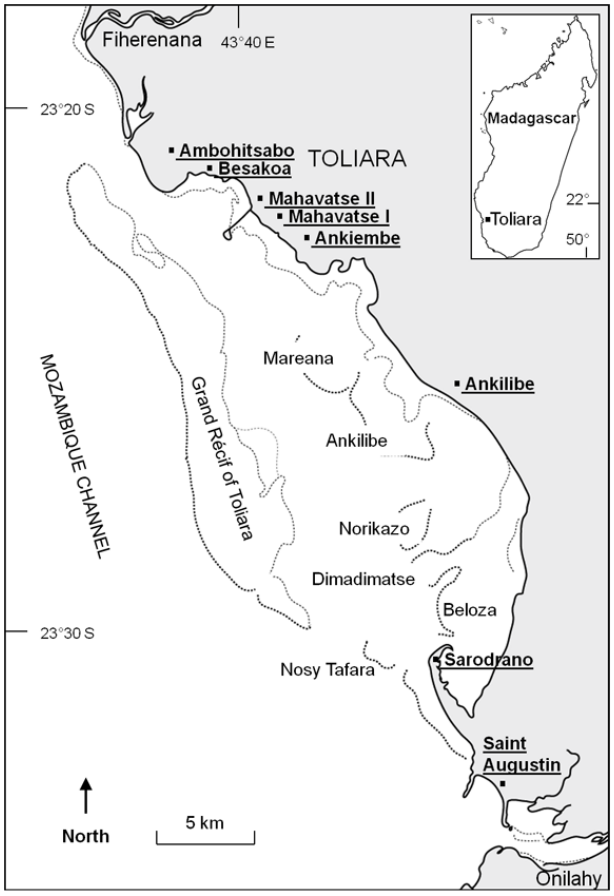

FIGURE 1. Map of Toliara Bay. Barrier reefs are represented by Grand Récif of Toliara and Nosy Tafara, coral banks by Mareana and Ankilibe, lagoon reefs by Norikazo, Dimadimatse and Beloza and fringing reef are lining the Sarodrano peninsula. The underlined names show location of the fishing villages and districts.

In order to meet both objectives of our study and after reviewing the available literature dealing with commonly-used methods for participatory monitoring programs of coral reef ecosystems and fisheries (Table 1), and checking local constraints and logistical feasibility in Toliara, we selected three participatory methods to implement in Toliara Bay: (i) catch landing monitoring by wholesale fish merchants; (ii) household survey of fishing catch and effort, and fish consumption, conducted by school children; (iii) semi-structured interviews of reef users.

LANDING MONITORING. In Toliara Bay, the women involved in the fish trade live near the beaches where the fish are landed and work there every fishing day. They wait for the fishers to bring their catch back to the beach in order to purchase fish for resale at the markets in Toliara. Three female fish sellers working on Ankiembe beach, the main landing site of Toliara bay where 40 % of the fishing gears are registered (Laroche and Ramananarivo 1995), were chosen and trained to carry out landings surveys in addition to their daily work. After testing their knowledge regarding the identification of the various fish species, an Ankiembe beach catch landing monitoring protocol was put forward to them. In order to estimate the catch per unit effort (CPUE) and catch composition for each fishing gear, the monitoring was carried out every fishing day for six months, covering part of the two main seasons between September 2006 and February 2007. Every fishing day, while still doing their normal work, these three women were asked to collect data from at least nine randomly chosen fishing boats landing on Ankiembe beach. For each sampling unit (landing boat), the number of fishers, the fishing site, the gear used and a visual estimation of the weight of each species caught were recorded. In total, 1,586 fishing trips were sampled (4.3 % of all the fishing boats landing at Ankiembe). From August 1989 to February 1990 an investigator recorded exactly the same parameters, on the same landing beach, by sampling fifteen landing boats twenty days per month (Laroche and Ramananarivo 1995). Comparison of the two studies allows us to describe the general evolution of the fishery over the last two decades.

HOUSEHOLD SURVEY. After a short training class, children of about ten years old from primary schools of fishing districts and villages along the coast of Toliara Bay were asked to conduct a survey in their own household and to return the questionnaires at school a few days later. This method relies on school children to collect fishing activity information from their respective households using a questionnaire, which is distributed and explained to them in detail at school. The training session at school was half a day long for each class, and allowed us to explain the objective of the study and to make sure that all children understood how to complete the survey once at home. All children from 12 classes from all of the eight public primary schools in the eight fishing districts and villages along the coast of Toliara Bay were involved in conducting surveys. We chose very young students in order to avoid bias due to withdrawal from school of children from the most vulnerable families in older classes (Hosch 2000), especially fishers' families that tend to prioritize the involvement of teenagers in household fishing activity instead of sending them to school. Thus, by targeting these school classes, we assumed that all children are attending school at this age, in order to survey a representative sample of households. This method seeks to gather information on fishing effort, fishery yield, catch composition and fish consumption based on declarations of household members. Some questions of the questionnaire were designed for the whole household (size of the household, fish consumption, number of canoes, number of fishers and number of women practicing reef gleaning living in the household). Other questions were asked to one fisher or one woman practicing reef gleaning of the household about fishing frequencies, fishing gears, fishing areas, species and quantity usually caught, and the use of their catches (Supplementary Material S1). Three hundred and twenty six questionnaires were correctly completed and returned (86 % of the questionnaires distributed in classes), which represents a sample size of 10.3 % of all the households in the fishing districts and villages along the coast of Toliara Bay.

PERCEPTION SURVEY. The third method involved semi-structured interviews and was conducted with reef and lagoon users with long fishing experience. Semi-structured interviews are more conducive to interaction and mutual confidence between the interviewee and the interviewer than questionnaires, and are especially suitable for the gathering of traditional ecological knowledge (Huntington 1998). We selected key informants by snowball sampling (Henry 1990) in each fishing district and village along the coast of Toliara Bay. Seventy interviews were conducted in July/August 2006. These interviews were two hours and twenty minutes long on average. The mean number of years of reef use by the informants was 31. Interviewees were asked about their perceptions of key

TABLE 1. Participatory monitoring methods commonly used to assess coral reef ecosystems and reef fisheries.

Objective	Method	Participant	Pros	Cons	Reference
To obtain subsistence fishery statistics	Questionnaire on household socio-economic characteristics and one week daily log sheets of household seafood consumption, fishing trips and catch characteristics	Fourteen to eighteen years old school students	Short time broad scale survey , Large educational benefits	Households sampled were not representative of all households Small portion of log sheets answered satisfactorily	(Hosch 2000)
To detect ecological changes in coral reef ecosystems	Underwater visual census of key components of coral reef ecosystems	Recreational divers Fishers Community members	Standardized protocols do exist allowing global scale surveys	Need of intense training Surveys are time consuming for the participants	(e.g., Pattengill, Semmens & Semmens 2003)
To identify historical trends in coral reef ecosystem components and fishery activity	Questionnaire on local resource user perceptions of trends in coral reef ecosystem components and fishery activity	Resource user (especially fishers)	Long term scientific studies are very rare Knowledge of past trends is critical	Subjective qualitative data	(e.g., Webb et al. 2004)
To obtain fishery statistics	Fishery logbooks	Fishers	Direct data of fishing trips and catch characteristics	Objectivity of the participants is questionable High number of fishers should be involved	(e.g., Uychiaoco et al. 2005)
To obtain fishery statistics	Landing surveys	Fishers	Direct data of fishing trips and catch characteristics	Difficult to implement for reef fisheries with high number of landing points	(e.g., Obura et al. 2002)

trends in resources, habitats, environmental parameters and fishing effort over the past three decades. In order to triangulate the information collected through these perception surveys, only trends observed by at least 50 % of the informants were considered further in our analysis. This allowed the identification of potential indicators of the level of fishery threats (e.g., perceived trends in the number of fishers, canoes, fishing trip frequency), fishery impacts (e.g., perceived changes in fishery resources abundance and size, proportion of the catch kept for subsistence consumption, mean weight of the catch per fishing trip) or fishing activity response (e.g., increase in fishing trip duration).

RESULTS

LANDING MONITORING. The catch landing monitoring revealed a higher CPUE for seine fishing (9.4±0.8 kg / fisher / trip) than for gill-net fishing (7.9±0.7 kg / fisher / trip) and line fishing (6.3±0.5 kg / fisher / trip). All results are given with a 95 % confidence interval. Because of potential inaccuracies in line catch weight estimation by wholesale fish merchants, we could not calculate the composition of the catch from line fishing during the cold season (May to October). Thanks to the distribution of scales we were able to address this problem before the start of the warm season. Scombridae (36.8 %) represent one-third on the fish biomass caught by line during the warm season. Loliginidae (16.7 %), Lethrinidae (11.0 %), Carangidae (8.6 %) and Siganidae (7.6 %) also represent significant proportions of warm season line fishing catch. There was distinct seasonal variation in the composition of the fish caught with gill-nets between the two seasons. Catch was strongly dominated by Clupeidae (61.2 %) and Acanthuridae (18.2 %) during the cold period, and by Lethrinidae (45.6 %) and Acanthuridae (41.3 %) during the warm period. Clupeidae, Engraulidae and Carangidae were the dominant families caught by seine fishing throughout the year (Supplementary Material S2).

HOUSEHOLD SURVEY. The household surveys indicate that there were 1,970±438 fishers and 1,902±317 canoes along the coast of Toliara Bay. The CPUE was 7.4±1.2 kg / fisher / trip with a mean fishing trip length of 6.4±0.2 hours and a departure and arrival time depending on the tides (Table 2). The proportion of the catch kept for subsistence consumption was 26 % . With the results of the household survey we were able to estimate a total production for the Toliara Bay fishery at 2,700±436 million tons per year (mt / y), and the annual yield at 14.2±2.3 mt / y / km^2. This estimation did not include the production of 955±166 mt / y by the 570±205 women practicing reef gleaning with a CPUE of 14.4±2.5 kg / woman / trip. This fishing activity on reef flats mostly targets sea cucumbers, octopuses and clams. The quantity of fish consumed in the fishing districts and villages was estimated as 50±4 kg / inhabitant / y, which highlights the importance of the fishery for protein supply.

TABLE 2. Results of the household survey in the fishing disctricts and villages along the coast of Toliara Bay (n = 326 households).

	Descriptor	Measure (± 95 % CI)
Fishing activity	Mean fishing trip length (hours)	6.4±0.2
	CPUE fishing (kg / fisher / trip)	7.4±1.2
	Fishery yield (mt / y)	2,700±436
	Fishery yield (mt / y / km)	14.2±2.3
	CPUE reef gleaning (kg / woman / trip)	14.4±2.5
	Reef gleaning yield (t / y)	955±166
Threats	Number of fishers (men >15 years old)	1,970v±v438
	Number of women practicing reef gleaning (women > 15 years old)	570±205
	Number of canoes	1,902±317
Fish consumption	Quantity of fish consumption in the fishers districts and villages (kg / inhabitant / y)	50±4
	Proportion of the catch kept for subsistence consumption	26 %

PERCEPTION SURVEY. Several trends were detected through the semi-structured interviews (Table 3). Over the last three decades, most of the respondents observed a general decrease in the abundance of resources (fish, sea cucumber, turtle, and lobster). They also perceived a lower mean size of targeted fish species, a reduction in coral and sea grass cover, and a decrease in the mean weight of the catch per trip and in the proportion of the catch kept for subsistence consumption. These trends lead to other impacts that have been also observed: they have to go further for fishing, especially north and south outside the bay, which increases the mean fishing trip duration. Respondents also observed increases in the number of fishers and canoes, and fishing trip frequency, as well as a trend towards the use of more efficient gears.

DISCUSSION

EVOLUTION OF TOLIARA BAY REEF FISHERY. Most of the results of this study suggest that Toliara Bay is overfished, with indicators calculated with the participation of the local community pointing to a potential overexploitation. Trends perceived by reef users indicate the degradation of resources and habitats (decrease in quantity of resources, size of fish, coral and sea grass cover and CPUE) over the last three decades while fishing pressure has increased (increase in number of fishers, canoes, fishing gears, and increase in fishing trip distance, duration and frequency). Our household survey underlines the increased number of fishers (1,970±438) in 2007 compared to previous studies: 1,556 in 1990 (Laroche and Ramananarivo 1995), and about 700 in 1972 (Bellemans 1989). These data provide insight into the general trend of fisher numbers but cannot lead to detailed analysis, as the methodologies were different for each study. This increased fishing effort probably comes from demographic growth and economic difficulties (Laroche et al. 1997), and confirm the trend observed by reef users through the perception survey. In 2007 there were 10.4 fishers / km² fishing in Toliara Bay, which is considered a high fishing pressure for reef ecosystems by McClanahan et al. (2002). The Toliara Bay fishery yield of 14.2±2.3 mt / y / km^2 exceeds the maximum sustainable yield that is estimated to be only 5 mt / y / km^2 for reef fisheries (Newton et al. 2007). These fishers, however, are not the only one to remove resources from Toliara Bay ecosystems, and 570±205 women also practiced reef gleaning in 2007. This activity obviously impacts benthic habitats and living resources (Vasseur 1997).

According to the perception survey, it seems that the fishers maintain their level of catch and revenue by increasing fishing effort and by keeping smaller proportions of their catches for subsistence consumption. Although CPUE in Toliara Bay seemed to be considerably higher in 1958, with one metric ton per trip frequently caught by gill-net (Lagouin 1959), it did not change significantly between 1989/1990 and 2006/2007. In 1989/1990 CPUE for line, gill-net and seine fishing, recorded from sampling of catch landings from the same beach as in our study, were 4.8±0.4, 6.7±1.8 and 8.2±1.9 kg/fisher/trip respectively (Laroche and Ramananarivo 1995). Thus, the CPUE seems to have dropped dramatically between the 1960s and the 1980s and remained relatively steady between the 1990s and 2007. As reported by the perception surveys, fishers have probably maintained CPUE by diversifying their fishing gears and using more efficient and less selective fishing gears (e.g., increase in net length and reduction of mesh size), increasing the fishing trip length and frequency, and targeting lower trophic level and value species. This is consistent with the analysis of the evolution in catch composition which shows that reef species or associated reef species (Siganidae and Caesionidae) that were dominant in seine captures in 1989/1990 (Laroche and Ramananarivo 1995) have been replaced by small coastal pelagic species (Clupeidae and Engraulidae) in 2006/2007. Another example is represented by the Acanthuridae, mostly low value species: they compose 18.2% of the gill-net catch during the cold season and 41.4% during the warm season in 2006/2007 while they were less than 2% of the gill-net catch in 1989/1990 (Laroche and Ramananarivo 1995). The increasing occurrence of these herbivorous species (Harmelin-Vivien 1981) in catches constitutes a potential sign of a phase shift in the ecosystem of Toliara Bay from a coral dominated habitat to an

TABLE 3. Trends perceived during the last three decades by at least 50% of the reef users surveyed along the coast of Toliara Bay (n= 70 interviews).

Theme	Observed trend	Percentage of informants having given this information
Fish consumption	Decrease in the proportion of the catch kept for subsistence consumption	100
Fishing activity	Decrease in the mean weight of the catch per trip	100
Threat	Increase in the number of fishers	100
Reef resources	Decrease in abundance of targeted fish resources	96
Threat	Increase in the number of canoes	94
Habitat	Decrease in coral cover	90
Habitat	Decrease in sea grass cover	90
Fishing activity	Increase in the distance of the fishing zones from the landing sites	69
Threat	Increase in the number of efficient fishing gears (e.g., nylon nets)	63
Fishing activity	Increase in the mean fish trip duration	60
Reef resources	Decrease of the mean size of targeted fish resources	59
Reef resources	Decrease in abundance of targeted sea cucumbers' resources	57
Reef resources	Decrease in abundance of turtles	54
Reef resources	Decrease in abundance of lobsters	54
Threat	Increase in fishing trip frequency	50

algae dominated habitat. This is consistent with the findings of Harris et al. (2010), who highlight a substantial decline in hard coral cover on the reefs of Toliara Bay over the last forty years, replaced to great extent by fleshy algae.

The findings of the present study largely agree with those of previous studies. Laroche and Ramananarivo (1995) and Laroche et al. (1997) found that Toliara Bay was heavily fished as indicated by the high fishing pressure and decreases in CPUE, fish size, and carnivorous species such as Serranidae relative to increases in herbivorous fishes such as Siganidae and Scaridae, and the general reduction of mesh size for seines and gill-nets and hook size for line fishing. This situation is worsening because households in the villages and fishing districts of Toliara Bay rely heavily on marine fish resources for nutrition (50±4 kg/inhabitant/y) and income (Laroche et al. 1997). Unfortunately, fishing is not the only activity that has adverse impacts on Toliara Bay's ecosystems: exploitation of mangrove forests, sedimentation and pollution are also major causes of degradation (Vasseur et al. 1988). Different strategies have been implemented to address the problems of reef fisheries in the Toliara region. In the 1990s many development interventions were designed to help fishers in adopting new fishing techniques, to diversify the resources targeted, and to improve access to markets. Few of these activities, however, have been successfully implemented, probably because of a lack of support from local communities to proposed regulations that are mostly designed by external entities (Ranaivomanana 2006). This strategy led to some counterproductive results such as international development organizations promoting shark fisheries, which have made this fishery unsustainable today (McVean et al. 2006). Progressively, international conservation NGOs proposed a new approach to reconcile development and conservation (Chaboud 2006). This approach aimed at implementing marine protected areas and encouraging the participation of local communities, and has met with some recent successes, especially in rural regions north of Toliara. Further challenges remain, however, such as the legitimacy of the local representatives involved in the management of these marine protected areas and their financial sustainability that still heavily depend on external partners (Harris 2007, Belle et al. 2009). This approach is much more difficult to implement at an appropriate scale in urban regions such as Toliara Bay with a very high demographic and fishing pressure and severely degraded habitats. Thus, the protection of productive areas should be carried out alongside fishery sustainability development strategies that are socially acceptable, economically efficient and environmentally benign. Development does not necessarily mean more catches but should lead to increased selectivity, reduced by-catch, greater added value for each catch, and increases in labour efficiency. The analysis of catch composition in our study showed that line fishing targets high-value species (Lethrinidae, Carangidae, Siganidae, Lujanidae, Serranidae), pelagic species found at greater distance from the coast that are less dependent to the state of the habitats of the bay (Scombridae) and species with short life cycles that are less vulnerable to relatively high fishing pressure (Loliginidae). For these reasons and because it is a highly selective gear, line fishing should be promoted, and fishers should be trained and equipped to be able to reach offshore fishing areas. Small coastal pelagic species, such as members of the family Clupeidae, are a very important resource for the bay and are targeted both by gill-net (mostly during the warm season) and seine fishing. This seasonal and short life-cycle resource can support relatively high fishing pressure but should be better managed as the only legislation to date is an annual closure; fish processing should also be improved. Finally, the analysis of seine fishing catch composition highlights its very low selectivity (about 30% of the catch is represented by numerous families contributing to less than 3% to the total fish biomass caught in each season) and potential overlap in targeted resources with other fishing gears (e.g., Siganidae). This low selectivity for species is also true for sizes as seine fishing catches small and juvenile fishes because of its very narrow mesh size (less than 20 mm and a cod end made of fly-screen). This fishing gear should be regulated. In order to sustain the reef fishery of Toliara Bay, many recommendations have already been made by previous studies such as improving fish processing, development of an offshore fishery, creation of marine protected areas, banning destructive fishing gears, allocating exclusive fishing rights, implementation of anchored fish aggregating devices, creation of non-fishing activities (e.g., algae farming), investment in education programs and stabilization of population growth. These recommendations seem to be relevant because they both suggest activities to build reef resources and address socioeconomic drivers of decline (Cinner et al. 2009). This should also be included in a broader framework that seeks to address the problem of poverty in the region.

RELEVANCE OF PARTICIPATORY METHODS FOR FISHERIES ASSESSMENT. By taking advantage of locally available knowledge and expertise, it is possible to quickly obtain a broad range of relevant information for the coarse characterization and assessment of the sustainability of a fishery, as the research in Toliara Bay and the analysis of the results demonstrate. Due to the involvement of the various reef users we were able to identify the impacts of fishing activity on resources (e.g., decrease in the size and availability of commercial species), ecosystems (e.g., decrease in coral cover and reef species abundance) and socio-economic systems (e.g., increase in number of fishers, canoes, fishing gears, and fishing trip distance, duration and frequency). It also provides information such as CPUE, fishery yield, quantity of fish consumption, and number of fishers. The experience also shows, however, that a major effort is required in terms of communication (rewarding and encouraging community members) and scientific supervision (establishment of data collection protocol, training, data quality checking, data analysis). Participatory monitoring does not mean the absence of involvement by scientists; human resources and skills in supervision and communication are crucial to ensure data quality. Further, the participatory methods tested in this study mostly provide imprecise or qualitative data that cannot always be used for statistical analysis and detailed description of a fishery. Much of the information on the fishery arising from household surveys, such as CPUE, is based on perceptions. These perceptions can be highly variable and lead to low precision in the data. It has also been shown that the estimated weight of the catch from snapshot surveys with fishers, to identify their perceptions of the average weight caught per trip, turned out to be from 42 to 64% higher than real catches (Lunn and Dearden 2006). Thus the CPUE and fishery yield data obtained through household surveys should be interpreted with caution. Besides their potential to improve

knowledge of a fishery, the use of participatory assessment methods is also an efficient strategy to involve local communities in the management process. It has been demonstrated that when the community is involved in data collection programs the delivery of timely, readily understandable, usable, and relevant information to the community and decision-makers is enhanced and leads to improved management (Danielsen et al. 2005). At the same time the involvement of the local community in data collection activities also promotes education and awareness regarding the conservation and sustainable use of natural resources (Stepath 1999). For example, in this specific case study twelve classes from eight primary schools of fishing districts and villages along the coast of Toliara Bay were first taught and trained in class for half a day before being able to put their new knowledge into practice by investigating their household. Data are crucial in obtaining a picture of what the ecosystem upon which the small-scale fishery depends looks like and how it evolves. Equally as important is the need for awareness-raising within the local community, and especially the young generation, in order to help them to understand the importance, the natural dynamics and the vulnerability of their coastal resources (Rodriguez-Martinez and Ortiz 1999). Involving local communities in the participatory assessment of reef fishery sustainability contributes to both aspects.

CONCLUSION

Participatory assessment methods proved to be useful for collecting large amounts of relevant information regarding the fishery and its sustainability, quickly and at low cost, while raising the awareness of local communities in charge of the management of natural resources, building capacity and contributing to experience sharing. This is particularly relevant in the current context of the socio-political and economic crisis prevailing in Madagascar where funding and capacity are lacking for the management of small-scale fisheries. In Toliara, information was enhanced and improved thanks to the efforts of the local community and highlight the critical state of the ecosystems of the bay and the urgent need for action. Participatory assessment of small-scale fisheries could be replicated in other places in Madagascar, especially where data are scarce. This could help generate a better understanding of the direct and indirect economic and social values of these small-scale fisheries and the risks and foregone benefits associated with overfishing or ecosystem degradation, facilitate large spatial and temporal comparisons, and help develop relevant local marine resource management plans while promoting the involvement of the local community in this process.

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REFERENCES

Belle, E. M., Stewart, G. W., De Ridder, B., Komeno, R. J.-L., Ramahatratra, F., Remy-Zephir, B. and Stein-Rostaing, R. D. 2009. Establishment of a community managed marine reserve in the Bay of Ranobe, southwest Madagascar. Madagascar Conservation & Development 4: 31–37.

Bellemans, M. 1989. Résultats de l'enquête cadre des pêcheries traditionnelles côtières malgaches, 1987/1988 – bilan diagnostic des caractéristiques structurelles. Project PNUD/FAO/MAG/85/014 Report No. 4.

Brenier, A. 2009. Pertinence des approches participatives pour le suivi écosystémique des pêcheries récifales. Unpubl. Ph.D. thesis, Université Pierre et Marie Curie, Paris. Available at <http://www.crisponline.net/Portals/0/New%20reports/FR%202009%20These%20Approches%20Participatives.pdf>

Chaboud, C. 2006. Gérer et valoriser les ressources marines pour lutter contre la pauvreté. Études Rurales 178: 197–212.

Cinner, J. E., McClanahan, T. R., Daw, T. M., Graham, N. A. J., Maina, J. , Wilson, S. K. and Hughes, T. P. 2009. Linking social and ecological systems to sustain coral reef fisheries. Current Biology 19, 3: 206–212. (doi:10.1016/j.cub.2008.11.055)

Danielsen, F., Jensen, A. E., Alviola, P. A., Balete, D. S., Mendoza, M., Tagtag, A., Custodio, C. and Enghoff, M. 2005. Does monitoring matter? A quantitative assessment of management decisions from locally-based monitoring of protected areas. Biodiversity and Conservation 14, 11: 2633–2652. (doi:10.1007/s10531-005-8392-z)

FAO (Food and Agriculture Organisation of the United Nations) 2003. The Ecosystem Approach to Fisheries. FAO, Rome, Technical Guidelines for Responsible Fisheries 4 Suppl. 2. Available at <http://www.fao.org/docrep/005/Y4470E/Y4470E00.HTM>.

Harmelin-Vivien, M. L. 1981. Trophic relationships of reef fishes in Tulear (Madagascar). Oceanologica Acta 4, 3: 365–374.

Harris, A. 2007. "To live with the Sea" – development of the Velondriake community-managed protected area network, southwest Madagascar. Madagascar Conservation & Development 2, 1: 43–49.

Harris, A., Manahira, G., Sheppard, A., Gough, C. and Sheppard, C. 2010. Demise of Madagascar's once Great Barrier Reef – Change in coral reef condition over 40 years. Atoll Research Bulletin 574: 1–18.

Henry, G. T. 1990. Practical Sampling. Sage Publications Inc., Newbury Park, CA.

Hilborn, R. 2007. Moving to sustainability by learning from successful fisheries. Ambio 36, 4: 296–303. (doi:10.1579/0044-7447(2007)36[296:MTSBLF]2.0.CO;2)

Hosch, G. 2000. The Use of Students in Surveying Subsistence Fisheries – a Pacific Island Case Study. FAO Fisheries Circular No. 962. FAO, Rome. Available at <ftp://ftp.fao.org/docrep/fao/005/x9006e/X9006E00.pdf>.

Huntington, H. P. 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51, 3: 237–242.

Jackson, J. B. C., Kirby, M. X., Berger, W. H., Bjorndal, K. A., et al. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293, 5530: 629–637. (doi:10.1126/science.1059199)

Lagouin, Y. 1959. La pêche côtière malgache dans la région de Tuléar. Bulletin de Madagascar 153: 95–106.

Laroche, J. and Ramananarivo, N. 1995. A preliminary survey of the artisanal fishery on coral reefs of the Tulear Region (southwest Madagascar). Coral Reefs 14, 4: 193–200. (doi:10.1007/BF00334341)

Laroche, J., Razanoelisoa, J., Fauroux, E. and Rabenevanana, M. W. 1997. The reef fisheries surrounding the south-west coastal cities of Madagascar. Fisheries Management and Ecology 4, 4: 285–299. (doi:10.1046/j.1365-2400.1997.00051.x)

Le Manach, F., Gough, C., Harris, A., Humber, F., Harper, S. and Zeller, D. 2012 (2011). Unreported fishing, hungry people and political turmoil: the recipe for a food security crisis in Madagascar? Marine Policy 36, 1: 218–225. (doi:10.1016/j.marpol.2011.05.007)

Lunn, K. E. and Dearden, P. 2006. Monitoring small-scale marine fisheries: An example from Thailand's Ko Chang archipelago. Fisheries Research 77, 1: 60–71. (doi:10.1016/j.fishres.2005.08.009)

Mathew, S. 2002. Small-scale fisheries perspectives on an ecosystem-based approach to fisheries management. In: Sinclair, M., Valdimarsson, G. (Eds.), Responsible Fisheries in the Marine Ecosystem. CAB International, Wallingford.

McClanahan, T., Polunin, N. and Done, T. 2002. Ecological states and the resilience of coral reefs. Conservation Ecology 6, 2: art 18. Available at <http://www.consecol.org/vol6/iss2/art18/>.

McVean, A. R., Walker, R. C. J. and Fanning, E. 2006. The traditional shark fisheries of southwest Madagascar: A study in the Toliara region. Fisheries Research 82, 1–3: 280–289. (doi:10.1016/j.fishres.2006.06.016)

Newton, K., Côté, I. M., Pilling, G. M., Jennings, S. and Dulvy, N. K. 2007. Current and future sustainability of island coral reef fisheries. Current Biology 17, 7: 655–658. (doi:10.1016/j.cub.2007.02.054)

Obura, D. O., Wells, S., Church, J. and Horrill, C. 2002. Monitoring of fish and fish catches by local fishermen in Kenya and Tanzania. Marine & Freshwater Research 53: 215–222. (doi:10.1071/MF01151)

Pattengill-Semmens, C. V. and Semmens, B. X. 2003. Conservation and management applications of the reef volunteer fish monitoring program. Environmental Monitoring and Assessment 81: 43–50. (doi: 10.1023/A:1021300302208)

Pauly, D., Alder, J., Bennett, E., Christensen, V., Tyedmers, P. and Watson R. 2003. The future for fisheries. Science 302, 5649: 1359–1361. (doi:10.1126/science.1088667)

Pichon, M. 1978. Recherches sur les peuplements à dominance d'Anthozoaires dans les récifs coralliens de Tuléar (Madagascar). Atoll Research Bulletin 222: 1–447.

Ranaivomanana, L. N. J. 2006. Identification des conditions d'appropriation de la gestion durable des ressources naturelles et des écosystèmes : cas du Grand Récif de Toliara. Unpubl. Ph.D. thesis, Université de Toliara, Toliara, and Agrocampus-ouest, Rennes. Available at <http://halieutique.agrocampus-ouest.fr/pdf/932.pdf>.

Rodriguez-Martinez, R. and Ortiz, L. M. 1999. Coral reef education in schools of Quintana Roo, Mexico. Ocean & Coastal Management 42, 12: 1061–1068. (doi:10.1016/S0964-5691(99)00061-7)

Sadovy, Y. 2005. Trouble on the reef: the imperative for managing vulnerable and valuable fisheries. Fish and Fisheries 6, 3: 167–185. (doi:10.1111/j.1467-2979.2005.00186.x)

Stepath, C. M. 1999. Does community-based coral reef monitoring promote awareness? Proceedings of the Hawaii Coral Reef Monitoring Workshop, 9-11 June 1998, Honolulu: 33–38.

Uychiaoco, A. J., Arceo, H. O., Green, S. J., De la Cruz, M. T., Gaite, P. A. and Alino, P. M. 2005. Monitoring and evaluation of reef protected areas by local fishers in the Philippines: tightening the adaptive management cycle. Biodiversity and Conservation 14, 11: 2775–2794. (doi: 10.1007/s10531-005-8414-x)

Vasseur, P. 1997. Écosystèmes côtiers en danger dans la région de Tuléar : analyse des agressions humaines et problèmes de gestion. In: Milieux et Sociétés dans le Sud-ouest de Madagascar. J. M. Lebigre (ed.), pp 97–120. Presses universitaires de Bordeaux (Collection Îles et Archipels 23), Bordeaux.

Vasseur, P., Gabrie, C. and Harmelin-Vivien, M. 1988. State of coral reefs and mangroves of the Tulear region (SW Madagascar): Assessment of human activities and suggestions for management. Proceedings 6th International 425 Coral Reef Symposium, Townsville 2: 421–426. Available at <http://www.reefbase.org/download/download.aspx?type=10&docid=10477>.

Webb, E. L., Maliao, R. J. and Siar, S. V. 2004. Using local user perceptions to evaluate outcomes of protected area management in the Sagay Marine Reserve, Philippines. Environmental Conservation 31: 138–148. (doi: 10.1017/S0376892904001377)

Zeller, D., Booth, S., Craig, P. and Pauly, D. 2006. Reconstruction of coral reef fisheries catches in American Samoa, 1950–2002. Coral Reefs 25: 144–152. (doi: 10.1007/s00338-005-0067-4)

SUPPLEMENTARY MATERIAL.

AVAILABLE ONLINE ONLY.

TABLE S1: Questionnaire used by children from eight public primary schools in the eight fishing districts and villages along the coast of Toliara Bay, to gather information on fishing effort, fishery yield, catch composition and fish consumption based on declarations of household members.

TABLE S2. Catch composition of the three main gears used by Toliara Bay traditional fishery estimated by participatory catch landing monitoring. Identification is to family level.

ARTICLE

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Understanding local differences in small-scale fisheries: a comparison of two fishing settlements in Antsiranana Bay, northern Madagascar

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ABSTRACT

The small-scale fishery in Antsiranana Bay, northern Madagascar, constitutes a very active industry with fishers using multiple methods based on traditional techniques. In this first study of the fishing activities in Antsiranana Bay, two villages were surveyed, both through direct observation and by means of interviews with local fishers. Antsisikala is a small zebu-farming village whose inhabitants supplement their income through small-scale fishing, whereas Ramena is primarily a fishing village that also caters for tourism. Our results show that fishers from both villages target multiple species of reef associated fish as well as invertebrates, and use a variety of fishing gears including hook and line, gill nets, beach seine nets, spearguns and traps. There were significant differences in the types of fishing gear preferentially used and catch sizes between the two villages, as well as in opinions regarding possible measures to utilise the marine resources more sustainably. We therefore stress the importance of understanding the local differences between small-scale fisheries and their impacts on the reef in order to design more effective management strategies.

RÉSUMÉ

La pêche artisanale dans la baie d'Antsiranana, au nord de Madagascar est une activité répandue parmi les pêcheurs qui utilisent des moyens diversifiés généralement basés sur les techniques traditionnelles. D'ordinaire, on considère que la pêche artisanale a un impact négligeable sur l'environnement par rapport aux pêcheries commerciales à grande échelle. Dans cette première analyse des activités de pêche artisanale dans la baie d'Antsiranana, deux villages situés de part et d'autre de la baie ont fait l'objet d'études, à la fois par le biais d'observations directes et au moyen de questionnaires auprès des pêcheurs locaux. Antsisikala est un petit village situé à l'ouest de la baie qui dépend principalement de l'élevage de zébus mais qui augmente son revenu grâce à la pêche. Le village de Ramena est en revanche situé à l'est de la baie et est essentiellement tourné vers la pêche complétée par quelques activités touristiques. Ces villages ont été choisis pour illustrer la variabilité des niveaux de pression sur les ressources marines et côtières causés par la pêche artisanale. Nos résultats montrent des similarités et des différences entre les deux villages, car si les pêcheurs des deux villages ciblent des poissons de plusieurs familles liés au récif ainsi que diverses espèces d'invertébrés et qu'ils sont conscients d'une baisse de production de la pêche au cours des dernières années, notre étude montre cependant des différences significatives dans les types de matériel de pêche utilisés et dans l'intensité de la pêche entre les deux villages. De plus, les pêcheurs des deux villages ont des avis divergents lorsqu'ils formulent des solutions destinées à permettre l'exploitation pérenne des ressources marines. Les pêcheurs de Ramena utilisent principalement des sennes de plage, tandis que ceux d'Antsisikala emploient surtout une combinaison de méthodes en utilisant aussi bien les lignes que les filets maillants. Le type de matériel utilisé à Ramena conduit à une fréquence de pêche bien plus importante lorsque les catégories de poids plus élevés sont recherchées. Dans la mesure où la population locale continue de croître, les pressions associées à la pêche dans la baie d'Antsiranana continueront d'augmenter, à moins que des mesures efficaces ne soient mises en place. Il est donc essentiel d'établir rapidement un plan de gestion en concertation avec les populations locales, afin d'assurer la longévité de la pêcherie. Pour être efficace, ce plan de gestion devra veiller à considérer les particularités propres des différents types de pêche.

INTRODUCTION

Despite their perceived abundance, aquatic resources are limited and need appropriate management to ensure that they are utilised in a sustainable manner (Pauly 2008). Fishing is widely recognised as having a major influence on marine ecosystems throughout the world. It is well documented that industrial fishing causes serious habitat degradation through benthic dredging and trawling (Thrush and Dayton 2002), as well as overexploitation of species (Pauly et al. 2005). Traditional, artisanal and small-scale fisheries, by contrast, are generally considered to be less of a threat to marine ecosystems and tend to be associated with relatively low environmental impacts

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(Hawkins and Roberts 2004). Defining the terms traditional, artisanal and small-scale fisheries can be difficult due to geographical variations in the characteristics of a fishery (Mathew 2002): these types of fisheries, however are typically near-shore and utilised by fishers using relatively small-sized vessels and labour intensive methods with little or no modern technology (Sowman 2006, FAO 2009), as well as a variety of fishing techniques to target multiple species (Allison and Ellis 2001). In developing countries, fishing in small-scale fisheries is often part of a complex of livelihood activities, which may include agriculture and other part-time occupations (Jentoft 2000). In Madagascar the term artisanal fisheries refers to numerous motorized boats fishing for domestic and international markets, while the term traditional or small-scale fisheries refers to non-motorized, kinship-based fishing for subsistence or for local markets, undertaken by fishers who respect local customs and taboos (Mathew 2002).

In some parts of the Pacific, small-scale fisheries have been documented to have no significant impact on the state of coral reef ecosystems despite the fact that they have existed over the last thousand years (Dalzell 1998). Numerous other studies worldwide, however, have highlighted the negative impacts small-scale fisheries can have on reef systems (Mumby et al. 2006, Newton et al. 2007, Lokrantz et al. 2009). These detrimental effects are often associated with an increase in neighbouring human population densities, as well as climate change (Aronson and Precht 2006, Clark 2006). Documented impacts include reduced fish biomass of target species, high vulnerability to low intensity fishing in high trophic level families such as groupers and snappers, high vulnerability to fishing of large bodied fish (Hawkins and Roberts 2004), loss of species diversity (McClanahan et al. 2008) and the complete elimination of species from reef areas leading to ecosystem collapse (Hardt 2009). In the case of traditional forms of marine resource use, overexploitation can result in irreversible economic, social and cultural loss to fishing communities (Agardy 2000).

Over the last few centuries, only a few modifications to fishing methods have been implemented in small-scale fisheries across the world. The introduction of motorised boats and modern materials, such as monofilament nylon lines and artificial bait, constitute the main changes (Hawkins and Roberts 2004). What has changed, however, is the number of people supported by these fisheries and, driven by ever-growing coastal populations, the number of small-scale fisheries in developing countries has increased significantly in recent years (Iida 2005, Béné 2006). This has put further pressure on ecosystems that are already at risk from anthropogenic and environmental impacts.

Coral reefs support small-scale fisheries and provide an important source of protein for local communities in many developing countries worldwide (Sadovy 2005), with coral reef fisheries contributing about two to five percent of global catches (Pauly et al. 2002). An estimated annual yield of between five and 15 tons of fish and seafood per square kilometre per year can be harvested from a healthy, well-managed reef (Spalding et al. 2001) amounting to a total global annual yield of 1.4 to 4.2 million tons (Pauly et al. 2002).

Madagascar's coral reefs are rich and diverse marine ecosystems with an estimated 6,000 reef-associated species, including 752 fish species and 340 coral species (McKenna and Allen 2003). These ecosystems support multiple fisheries around the country with an estimated 43% of all fisheries per year (or 65,090 tons) being based on coral reefs (FAO 1999). As in many developing countries of the world, fishing constitutes an important source of food in Madagascar and to a lesser extent a source of income (Westmacott et al. 2000).

Antsiranana Bay, situated in the far north of Madagascar, comprises numerous sub-bays, which present a range of tropical coastal habitats including coral reef, seagrass and mangrove (Browne et al. 2007). These diverse habitats constitute an important natural resource for neighbouring villages. Due to a range of natural and anthropogenic factors, the bay exhibits variation in the condition of its reefs in terms of coral cover, fish diversity and fish biomass (Browne et al. 2007). The bay has a thriving small-scale fishing industry about which very little is known (Bigot et al. 2000), based on the daily use of fishing methods combining traditional techniques with modern materials.

This study focuses on two villages on opposite sides of the bay. The aim of the study was to use these two villages to assess the state of the fishery in Antsiranana Bay and identify trends or differences in the fishing techniques used as well as the opinion of local fishers towards resource use. The research was carried out to provide information for future resource management and conservation strategies, which take into account trends and differences between local fisheries in the bay.

METHODOLOGY

ANTSIRANANA BAY. Antsiranana Bay is located in northern Madagascar near the city of Antsiranana, formerly known as Diego Suarez (49°17'43" E, 12°17'17" S) (Figure 1). It is a shallow tropical bay with a mean depth of 30 m, entered by the Indian Ocean from the east. The interior of the bay is characterised by numerous small islands (Nosy Fano, Nosy Koba, Nosy Langoro, Nosy Laopasana, Nosy Volana, Nosy Longo), and a coastline lined with many, almost continuous, shallow fringing reefs. We divided the mainland coast of Antsiranana Bay into 13 arbitrary sectors to reflect potential differences in environmental conditions amongst the smaller sub-bays. Residents of Antsiranana, as well as eight village communities, use the bay for fishing; these include the two villages of Antsisikala and Ramena where surveys were conducted.

STUDY VILLAGES. Antsisikala, which is situated in the north of the bay, is a small village of approximately fifty houses (Antsisikala village president, pers. comm. December 2008). The villagers generate the majority of their income through zebu farming (a domestic breed of tropical cattle); fishing is carried out principally for subsistence and small-scale trading (Antsisikala village president, pers. comm. December 2008). This village was chosen because a less intensive level of fishing appears to take place there. By contrast, Ramena is a fishing village with an estimated population of 4,000 (ILO census data, Cornell University 2002) situated in the east of the bay, close to its entrance. Fishing is traditionally the main livelihood for locals in this village, although Ramena is increasingly becoming a tourist destination, and some fishers also provide tourist excursions (Ramena village member, pers. comm. July 2008). This village was chosen because a more intensive level of fishing was initially observed.

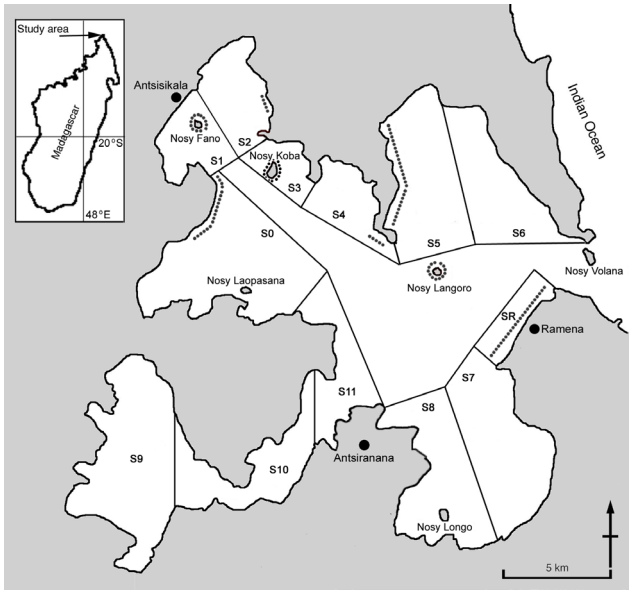

FIGURE 1. Map of Antsiranana Bay showing 13 designated study sectors (S0-S11 and Sector Ramena (SR)), islands and popular fishing areas (represented by dotted lines). Large black dots denote the regional capital Antsiranana and the two study villages Ramena and Antsisikala.

DIRECT OBSERVATIONS OF THE FISHERY. To describe the characteristics of the fishery the following observations were completed. One investigator made visual observations of fishing practices in the area surrounding Antsisikala (sectors 1, 2 and 3) between March and December 2008 and in the area surrounding Ramena (sector Ramena) between July and August 2008. These observations were made haphazardly at different times of the day depending on accessibility to fishers, with observation periods ranging from one to three hours. A total of ten hours observation over eight sampling days in Antsisikala and six hours observation over three sampling days in Ramena took place. Details of fishing effort, techniques and equipment used, time of day the fishing activity took place, and species caught were recorded.

FISHING AREAS. Each sector was surveyed for fishing vessels at random times during the day over the ten-month observation period to determine the most popular fishing areas during daylight hours (0600h to 1800h). Islands not in a sector were considered separately (Nosy Langoro, Nosy Volana). The number of fishing vessels observed in each sector or around Nosy Langoro and Nosy Volana were recorded during a period of one hour. The area of each sector/island was calculated by creating a polygon in Google Earth (version 5) and copying its properties into an online tool for Google Earth (Earthpoint 2011).

FISHER INTERVIEWS. To assess the current status of the fishery in Antsiranana Bay and to obtain fishers' opinions about resource use within the bay, a series of questionnaire interviews were conducted with fishers from the villages of Antsisikala and Ramena. Respondents were selected by asking village elders to identify specific village members who fish on a regular basis that would be willing to contribute to this study. Twenty-one different fishers were interviewed in Antsisikala on two separate occasions (July 2006 and August 2008) and 19 different fishers were interviewed in Ramena in December 2006. Interviews were conducted in Malagasy with the assistance of a translator. The interviews included fishers' personal details including age, marital status, number of children, main occupation/income and alternative sources of income. Fishers were asked questions on their use of marine resources within the bay focusing specifically on fishing activity, equipment preferences, target species, catch sizes, cultural traditions and their perceptions of how resources have changed over time. In order to determine the level of environmental awareness fishers have towards the use of marine resources within the bay, they were asked to choose the response (I strongly agree, I agree, neutral, I disagree, I strongly disagree) that best represented their opinion on a series of resource use based questions. A fish identification guide (Lieske and Myers 2001) was used to help the fishers correctly identify reef fish referenced in the interview.

DATA ANALYSIS. Chi-squared tests were performed to compare the total frequency counts for each fisher from Antsisikala and Ramena (collected during the questionnaire interviews) on the use of each gear type, the quantity of the total average daily catch, and how fish stocks have changed over time.

RESULTS

FISHERY CHARACTERISTICS OF ANTSISIKALA. In Antsisikala, fishing techniques are simple and based on traditional methods using modern materials. Fishers mainly employ a combination of methods using both hook and line and gill nets, the latter being used typically by a single fisher or by one pair of fishers. Three additional methods were observed at a lower frequency: (i) trolling, (ii) hand collection, and (iii) speargun fishing using snorkelling equipment. The use of each method differs according to the number of people and type of boat used, as described below.

The hook and line (*manjono tadim-bintana*) method is employed by all types of fishers from the village; lone fishers, fishers who work in a pair and groups of three to six fishers. Lone fishers typically use a wooden dugout canoe (pirogue) approximately two to 2.5 m in length, powered by a small sail made from rice sacks and / or a wooden oar. One pair of fishers uses a pirogue approximately three to four metres in length, powered by a small sail made from rice sacks and / or a wooden oar and / or five horsepower outboard. Groups of three to six fishers use large wooden boats approximately six metres in length powered by outboard engines ranging in horsepower between five and 25, used in combination with a large sail made from thick cotton. For all three groups of fishers, fishing activity was observed to occur during the day and night using this method. Fishing is typically carried out over a reef or on the reef edge using baited fishing hooks (ranging in hook size number 10–14) on a monofilament nylon fishing line ranging from 0.5 to 2 mm in diameter. Species caught included Carangidae, Lutjanidae, Mullidae, Siganidae, Lethrinidae, Serranidae, Nemipteridae, Labridae, Haemulidae, Caesionidae, Carcharhinidae, Scrombridae, Balistidae and Sphyraenidae. There was no by-catch observed with this method as all fish caught were landed and stored.

Gill nets (*mihaza talirano*) are typically used by lone fishers or by a pair of fishers. Nylon gill nets with floats attached to the top and weights to the bottom are used with a mesh size of three to four centimetres, ranging in length from 15 to 25 m. Nets are commonly placed over coral reefs and adjacent seagrass beds during the late afternoon, left *in situ* for up to ten hours and retrieved in the morning of the following day before sunrise. Species caught included Carangidae, Lutjanidae, Mullidae,

Siganidae, Scaridae, Nemipteridae, Acanthuridae, Lethrinidae, Haemulidae, Caesionidae, Carcharhinidae, Scrombridae, Balistidae, Dasyatidae and Sphyraenidae. There was minimal by-catch associated with this method, with only members of the family Tetraodontidae observed being caught and discarded.

Trolling (*mandraverave*) is predominantly used by pairs of fishers or groups of three to six using boats powered by large sails or outboard engines. Fishing activity was observed to occur during the day and night using this method, with up to six lines being observed in the water trolling at a single time. Fishers use thick monofilament nylon fishing line approximately three millimetres in diameter with a florescent lure attached to a three pronged hook (treble-hook) ranging in hook size number 6–10. Species caught included Carangnidae, Scrombidae and Sphyraenidae. There was no by-catch observed with this method.

The larger groups of three to six fishers hand collect edible sea cucumbers (holothuria – *trepang*) principally for export markets due to their high market value, and use speargun fishing (*saboa)* during daylight hours. Both methods used snorkelling equipment in free dives. Fish caught using the speargun method included Lutjanidae, Mullidae, Acanthuridae, Lethrinidae, Haemulidae and Serranidae.

FISHERY CHARACTERISTICS OF RAMENA. Fishers from Ramena employ larger-scale and more labour intensive fishing methods than those used in Antsisikala. Fishing takes place during daylight hours, using predominantly larger boats and beach seine nets. A total of five beach seines were noted during the observation period. Beach seines (*ragiragy)* are used by groups of six to ten fishers who assist in deploying the net from a large wooden boat (approximately six metres in length powered by outboard engines ranging in horsepower between five and 25) and bringing it to the shore with hauling ropes. Three to four men with snorkelling equipment swim or stand in the water around the net, aggressively hitting the surface of the water to herd the fish into the net. This process lasts for approximately one hour, with as many as eighteen people assisting to pull in the net. Beach seine nets are commonly modified, constructed from many pieces of different nylon nets with mesh sizes ranging from one to three centimetres, which tapers towards the back of the net, ending in a mesh size as small as one centimetre. The catch is dumped on the sand, sorted into species, placed into plastic baskets and washed. The fish species caught belonged to the following families: Clupeidae, Sphyraenidae, Lethrinidae, Siganidae, Hemirhamphidae, Fistulariidae, Tetraodontidae, Ostraciidae and Labridae. Discarded fish occasionally included pufferfish (Tetraodontidae), cowfish (Ostraciidae), cornetfish (*Fistularia* spp.), three-ribbon wrasse (*Stethojulis trilineata*) and striped catfish (*Plotosus lineatus*); these were left on the beach or in the case of striped catfish, placed in a hole in the sand and covered to prevent accidental injury caused by touching the venomous pectoral and dorsal spines. Fishing traps were seen stacked on the beach; however, no observations of the fishers deploying them were made. Guides on tourist boats within the bay were observed on three occasions attempting opportunistic fishing with spearguns. Although fishers listed use of hook and line or gill nets as fishing methods during the interviews, none of these were observed.

FISHING AREAS. The area around Ramena had the largest number of fishing vessels present per survey, suggesting a very high fishing pressure at this site in relation to its small area (2.02 km^2). Sectors 0, 4, 5 and Nosy Langoro also showed a relatively high number of fishing vessels, although not as high as in the sector surrounding Ramena (Supplementary Material S1). Nosy Langoro showed the highest level of fishing pressure relative to its size (0.01 km^2).

FISHER INTERVIEWS. The percentage of fishers responding to each question was calculated using the total number of responses given (n represents the total number of responses, not the number of respondents). Fishers from Antsisikala had an average age of 39, with the majority being married (70 %; n=21) with an average of three children. Eighty-five percent stated fishing (n=21) as their main occupation/income followed by farming (5 %; n=21) and other (10 %; n=21), including boat operator and carpenter. Alternative incomes for fishers came from farming (55 %; n=22), fishing (14 %; n=22), other (5 %; n=22), while 26 % (n=22) stated they had no alternative income. Ramena fishers had an average age of 32, with 80 % (n=19) being married with an average of two children. The majority of interviewees stated tourism (58 %; n=19) was their main income, while fishing was the main income for 42 % (n=19) fishers. Alternative incomes came from fishing (53 %; n=19) and other (5 %; n=19). Forty-two percent of fishers (n=19) said they had no alternative income.

Out of 40 interviewees 27 chose to respond to the question regarding fishers' interest in the bay (some fishers did not want to comment), stating fishing (Antsisikala 33 %; n=15, Ramena 44 %; n=18), subsistence (Antsisikala 40 %; n=15, Ramena 6 %; n=18) and transport (Antsisikala 7 %; n=15, Ramena 50 %; n=18) were the three most important in Antsiranana Bay. In Ramena, transport constituted the main interest in the bay by fishers, followed by fishing. Only 6 % (n=18) in Ramena stated subsistence was the most important interest in the bay compared to 40 % (n=15) in Antsisikala, with fishers stating that their interests in the bay can change on the basis of demand for food from the village. Twenty percent of fishers from Antsisikala declared conservation of the bay and its resources to be the main interest (n=15), none of the respondents in Ramena felt this way. Moral obligation, aesthetic value, religious value and tourism were not mentioned by fishers from either group as a main interest in the bay.

SEASONALITY. Sea conditions within the bay vary during the year with a calm season from November to March and a windy season during the austral winter from April to October, which complicates the use of areas exposed to the wind. The summer months of November to January were cited as the most favourable months for Antsisikala fishers (November 13 %, December 15 % and January 9 %; n=55). By contrast, in Ramena all fishers stated that they fish all year around with no particular preference (100 %; n=19).

RESOURCE USE. In order to identify how fishers use fish as a resource, they were asked why they target certain species. Targeting multiple species was common among fishers from Antsisikala with 80 % (n=20) targeting three species or more. Fishers (Antsisikala 32 %; n=34, Ramena 95 %; n=19) target certain species principally because they are common and widely available. Income (29 %; n=19) and the availability of gear (23 %; n=19) were only important factors for fishers from Antsisikala. Few fishers from Antsisikala targeted a particular fish species because they are what people like to eat (3 %; n=19) or because fishers are used to catching particu-

lar species (3 %; n=19). Additional reasons given for targeting specific fish by fishers from Antsisikala (9 %; n=19) included targeting abundant or 'non-competitive' species. Fishers stated that targeting fish that produce a large number of eggs would help prevent overfishing of the resource as there are many new small fish being produced. Catching large predatory fish such as sharks and jacks was considered to help boost numbers of fish lower down the food chain.

GEAR USE. To determine the differences in gear preferentially used within the two villages, fishers were asked which gear type they prefer. There is a striking difference between Ramena and Antsisikala in the types of gear used by fishers (Figure 2). Chi-square tests using the total frequency counts for fishers using each gear from Ramena and Antsisikala showed a significant association between gear use and which village the fishers come from (χ^2=16.90, p<0.005). Most notably, beach seine nets are used by 24 % (n=46) of fishers in Ramena, but none of the fishers from Antsisikala. Poison and dynamite were not mentioned as a fishing technique. When questioned about the evolution of fishing techniques, 100 % (n=21) of Antsisikala fishers and 84 % (n=19) of Ramena fishers said that they had never changed their technique for as long as 57 years. Only fishers from Ramena declared a change in fishing technique (16 %; n=19).

CATCH SIZE. To identify the quantity of fish caught on a daily basis, fishers were asked to estimate a figure of their total average daily catch (in kilogrammes). The majority of fishers from Antsisikala (95 %; n=21) reported a mean daily catch weight between 0–24 kg, compared to 58 % (n=19) from Ramena. There was a significantly higher frequency of reported catches from the 25–49 kg (Antsisikala 0 %; n=21, Ramena 21 %; n=19) and 50–75 kg (Antsisikala 6 %; n=34, Ramena 5 %; n=19) weight classes by fishers from Ramena compared to Antsisikala (χ^2=8.53, p<0.05). Five percent of fishers from Ramena reported total mean daily catch weights >75 kg. No fishers from Antsisikala reported a daily catch of over 75 kg.

PERCEPTION OF CHANGE. Fishers were asked how they perceive fish stocks to have changed over time within the bay. A greater percentage of fishers from Antsisikala perceived a recent decline in both catch size (71 %; n=21) and abundance (95 %; n=21) (Figure 3). Fishers from Ramena perceived a decrease in abundance (67 %; n=18), but no change in catch size (53 %; n=19) or average size of fish caught (63 %; n=19). Very few fishers perceived that there had been an increase in catch size, abundance or average fish size. The difference in opinions of fishers from Ramena and Antsisikala regarding the evolution of fish resources was not statistically significant (χ^2=18.45, p>0.10). Fishers were asked to provide potential reasons for the change in fish resources. There was no common answer to this question,

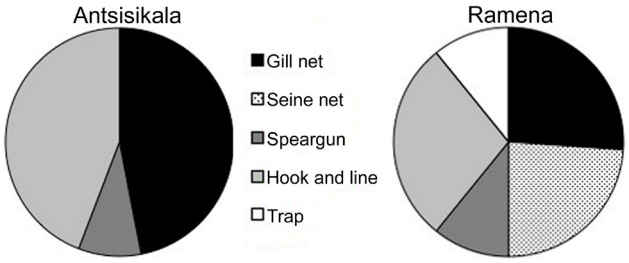

FIGURE 2. Percentage of different fishing gears used by fishers in a) Ramena (19 respondents) and b) Antsisikala (21 respondents).

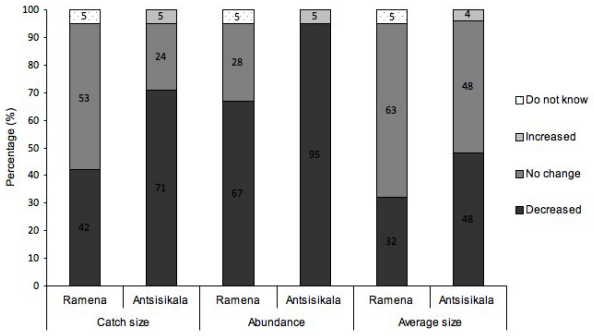

FIGURE 3. Fishers' opinion of the state of fish resources (Antsisikala, 21 respondents; Ramena, 19 respondents). The responses "do not know", "increased", "no change" and "decreased" refer to fishers' perception of how each catch parameter has changed over time.

either in Antsisikala or Ramena. Among those who perceived a change in Ramena, the majority suggested the lack of rain that forced farmers to turn to fishing (21 %; n=19); another reason stated was that octopus had moved to deeper water (11 %; n=19). Additional responses from the Ramena fishers included overfishing and climate change (5%; n=19). By contrast, in Antsisikala interviewees blamed the following: overfishing by fishers from Ramena through the use of beach seine nets; an increase in the number of fishers; climate change; seasonal variations (9 %; n=22) followed by less rain leading to more fishing instead of farming; coral damage through spear fishing techniques; and octopus moving to deeper water (5 %; n=22). Eighteen percent gave additional responses that included: the weather becoming increasingly windy; too many fishers do not throw small fish back; and there are no laws regulating fishing. Fifty-three percent of fishers in Ramena perceived no change compared to 9 % of fishers from Antsisikala.

HANDLING OF BY-CATCH. Interviewees were asked under which circumstances they would return fish to the ocean to assess their opinion on catching non-target species or juvenile fish. For each village, 20 % (Antsisikala n=35; Ramena n=15) of fishers said they would never throw any of their catch back. Fishers from Ramena would only throw fish back if they are too small (80 %; n=15). Fishers from Antsisikala would throw fish back if they are either too small (34 %; n=35), non-target species (32 %; n=35) or not valuable (14 %; n=35).

SELLING FISH. Fishers were asked where they prefer to sell their fish. The city of Antsiranana was the most popular place to sell fish for fishers from Ramena (63 %; n=19), which was followed by selling it locally (37 %; n=19). Antsisikala is different, with fishers selling the majority of their catch to their own village (44 %; n=27), with Antsiranana the second most popular place to sell fish (33 %; n=27). Fishers also chose to sell to a collector in Antsiranana (15 %; n=27). A minority of fishers from Antsisikala (7 %; n=27) chose not to sell their fish at all.

CULTURAL ASPECTS. To identify how cultural traditions influence fishing activity in the bay, fishers were asked whether they follow certain *fady* (traditional beliefs or taboos) when fishing. Out of the 20 interviewees from Antsisikala who responded to the question regarding *fady*, the majority of fishers (55 %) stated that there were no local *fady* associated with fishing in Antsiranana Bay. By contrast, all fishers from Ramena (100 %; n= 19) said that there were *fady*. The *fady* differed

from fisher to fisher and included the following: not offending the ancestors; not cursing while fishing; not fishing at night; not using lights at night to fish; not banging the water; and not using metal in the water.

ENVIRONMENTAL AWARENESS. In order to determine the level of environmental awareness towards the use of marine resources within the bay, fishers were asked to give their opinion on how best to ensure the availability of marine resources for future generations. These suggestions were provided to also gain an idea of their opinion on potential conservation and resource management strategies. The responses to these questions were very diverse (Table 1). In both villages, the majority agreed that using fishing nets with a mesh superior to four centimetres and stopping deforestation in coastal areas would help ensure the availability of marine resources in the bay. It was also thought that an increase in tourism would be beneficial in bringing alternative sources of income. A majority of fishers from both villages (Antsisikala 56 % agree (n=18)), in particular from Ramena (21 % strongly agree, 56 % agree; n=18), also stated that nothing needed to be done as there were enough fish and that fishers themselves should decide how much fish they catch. They also agreed that praying to the ancestors would help improve fish abundance. The majority of fishers from Antsisikala (39 % strongly agree, 39 % agree; n=18), and a minority in Ramena (37 % strongly agree, 10 % agree; n=18) agreed that different communities should work more closely together to manage marine resources and that fishers should catch only large fish and certain species, or only fish in specific areas and on certain days. Eating less fish was also suggested and eating more zebu was mentioned by some fishers as an alternative. In addition, a majority of fishers from Antsisikala (28 % strongly agree, 55 % agree; n=18) suggested that the village chief should control the size of fish catch, whereas in Ramena a higher proportion of fishers agreed that the government in Antsiranana should control fish catch sizes.

DISCUSSION

Antsiranana Bay provides essential marine resources for the two coastal communities studied, whose incomes depend heavily on fishing for both commercial and non-commercial gain. Since local roads are poorly maintained, the water also provides an important means of transporting for both people and goods, such as livestock and fish, between local villages and the main port of Antsiranana. The different uses of marine resources in the bay are representative of many other coastal areas in Madagascar (Laroche et al. 1997, Billé and Mermet 2002, Rakotoson and Tanner 2006).

Fishing, which is one of the principal means of income of fishers within the bay and hence constitutes an important part of the local economy, is directly affected by seasonal changes in weather. Annual differences in climatic conditions which occur in the north of Madagascar appear to affect the level of fishing activity carried out in the bay throughout the year. During the austral winter (April to October) strong onshore winds originating from the Indian Ocean are present. These winds, locally known as *varatraza*, cause considerable wave action in the bay given its enclosed nature and can prove hazardous to small vessels operating within the bay (Antsisikala village fisher, pers. comm. December 2008). Fishing practices in Antsisikala which tend to use smaller non-motorised vessels appear to be heavily influenced by the weather conditions, with more fishing activities occurring during the summer season (November to March) when sea conditions are calm. In Ramena, however, fishers who use larger motorised boats tend to fish the whole year round. The influence of seasons therefore reflects the different livelihood characteristics of each village.

The majority of fishers, both in Ramena and Antsisikala, choose to target multiple fish species using various methods. This non-discriminative fishing practice is characteristic of reef fisheries across the world (McClanahan and Mangi 2004) and in other regions of Madagascar (Laroche et al. 1997, Harris 2007),

TABLE 1. Fishers' opinion on how best to ensure the sustainable use of marine resources. Ram = Ramena, Ant = Antsisikala (Total number of respondents 40).

Question	Response									
	Strongly agree %		Agree %		Neutral %		Disagree %		Strongly disagree %	
	Ram	Ant	Ram	Ant	Ram	Ant	Ram	Ant	Ram	Ant
Communities should work together	37	39	10	39	53	11	0	11	0	0
Deforestation in coastal areas should be stopped	33	50	56	38	11	0	0	6	0	6
Each fisherman should decide ho much fish he catches	21	22	79	56	0	11	0	11	0	0
Eat less fish	17	33	11	17	72	33	0	6	0	11
Get more tourists to the bay as an alternative source of income	12	39	75	44	13	6	0	11	0	0
Nothing specific, there is enough fish	21	0	56	56	17	6	6	32	0	6
Only catch certain fish species	5	17	0	39	84	28	11	16	0	0
Only catch large fish	16	50	26	44	58	6	0	0	0	0
Only fish in specific areas	0	22	6	28	88	11	6	39	0	0
Only go out fishing on certain days	5	22	37	61	42	5	16	6	0	6
Prey for more fish/ask ancestors	37	11	58	44	5	28	0	17	0	0
The government in Diego should control fish catch size	21	6	26	33	53	33	0	17	0	11
The village head/chief should control the size of fish catches	26	28	16	55	58	11	0	0	0	6
Use fishing nets with >4cm mesh	44	33	25	44	31	17	0	6	0	0

where the assemblages over reefs contain a variety of families (Choat and Robertson 2006). The choices of fishers to target particular species could have wider implications for future fisheries management, as repeatedly targeting the same species can result in numerous associated environmental impacts in the context of overfishing (Hawkins and Roberts 2004, Lokrantz et al. 2009).

Fishing equipment often determines which species fishers catch, as different types of equipment are used to target fish at different trophic levels. The hook and line method and traps (depending on mesh size) are moderately selective, while spearguns are highly selective; beach seine nets and gill nets, by contrast, are largely non-selective (McClanahan and Mangi 2004). Gear selectivity can have impacts at different trophic levels and therefore affect the structure of the fishery and the structural complexity of food webs (McClanahan and Mangi 2004). Further study into gear selectivity and catch composition, specific to this region of Madagascar would assist in the development of gear-based management recommendations for local fisheries.

The majority of fishers from Antsisikala fish from single pirogues using hook and line or gill nets in small-scale fishing efforts for subsistence and small-scale trade rather than commercial purposes. This is typical of small-scale reef fisheries, as enough fish are caught to provide for a family or village, with any excess being sold (McGoodwin 2001). By contrast, beach seine nets and traps are used significantly more frequently in Ramena. Although these fishers claimed to use hook and line and gill nets, they were never observed using it; a contradiction that could be explained by the small sample size of fishery observations in Ramena. Hook and line, gill nets, traps and spearguns do not yield large amounts of fish, as most fishers using these techniques had an average catch weight of 0–24 kg. Fishers from Ramena tend to report heavier total average daily catches than those fishers from Antsisikala, which is likely due to the use of small mesh size beach seine nets. The use of beach seine nets requires a high fishing effort from community members, who assist in pulling the net in. With this large amount of community participation, the catch is distributed around those that helped. However, the use of beach seine nets is detrimental to the habitats where it is used, because it is both unselective and removes juveniles (McClanahan and Mangi 2004), and it also tends to destroy corals, sponges and seagrass beds over which the nets are dragged (McClanahan and Mangi 2001). The lack of selectivity of this type of gear is highlighted by the fact that catches frequently comprise a mix of reef, seagrass, reef-associated and coastal pelagic fish, including juvenile fish and non-edible fish.

The fisheries of both Ramena and Antsisikala generally have very little wastage, with fish being thrown back only if they are too small, not valuable or inedible. However, fishers using beach seine nets in Ramena were observed sorting the catch on the sand into fish types and discarding inedible or poisonous fish. Although 80 % of fishers from Ramena stated in their interviews that undersized fish were returned to the water, the contrary was often observed. This indicates a lack of understanding of the ecological importance of returning fish to the water. Indeed, if fishers used unmodified nets with transparent monofilament nylon panels of mesh inserted in the anterior region of the bunt section of the net, immediately before the mouth of the net, then it would greatly improve size selectivity and the by-catch of non-target reef species could be dramatically reduced (Gray et al. 2000). Based on the behavioural responses of fish in seine nets, the addition of these panels provides undersized or slow moving fish an alternative clear passage to entering the net mouth as fish naturally swim towards areas of the net with higher light levels (Gray et al. 2000).

By-catch on coral reefs is commonly associated with a decline in ecosystem function caused by the removal of fish, leading to cascading effects on the composition, biomass and density of other reef fish species (Hall et al. 2000). The use of non-selective equipment such as gill nets, beach seine nets and traps, particularly when modified to have small mesh sizes as in the case of the beach seine nets used in Ramena, is widely recognised as having negative impacts on coral reef ecosystems (McClanahan and Mangi 2001, 2004). Fine mesh nets and traps are commonly associated with the removal of non-target species and juvenile fish (McClanahan and Mangi 2004). There is therefore the need to implement management strategies to regulate the types of gear used to reduce by-catch.

According to fishers, techniques have not changed in the time they have been fishing with fishers from both villages observed using modern materials, reflecting similar findings in other coastal fishing communities in Madagascar (Gough et al. 2009). Nylon fishing line and nets are commonly used, as they are lighter, more durable and less visible to the fish than traditional natural materials. The use of these modern materials is likely to have led to an increase in the effectiveness of fishing methods leading to a greater proportion of available fish being caught. For these reasons, any decrease in overall fish populations could potentially have been masked (Sabetian and Foale 2006).

Fishers' opinions on the state of marine resources within the bay differ greatly between Ramena and Antsisikala. Fishers from Antsisikala generally perceived that fish populations within Antsiranana Bay have declined, with a greater proportion of fishers acknowledging a decline in catch size and abundance in Antsisikala than Ramena. Among the fishers who had noticed such a decline, most respondents believed that a certain level of overfishing was taking place. The acknowledgement of practices leading to overfishing could provide an important trigger for local people to consider the introduction of resource management plans.

Fishers stated a number of locations where they sell their catch. The high level of demand for seafood and the lucrative prices offered by wholesale buyers and restaurants in Antsiranana provides an attractive location for fishers to sell their catch (Antsisikala village fisher, pers. comm. December 2008). Fishers from Ramena are geographically closer to Antsiranana making it more convenient to sell their catch there on a daily basis. They also choose to sell it locally, which is likely to be supplying the growing demand from tourists in Ramena. Fishers from Antsisikala need to travel a greater distance to sell their catch and will thus only do so when they have a surplus of fish from an unusually large catch. Further investigation is required to accurately assess the level of demand for seafood products from Antsiranana and Ramena and how it affects local fisheries within the bay.

With an average 3.2 % population growth in Madagascar (Billé and Mermet 2002) and an increase in the number of tourists in Antsiranana Bay (Christie and Crompton 2003), fishing pressure is likely to become exacerbated, especially in Ramena where tourism is expanding (Hotel proprietor, pers. comm. July 2008). Ramena is traditionally a fishing village, although many fishers now consider tourism as their main source of income reflecting the expansion of tourism in this village. The effects of an increasing coastal population and growing demand of seafood products have been well documented by fishery studies globally (Gedamke et al. 2007) and in sub-Saharan Africa (Tietze et al. 2000, Machena and Moehl 2001). The rise in fishing pressure presents a significant management issue, which needs to be addressed to ensure fish populations are safeguarded for future generations. This increase in fishers and fishing pressure is characteristic of many other coastal areas in Madagascar (Laroche and Ramananarivo 1995, McVean et al. 2005) and beyond (Kaunda-Arara et al. 2003).

While fishing pressure is likely to increase within the bay, with many fishers from both villages perceiving a decrease in fish catch size and abundance, the collection of baseline data on fish stocks and the monitoring of changes over time are recommended to allow the development of management strategies to use fish resources sustainably. The negative responses from Ramena's fishers regarding how best to ensure the sustainable use of marine resources within the bay, suggest that they are more likely to show some resistance to management plans such as no-take zones, which would restrict where they are permitted to fish. Fishing in both Antsisikala and Ramena is one of the main livelihood activities, and imposing restrictions on fishing activity is therefore likely to affect both villages. Any future fisheries management plans for Antsiranana Bay will need to take into account these crucial differences between small-scale fisheries and opinions on resource use within the bay.

The investigation of fishing practices in Ramena and Antsisikala highlighted important differences between the two villages in their fishing style, the amount of fish they catch, the type of gear they use, and the opinions on the current state of the fishery. The methods used to obtain the data for this study were limited by a number of factors such as sea conditions, time available to carry out data collection, financial resources, accessibility to fishers and their trust towards the investigators performing the research. Therefore, a flexible approach towards data collection was employed to enable information gathering whenever opportunities presented themselves. Spending more time within the community and directly with fishers would increase levels of trust between fishers and investigators to allow a more structured and systematic approach to data collection.

RECOMMENDATIONS FOR MANAGEMENT. Community-based governance of the coastal zone and marine resources has been recommended as a management strategy by numerous studies globally and in Madagascar, to assist enforcement of regulations governing resource use (McKenna and Allen 2003, Rakotoson and Tanner 2006, Cinner and Aswani 2007). In Madagascar, *dina* as a voluntary social code of conduct that governs relations within and between communities, has become a widely-used tool to facilitate natural resource management (Andriamalala and Gardner 2010). *Dina* is a legally recognised governance tool that allows local communities to have a participatory role in managing their resources, as well as being able to enforce regulations and resolve conflicts between users. This study found that local beliefs and traditions (e.g., *fady*) are still alive in the region (e.g., Ramena). Many of these *fady* are specific to villages and may even differ within each village. Where practical, and particularly if they support resource management, incorporating local traditions and beliefs into prospective management strategies through using *dina* as its mechanism, could be a viable tool to engage local peoples to manage the marine and coastal resources of Antsiranana Bay (Rakotoson and Tanner 2006). Combining *dina* as the legitimate 'bottom up' governance tool, with legal governmental framework as the 'top down' governance tool could be a viable management strategy, as examples from other parts of Madagascar such as Antongil Bay on the north-eastern part of the country proved successful (Rakotoson and Tanner 2006).

Improving the sustainability of fisheries within Antsiranana Bay by reducing the overexploitation of fish resources is unlikely to be achieved without identifying and supporting alternative livelihoods for many of the people currently dependent on reef fisheries (Newton et al. 2007). Both villages stated that they participated in alternative livelihood activities such as tourism in Ramena and farming in Antsisikala to create income. Further diversifying their livelihood activities particularly through an increase in tourism, a strategy welcomed by many fishers from both villages, as well as encouraging children to remain in education and providing information on achievable career opportunities could help reduce the number of people from future generations becoming fishers (Davies et al. 2009).

The implementation of a regional environmental education programme including participatory workshops for the local communities that rely on the bay and its marine resources could raise awareness and knowledge on a number of important issues affecting marine resources within the bay. As the responses from each village regarding environmental awareness towards the use of the marine resources varied considerably, an education programme could help to raise awareness and understanding, which could in turn increase cooperation between villages making management strategies more likely to succeed. This could further provide a mechanism to help improve the sustainable use of the bay's resources and promote the development of responsible fishing, especially in villages like Ramena where fishing is more intensive and non-selective equipment is used. Following these initiatives, community involvement will be key to the long-term conservation of Antsiranana Bay and the sustainable use of its marine resources.

The use of mesh sizes smaller than 25 mm is illegal in Madagascar (Rakotoson and Tanner 2006) and is recognised as a highly unsustainable and destructive technique in many east African and Indian Ocean coastal states (McClanahan and Mangi 2004, Tobey and Torell 2006). However, a lack of knowledge by fishers and lack of law enforcement are likely to be the reason for the continual use of small mesh size beach seine nets. A complete ban on beach seine nets is unlikely to be successful as using this type of fishing gear is the most effective method of catching coastal pelagic species (Clupidae) that are known to be an important fish resource for coastal communities in Madagascar (McClanahan and Mangi 2004, Davies et al. 2009). Restricting the use of beach seine nets and regulating mesh sizes of all fishing nets through the use of *dina*, therefore build-

ing on the opinion of many fishers from both villages who stated that using larger mesh size nets is a viable option for exploiting marine resources more sustainably, would help reduce by-catch and diminish the negative effects of overexploitation of fish resources (Lindholm et al. 2001, McClanahan and Mangi 2004, Rakotoson and Tanner 2006).

CONCLUSIONS

With a steady growth in the population of Antsiranana and other villages around the bay and an increase in tourism, the future of the fishery in Antsiranana Bay needs to be regulated, as with many fisheries in developing and developed countries, to ensure sustainable resource use. The establishment of an Antsiranana Bay fishery alliance that would include representatives from key stakeholder groups such as fishers from each village, business and hotel owners, local government officials from Antsiranana and local conservation organisations, could help develop actions for responsible fishing practices though the use of *dina*. The formation of such a body could help to sustainably manage the bay's resources. The different needs of each village, including differences in opinion on marine resource use, who they would like to see manage these resources and the fishing techniques used as highlighted in Ramena and Antsisikala, should be taken into consideration, in addition to incorporating local beliefs and ecological/fishery information into management plans, wherever possible.

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REFERENCES

Agardy, T. 2000. Viewpoint effects of fisheries on marine ecosystems: a conservationist's perspective. ICES Journal of Marine Science 57: 761–765.

Allison, E. H. and Ellis, F. 2001. The livelihoods approach and the management of small-scale fisheries. Marine Policy 25, 5: 377–388. (doi:10.1016/S0308-597X(01)00023-9)

Andriamalala, G. & Gardner, C. J. 2010. L'utilisation du dina comme outil de gouvernance des ressources naturelles: Leçons tirés de Velondriake, sud-ouest de Madagascar. Tropical Conservation Science 3, 4: 447–472.

Aronson, R. B. and Precht, W. F. 2006. Conservation, precaution, and Caribbean reefs. Coral Reefs 25, 3: 441–450. (doi:10.1007/s00338-006-0122-9)

Béné, C. 2006. Small-scale fisheries: assessing their contribution to rural livelihoods in developing countries. FAO Fisheries Circular. No. 1008, pp 46. FAO, Rome.

Bigot, L., Charpy, L., Maharavo, J., Rabi, F. A., Paupiah, N., Aumeeruddy, R., Villedieu, C. and Lieutaud, A. 2000. Status of coral reefs of the southern Indian Ocean: The Indian Ocean Commission Node for Comoros, Madagascar, Mauritius, Reunion and Seychelles. In: Status of Coral Reefs of the World. C. Wilkinson (ed), pp 77–94. Australian Institute of Marine Science, Australia. Available at <http://gridnairobi.unep.org/chm/EAFDocuments/Eastern_Africa/reefbase_GCRMN2000_CH5.pdf>

Billé, R. and Mermet, L. 2002. Integrated coastal management at the regional level: Lessons from Toliary, Madagascar. Ocean & Coastal Management 45, 1: 41–58. (doi:10.1016/S0964-5691(02)00048-0)

Browne, N. B., Markham, H., Fanning, E. and Weaver, D. 2007. A Proposed Marine Management Strategy: Antsiranana Bay. Frontier-Madagascar Environmental Research Report 16. Society for Environmental Exploration, UK and L'Institut Halieutique et des Sciences Marines, Toliara. Available at <http://www.frontier.ac.uk/Publications/Files/2010_11_22_17_24_26_564.pdf>

Christie, I. T. and Crompton, D. E. 2003. Republic of Madagascar: Tourism Sector Study. Africa Region Working Paper. Series No. 63. The World Bank.

Choat, J. H. and Robertson, D. R. 2006. Age-based studies. In: Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem. P. F. Sale (ed.), pp 57–80. Academic Press, London.

Cinner, J. E and Aswani, S. 2007. Integrating customary management into marine conservation. Biological Conservation 140, 3–4: 201–216. (doi:10.1016/j.biocon.2007.08.008)

Clark, B. M. 2006. Climate change: A looming challenge for fisheries management in southern Africa. Marine Policy 30, 1: 84–95. (doi:10.1016/j.marpol.2005.06.006)

Dalzell, P. 1998. The role of archaeological and cultural-historical records in long-range coastal fisheries resources management strategies and polices in the Pacific Islands. Ocean & Coastal Management 40, 2–3: 237–252. (doi:10.1016/S0964-5691(98)00043-X)

Davies, T. E., Beanjara, N. and Tregenza, T. 2009. A socio-economic perspective on gear-based management in an artisanal fishery in south-west Madagascar. Fisheries Management and Ecology 16, 4: 279–289. (doi:10.1111/j.1365-2400.2009.00665.x)

Earth Point. 2011. <http://www.earthpoint.us/Shapes.aspx> accessed 25 March 2011.

FAO. 1999. Number of fishers 1970–1996, revision 1. Fishery Information Data and Statistics Unit. Food and Agriculture Organization of the United Nations, Rome.

FAO. 2009. Fisheries and Aquaculture Report/FAO Rapport sur les pêches et l'aquaculture. No. 904. Food and Agriculture Organization of the United Nations, Rome.

Gedamke, T., Hoenig, J. M., Musick, J. A., DuPaul, W. D. and Gruber, S. H. 2007. Using demographic models to determine intrinsic rate of increase and sustainable fishing for elasmobranchs: Pitfalls, advances, and applications. North American Journal of Fisheries Management 27, 2: 605–618. (doi: 10.1577/M05-157.1)

Gough, C., Thomas, T., Humber, F., Harris, A., Cripps, G., and Peabody, S. 2009. Vezo Fishing: An Introduction to the Methods Used by Fishers in Andavadoaka Southwest Madagascar. Blue Ventures Conservation Report. Blue Ventures, UK. Available at <http://blueventures.org/images/downloads/research/Fisheries_Report_final_web.pdf>

Gray, C. A., Larsen, R. B. and Kennelly, S. J. 2000. Use of transparent netting to improve size selectivity and reduce bycatch in fish seine nets. Fisheries Research 45, 2: 155–166. (doi:10.1016/S0165-7836(99)00111-3)

Hall, M. A., Alverson, D. L. and Metuzals, K. I. 2000. By-catch: Problems and solutions. Marine Pollution Bulletin 41, 1–6: 204–219. (doi:10.1016/S0025-326X(00)00111-9)

Harris, A. 2007. "To live with the Sea" – development of the Velondriake community managed protected area network, southwest Madagascar. Madagascar Conservation & Development 2: 43–49.

Hardt, M. J. 2009. Lessons from the past: The collapse of Jamaican coral reefs. Fish and Fisheries 10, 2: 143–158. (doi:10.1111/j.1467-2979.2008.00308.x)

Hawkins, J. P. and Roberts, C. M. 2004. Effects of artisanal fishing on Caribbean coral reefs. Conservation Biology 18, 1: 215–226. (doi:10.1111/j.1523-1739.2004.00328.x)

Iida, T. 2005. The past and present of the coral reef fishing economy in Madagascar: Implications for self-determination in resource use. Senri Ethnological Studies 67: 237–258.

ILO Census Data. 2002. Cornell University. <http://www.ilo.cornell.edu/ilo/data.html> accessed 25 March 2011.

Jentoft, S. 2000. The community: a missing link of fisheries management. Marine Policy 24, 1: 53–60. (doi:10.1016/S0308-597X(99)00009-3)

Kaunda-Arara, B., Rose, G. A., Muchiri, M. S. and Kaka, R. 2003. Long-term trends in coral reef fish yields and exploitation rates of commercial species from coastal Kenya. Western Indian Ocean Journal of Marine Science 2, 2: 105–116.

Laroche, J. and Ramananarivo, N. 1995. A preliminary survey of the artisanal fishery on coral reefs of the Tulear region (southwest Madagascar). Coral Reefs 14, 4: 193–200. (doi:10.1007/BF00334341)

Laroche, J., Razanoelisoa, J., Fauroux, E. and Rabenevanana, M. W. 1997. The reef fisheries surrounding the southwest coastal cities of Madagascar. Fisheries Management and Ecology 4, 4: 285–299. (doi:10.1046/j.1365-2400.1997.00051.x)

Lieske, E. and Myers, R. 2001. Coral Reef Fishes: Indo-Pacific & Caribbean. Princeton University Press, New Jersey.

Lindholm, J. B., Auster, P. J., Ruth, M. and Kaufman, L. 2001. Modelling the effects of fishing and implications for the design of marine protected areas: Juvenile fish responses to variations in seafloor habitat. Conservation Biology 15, 2: 424–437. (doi:10.1046/j.1523-1739.2001.015002424.x)

Lokrantz, J., Nystrom, M., Norstrm, A. V., Folke, C. and Cinner, J. E. 2009. Impacts of artisanal fishing on key functional groups and the potential vulnerability of coral reefs. Environmental Conservation 36, 4: 327–337. (doi:10.1017/S0376892910000147)

Machena, C. and Moehl, J. 2001. Sub-Saharan African aquaculture: regional summary. In: Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand. R. P. Subasinghe, P. Bueno, M. J. Phillips, C. Hough, S. E. Clattery and J. R. Arthur (eds.), pp 341–355. NACA, Bangkok and FAO, Rome.

Mathew, S. 2002. Small-scale fisheries perspectives on an ecosystem-based approach to fisheries management. In: Sinclair, M., Valdimarsson, G. (Eds.), Responsible Fisheries in the Marine Ecosystem. CAB International, Wallingford.

McClanahan, T. R. and Mangi, S. 2001. The effect of a closed area and beach seine exclusion on coral reef fish catches. Fisheries Management and Ecology 8, 2: 107–121. (doi:10.1046/j.1365-2400.2001.00239.x)

McClanahan, T. R. and Mangi, S. C. 2004. Gear-based management of a tropical artisanal fishery based on species selectivity and capture size. Fisheries Management and Ecology 11, 1: 51–60. (doi:10.1111/j.1365-2400.2004.00358.x)

McClanahan, T. R., Hicks, C. C. and Darling, E. S. 2008. Malthusian overfishing and efforts to overcome it on Kenyan coral reefs. Ecological Applications 18, 6: 1516–1529. (doi:10.1890/07-0876.1)

McGoodwin, J. R. 2001. Understanding the cultures of fishing communities: A key to fisheries management and food security. FAO Fisheries Technical Paper. No. 401. FAO, Rome.

McKenna, S. A. and Allen, G. R. (eds.) 2003. A rapid marine biodiversity assessment of northwest Madagascar. Conservation International, Washington, DC. Available at <http://www.conservation.org/Documents/RAP_Reports/RAP31_Coral_NW_Madagascar_Jan-2002.pdf>

McVean, A. R., Hemery, G., Walker, R. C. J., Ralisaona, B. L. R. and Fanning, E. 2005 Traditional sea cucumber fisheries in southwest Madagascar: A case-study of two villages in 2002. SPC Beche-de-mer Information Bulletin 21: 15–18. Available at <http://frontier-publications.co.uk/reports/Madagascar/PeerReview/Marine/410McVeanetal2005.pdf>

Mumby, P. J., Dahlgren, C. P., Harborne, A. R., Kappel, C. V. et al. 2006. Fishing, trophic cascades, and the process of grazing on coral reefs. Science 311, 5757: 98–101. (doi:10.1126/science.1121129)

Newton, K., Côté, I. M., Pilling, G. M., Jennings, S. and Dulvy, N. K. 2007. Current and future sustainability of island coral reef fisheries. Current Biology 17, 7: 655–658. (doi:10.1016/j.cub.2007.02.054)

Pauly, D., Christensen, V., Guénette, S., Pitcher, T. J., Sumaila, R. U., Walters, C. J., Watson, R. and Zeller, D. 2002. Towards sustainability in world fisheries. Nature 418: 689–695. (doi:10.1038/nature01017)

Pauly, D.,Watson, R. and Alder, J. 2005. Global trends in world fisheries: Impacts on marine ecosystems and food security. Philosophical Transactions of the Royal Society B 360, 1453: 5–12. (doi:10.1098/rstb.2004.1574)

Pauly, D. 2008. Global fisheries: A brief review. Journal of Biological Research-Thessaloniki 9: 3–9.

Rakotoson, L. R. and Tanner, K. 2006. Community-based governance of coastal zone and marine resources in Madagascar. Ocean & Coastal Management 49, 11: 855–872. (doi:10.1016/j.ocecoaman.2006.08.003)

Sabetian, A. and Foale, S. 2006. Evolution of the artisanal fisher: Case studies from Solomon Islands and Papua New Guinea. SPC Traditional Marine Resource Management and Knowledge Information Bulletin 20: 3–10.

Sadovy, Y. 2005. Trouble on the reef: The imperative for managing vulnerable and valuable fisheries. Fish and Fisheries 6: 167–185.

Sowman, M. 2006. Subsistence and small-scale fisheries in South Africa: A ten-year review. Marine Policy 30, 1: 60–73. (doi:10.1016/j.marpol.2005.06.014)

Spalding, M. D., Green, E. P. and Ravilious, C. 2001. World Atlas of Coral Reefs. University California Press, Berkeley, California.

Tietze, U., Groenewold, G. and Marcoux, A. 2000. Demographic change in coastal fishing communities and its implications for the coastal environment. FAO Fisheries Technical Paper No. 403. FAO, Rome.

Thrush, S. F. and Dayton, P. K. 2002. Disturbance to marine benthic habitats by trawling and dredging: Implications for marine biodiversity. Annual Review of Ecology and Systematics 33: 449–473. (doi:10.1146/annurev.ecolsys.33.010802.150515)

Tobey, J. and Torell, E. 2006. Coastal poverty and MPA management in mainland Tanzania and Zanzibar. Ocean & Coastal Management 49, 11: 834–854. (doi:10.1016/j.ocecoaman.2006.08.002)

Westmacott, S., Cesar, H. S. J., Pet-Soede, L. and Lindén, O. 2000. Coral bleaching in the Indian Ocean: Socio-economic assessment of effects. In: Essays on the Economics of Coral Reefs. H. S. J. Cesar (ed.), pp 94–106. CORDIO, Kalmar University, Sweden.

SUPPLEMENTARY MATERIAL.

AVAILABLE ONLINE ONLY.

TABLE S1. Number of vessels recorded in each sector of the bay.
TABLE S2. Sample questionnaire – village fishers.

ARTICLE

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A conservation assessment of *Rousettus madagascariensis* (G. Grandidier, 1928, Pteropodidae) roosts in eastern Madagascar

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ABSTRACT

We visited four cave roosts of the near threatened, and endemic, fruit bat *Rousettus madagascariensis* over a five year period and found major threats to the bats from hunting and deforestation. The conservation of this species is particularly challenging because it is legally hunted inside its cave roosts. Although provisional protected area status was obtained for two sites with community support, hunting continued. *R. madagascariensis* roosts were associated with humid forest and the loss of vegetation around caves rendered them unsuitable for the bats at two abandoned sites. A few individual hunters can have a rapid and destructive impact on *R. madagascariensis* roosts and future initiatives in this area should involve working with hunters to develop realistic solutions to reduce hunting. These efforts need to be supported by habitat protection measures.

RÉSUMÉ

L'espèce de chauve-souris frugivore Quasi Menacée *Rousettus madagascariensis* est endémique à Madagascar. Nous avons étudié quatre gîtes dans des grottes où cette espèce a établi des dortoirs diurnes en procédant à des visites multiples au cours d'une période de cinq ans et avons trouvé que la chasse et la déforestation constituaient les principales menaces pesant sur *R. madagascariensis*. La conservation de cette espèce est particulièrement difficile dans la mesure où la chasse dans ses dortoirs ou gîtes est permise. Bien que les deux sites abritant l'espèce bénéficient du statut de Nouvelle Aire Protégée avec le soutien de la communauté locale, la chasse ne cesse de s'intensifier. Les gîtes de *R. madagascariensis* sont associés à la forêt humide, de sorte que la disparition de la végétation arborée autour de deux de ces gîtes les a rendus impropres à héberger *R. madagascariensis* qui a fini par les abandonner. La disparition de la végétation arborée autour du gîte pourrait être à l'origine d'un changement de microclimat à l'intérieur de la grotte qui constitue le gîte diurne. Les activités de certains chasseurs peuvent aussi avoir un impact destructif rapide sur les gîtes de *R. madagascariensis* et des initiatives à mener conjointement avec les chasseurs sont nécessaires pour élaborer des mesures réalistes afin de réduire la chasse. De tels efforts doivent être étendus et appuyés par des mesures de protection de l'habitat car plusieurs autres gîtes pourraient exister dans les forêts du versant est de Madagascar et subir les mêmes pressions anthropiques. Des recherches récentes ont également montré que l'histoire naturelle de *R. madagascariensis* est étroitement liée à la forêt naturelle, de sorte que la perte de la biodiversité de la forêt naturelle malgache menace les plantes dont se nourrit cette espèce ainsi que l'équilibre de l'ensemble de l'écosystème dont elle dépend.

INTRODUCTION

Madagascar's three endemic fruit bat species are threatened by hunting, and habitat loss (MacKinnon et al. 2003; Andriafidison 2008a,b,c). Although these bats are classed as game and can be legally hunted between May and August (Durbin 2007, Rakotoarivelo et al. 2011), hunting legislation is rarely enforced (Racey et al. 2010). Bats are hunted for bushmeat in Madagascar whilst feeding on trees at night or roosting in colonies during the day (Jenkins and Racey 2008). Aggregations of roosting bats provide hunters with prime opportunities for capturing or killing large numbers of fruit bats. Hunting can cause fruit bats to abandon, or temporarily desert, their roosts (MacKinnon et al. 2003) and can therefore have direct and indirect impacts on the bats through mortality and the costs of roost switching respectively. The small fruit bat *Rousettus madagascariensis* is particularly vulnerable to hunters because it roosts inside caves, or at cave entrances, where hunters can kill or intercept a large number of bats in a short time (e.g., Rakotonandrasana and Goodman 2007). Although *R. madagascariensis* is widespread in eastern and western Madagascar only a few roost sites are known to biologists (Goodman et al. 2005, Cardiff et al. 2009), which suggests that these bats have specific roosting requirements and

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that suitable caves may be scarce (Cardiff 2006) or that a large number of roosts remain undiscovered.

Unfortunately, even *Rousettus madagascariensis* colonies in caves inside protected parks and reserves are also subject to illegal hunting (Cardiff et al. 2009). *R. madagascariensis* roosts are subject to least hunting pressure when the caves are difficult or dangerous for hunters to access or when they are associated with a taboo (*fady*). Fruit bats are important seed dispersers and pollinators and their conservation therefore maintains ecosystem services (e.g., Hodgkison 2003). Although there are no quantitative studies from Madagascar on the value of these bats to promoting forest regeneration or maintaining the survival of plants of cultural and economic importance, there is evidence that they disperse seeds (Andrianaivoarivelo et al. 2011, Andrianaivoarivelo et al. In press). There are therefore compelling reasons for managing hunting at sustainable levels in some roosts and prohibiting it all together in others.

In this article we present the results from roost surveys conducted between 2006 and 2010 in eastern Madagascar. Conservation work conducted from 2007 in communities living near the roosts focused on raising peoples' awareness about the ecological roles that bats play. In 2008, two of the roosts became focal sites for the creation of new community-managed protected areas where local people were dedicated to conserving and sustainably using the remaining forest and its resources. Both sites, Sahavoa (1,500 ha) and Ambatofotsy (1,200 ha) obtained provisional protected area status in 2008 and although sustainable use is permitted throughout most of the forest, the community groups (Tahiry, Tsinjo, Fanilo and Maintso) have opted to prohibit hunting in the caves. We sought to determine patterns of occupancy in six *Rousettus madagascariensis* roosts and to evaluate the threats to each site.

METHODS

This study was conducted in the Anosibe An'Ala District (E047° 57'–048° 19', S19° 24'–19° 32') of the Alaotra Mangoro Region. The western part of the district has retained significant mid-altitude humid forest cover but large areas of land are used for agriculture, and slash and burn clearance occurs at the edge of the humid forest.

We used informal discussions with local authorities and the public to discover the whereabouts of *Rousettus madagascariensis* roosts. Basic information was collected at each roost: entrance height and cave length were measured, and vegetation clutter (branches and leaves) within 10 m of the main bat emergence exit was classed as high, medium or low. Penetration of caves by people is impeded, or even prevented, by dangerous or blocked access routes. We therefore assessed each cave as providing high, medium or low ease of penetration to people, with features such as steep cliffs, slippery rocks and dense vegetation limiting access during the study. Bat abundance was either assessed by directly counting the number of roosting individuals by torch light, or if the colony size was large, a sample of the roosting bats was counted and extrapolated to the total abundance based on the surface area occupied by the bats (following Albayrak et al. 2008). If a cave was reported by local people as abandoned by bats, and no evidence of bat use was detected during the visits, we obtained information on the last date when people remembered bats being present in the cave. Direct evidence of hunting in each roost was based mainly on the presence of throwing-sticks, traditional blowpipe darts and fires. Slash and burn clearance near the roosts was also noted. We moved throwing-sticks to the side of each cave and checked for new sticks on subsequent visits. Additional information about the roost was obtained during informal interviews with people who lived nearby.

RESULTS

We found six *Rousettus madagascariensis* roosts. Four were located in a large block of humid forest, one in the east and three in the west of the Mangoro River and two were in isolated forest fragments, one in the south near Maromitety and one in the northeast near Tsaravinany (Figure 1).

CAVE CHARACTERISTICS. The height of the primary cave aperture at each roost ranged from 2.5 m to 4.5 m and the length was between 8 m and 15 m (Table 1). Five of the six roosts were located inside humid forest, within 800 m of the edge, and local people also reported that the Valanirana roost used to be inside the forest but it was cleared of vegetation by farmers prior to 1998. Access to the cave roosts by people was generally difficult, apart from at Valanirana from where all vegetation had been removed. At Androrangabe, the forest adjacent to the roost was replaced by agriculture between our January and December visits in 2008.

BAT COLONIES. Colony size was largest at Antsahahety, followed by Ambohimanjaka with bats often numbering in excess of 500 individuals (Table 1). Colonies at Ambatofotsy and Sahavoa were smaller, with up to a few hundred bats (Table 1). Colony size varied markedly between visits to all caves. At Antsahahety for example, we estimated 4,200 bats in July 2007 but there were only 200 present in December 2008. Whilst at Ambatofotsy, we counted 750 bats in July 2007 and only 40 in December 2008. The colony at Sahavoa underwent a major change in size from 600 bats in November 2009 to a single bat in November 2010.

THREATS. The removal of humid forest around caves represented a disturbance at three roosts. Local people attributed this to the loss of the bat colony at Valanirana before 2006. Similarly, bats ceased using the cave at Androrangabe after the surrounding forest was cleared in 2007. Slash and burn

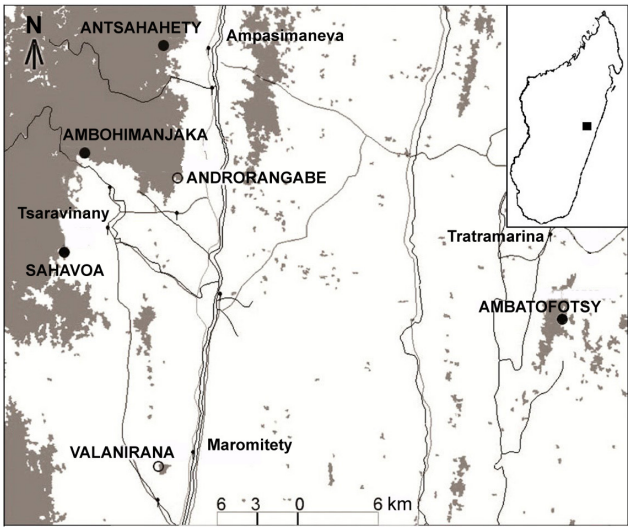

FIGURE 1. Location of study area and *Rousettus madagascariensis* roosts. (• = occupied roost, o**x**= abandoned roost, shaded areas = remaining humid forest)

TABLE 1. The colony size and cave dimensions for six *Rousettus madagascariensis* roosts. (Valanirana cave was told by local villagers to shelter *R. madagascariensis* before 1998, (dc) = direct counts, (e) = estimates, '-' indicates no visit)

Month/Year	Ambohimanjaka	Sahavoa	Valanirana	Ambatofotsy	Antsahahety	Androrangabe
May 2006	800 (e)	350 (e)	-	-	-	110 (dc)
January 2007	600 (e)	350 (e)	-	-	-	83 (dc)
April 2007	-	-	-	-	-	-
July 2007	850 (e)	400 (e)	-	750 (e)	4200 (e)	-
December 2007	-	-	-	-	-	-
December 2008	350 (e)	250 (e)	-	40 (dc)	200 (e)	-
March 2009	280 (e)	400 (e)	-	50 (dc)	2800 (e)	-
July 2009	700 (e)	200 (e)	-	35 (dc)	2000 (e)	-
November 2009	-	600 (e)	-	70 (dc)	800 (e)	-
February 2010	-	350 (e)	-	110 (e)	800 (e)	-
July 2010	-	350 (e)	-	230 (e)	3600 (e)	-
November 2010	-	1	-	480 (e)	1200 (e)	-
Entrance height (m)	3	4	3.5	2.5	4.5	4
Maximum cave interior length (m)	15	11	9	8	8	11
Roost to interior forest edge (m)	600	200	No forest	200	800	400

occurred within 400 m of roost entrance at Sahavoa between July and November 2010, and this may have directly impacted the bats, or indirectly impacted them through improved access to the cave for hunters. We found evidence of hunting in all of the five caves used by *Rousettus madagascariensis* during the study (Supplementary Material S1). This usually consisted of discarded throwing-sticks found inside the cave but also included traditional blow-pipe darts at Sahavoa in November 2010. In December 2008 we encountered evidence of recent hunting at Antsahahety, with four dead and four wounded bats indicating that hunters had been present within hours of our arrival. There were no bats roosting in the cave but a small group of 20 individuals (not included in Table 1) was located on nearby trees and had been discovered by a diurnal raptor (*Buteo brachypterus*). The day after, approximately 200 bats returned to the cave (Table 1). Hunting at the Ambatofotsy roost appeared to have declined since 2008 and there was a gradual increase in bats between 2008 and 2010. The local people and authorities with whom we spoke informally during the course of our work were unaware of the number of active bat hunters and generally appeared reticent to inform us about hunting. We did not find any evidence of fruit bats in the markets or restaurants in three towns in the study area (Ampasimaneva, Maromitety and Tsaravinany). We therefore tentatively conclude that hunting is undertaken by a small number of individuals at each roost, and that bats are destined for domestic consumption. The blow darts we observed in the Sahavoa cave resembled those used by lemur hunting in the Anosibe An'Ala District and the bats may have been targeted during general hunting missions.

DISCUSSION

This survey found four active cave roosts of *Rousettus madagascariensis* in humid forests that are currently threatened through deforestation and hunting. There was considerable variation in the size of the bat colonies in the different caves, and between different visits to the same cave. This variation was probably caused by anthropogenic disturbance and the mobile habits of this species.

METHODOLOGICAL CAVEATS. Cavernicolous bats that roost in colonies are difficult to count (e.g., Cardiff et al. 2009). Although we reduced potential observer bias through largely maintaining the same survey team it was still difficult to count the bats because some individuals may have remained hidden from view. Also, we were unable to maintain a systematic survey schedule and certain sites received more visits over a longer duration than others. Even though the evidence of a gap in information caused by the lack of confidence from villagers, we did not see the hunters as well but the results of our interview and observation would be sufficient to argue the fact that, *Rousettus madagascariensis* is threatened in its day roost. Within this context, it is particularly important to revisit Sahavoa, Ambohimanjaka and Androrangabe in the future to determine if the bats have resumed use of these caves.

COLONY SIZE. Colony size in the roosts that we visited were generally less than a thousand individuals and therefore smaller than those reported from Ankarana Special Reserve and Mahavavy-Kinkony (Rakotoarivelo and Randriandrianina 2007, Cardiff et al. 2009) in the north and west of Madagascar, respectively. However, colonies of *Rousettus madagascariensis* elsewhere, such as in the Anjohikinakina cave at Tsingy de Bemaraha National Park in the center west of Madagascar and Ankerana cave on Île Sainte Marie in the east, were smaller in size and more similar to those in this study (Kofoky et al. 2007, Rakotonandrasana and Goodman 2007).

ROOSTING ECOLOGY. In areas with a high abundance of caves, *Rousettus madagascariensis* occupancy rates are rather low, suggesting that this species has rather narrow requirements for roosting conditions (Kofoky et al. 2007, Cardiff et al. 2009). All of the roosts in our study were currently, or formerly, found inside humid forest and it is possible that vegetation reduces predation pressure from birds or helps to maintain the microclimate in the caves (Fenton 1983, Jenkins et al. 1998). The extent to which forest cover influences the suitability of caves will likely depend on particular cave characteristics at each site, and further research is needed to better understand the roosting biology of *R. madagascariensis*. Goodman et al. (2005) noted that a *R. madagascariensis* roost

in Anjohibe in western Madagascar was at least 30 km from the nearest degraded forest and concluded that this was not a forest-dependent species. The extent to which this species requires forest, either when related to roosting conditions or food supply is poorly understood. In the east of Madagascar, for example, it feeds on forest trees as well as plants located in gardens and plantations (Andrianaivoarivelo et al. 2011).

The variation in colony size in our study could have been the result of bats temporarily deserting the cave during hunting, normal dispersal or observer error. The latter may explain relatively small differences between surveys but we occasionally encountered very large differences in abundance that could only be caused by the presence of fewer bats in the cave compared to previous visits. Madagascar has a single *Rousettus madagascariensis* population with relatively frequent mixing of individuals and weak genetic differentiation (Goodman et al. 2010). *R. madagascariensis* regularly travel over 8 km at night (Andrianaivoarivelo et al. 2011) and the roosts in our survey may be acting as a meta-roost with regular exchange of bats. The bats therefore probably move frequently and over considerable distances, although there is little information however on triggers for roost-switching, and especially the role that hunting and the spatial variation in food resources play. Our observations at Antsahahety and Sahavoa show that *R. madagascariensis* react to hunting by deserting the roosts. At Antsahahety and Ambatofotsy at least, the bats had returned by our subsequent visits some months later, but our data set does not provide information on the pace or timing of the recovery. It is important to track the future of the Sahavoa colony since the colony had declined to a single bat in November 2010. It is premature however to attribute causality to a particular type of disturbance until more is known about the roosting ecology of these bats in sites where they are not hunted. Additional information is required on *R. madagascariensis* movements between roosts, both at the scale of our study and at the regional or national level within Madagascar.

CONSERVATION. Successful conservation of the *Rousettus madagascariensis* initially requires effective measures targeted at the proximate threats to the sites. Our results indicate that hunting for bushmeat is a direct threat inside caves and that although this initially reduces the number of bats and causes roost desertion, the bats are able to return to the roost. Our results also suggest that the removal of humid forest around the caves is an indirect threat because it renders the roost sites less suitable for *R. madagascariensis*. Whilst the reduction of hunting might be favourable from a conservation stand point, *R. madagascariensis* is a game species (Category III, Décret 2006-400) and can be legally hunted between 1 May and 1 September (Rakotoarivelo et al. 2011). This legislation is difficult to enforce because of the difficulty of the access to the sites (at least one day following foot paths from the nearest village) absence of means and conservation agency in the areas (office and personnel), and people hunt *R. madagascariensis* outside the legal season in our study sites and elsewhere in Madagascar (Rakotonandrasana and Goodman 2007, Jenkins and Racey 2008, Golden 2009). Data on the demand for *R. madagascariensis* meat is lacking although it seems that fruit bats are not a widely appreciated bushmeat in eastern Madagascar (Jenkins et al. 2011). The decisions whether to allow hunting at roosts during the four-month open season, or to establish local conventions to prohibit hunting are made by local communities who have management rights of the forest. In Anosibe An'Ala the consensus during consultations with community groups and local authorities at Sahavoa and Ambatofotsy was for sustainable management of the forests whilst prohibiting hunting within the *R. madagascariensis* roost all year around. Conservation activities at these sites therefore now have a strong mandate and both are included in the list of new protected areas in Madagascar. Hunting and deforestation continue to threaten these forests and additional effort is now needed to deliver effective community conservation.

ACKNOWLEDGMENTS

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REFERENCES

Albayrak, I., Ayan, N. and Yorulmaz, T. 2008. The natural history of the Egyptian fruit bat, *Rousettus aegyptiacus*, in Turkey (Mammalia: Chiroptera). Turkish Journal of Zoology 32: 11–18.

Andriafidison, D., Cardiff, S. G., Goodman, S. M., Hutson, A. M., Jenkins, R. K. B., Kofoky, A. F., Rabearivelo, A., Racey, P.A., Ranivo, J., Ratrimomanarivo, F. H. and Razafimanahaka, H. J. 2008a. *Pteropus rufus*. In: IUCN Red List of Threatened Species Version 2011.1. <www.iucnredlist.org> accessed 24 October 2011.

Andriafidison, D., Cardiff, S. G., Goodman, S. M., Hutson, A. M., Jenkins, R. K. B., Kofoky, A. F., Racey, P.A., Ranivo, J., Ratrimomanarivo, F.H. and Razafimanahaka, H. J. 2008b. *Eidolon dupreanum*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org> accessed 24 October 2011.

Andriafidison, D., Cardiff, S. G., Goodman, S. M., Hutson, A. M., Jenkins, R. K. B., Kofoky, A. F., Racey, P. A., Ranivo, J., Ratrimomanarivo, F. H. and Razafimanahaka, H. J. 2008c. *Rousettus madagascariensis*. In: IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org> accessed 24 October 2011.

Andrianaivoarivelo, R. A., Petit E. J., Razafindrakoto, N. and Racey P. A. 2012 (In press). Alimentation et dispersion de graines chez *Rousettus madagascariensis* G. Grandidier 1928, dans le Nord-Ouest de Madagascar. Revue d'Écologie (Terre et Vie) 67.

Andrianaivoarivelo, R. A., Ramilijaona, O. R. and Andriafidison, D. 2007. *Rousettus madagascariensis* Grandidier 1929 feeding on *Dimnocarpus longan* in Madagascar. African Bat Conservation News 11: 3–4.

Andrianaivoarivelo, R. A., Ramilijaona, O. R., Racey, P. A., Razafindrakoto, N. and Jenkins, R. K. B. 2011. Feeding ecology, habitat use and reproduction of *Rousettus madagascariensis* Grandidier, 1928 (Chiroptera: Pteropodidae) in eastern Madagascar. Mammalia 75, 1: 69–78. (doi:10.1515/MAMM.2010.071)

Cardiff, S. G. 2006. Bat Cave Selection and Conservation in Ankarana, Northern Madagascar. Unpub. MSc. Thesis, Columbia University, New York.

Cardiff, S. G., Ratrimomanarivo, F. H., Rembert, G. and Goodman, S. M. 2009. Hunting, disturbance and roost persistence of bats in caves at Ankarana, northern Madagascar. African Journal of Ecology 47, 4: 640–649. (doi:10.1111/j.1365-2028.2008.01015.x)

Durbin, J. 2007. New legislation for the protection of Malagasy species. Lemur News 11: 4–6.

Fenton, M. B. 1983. Roosts used by the African bat, *Scotophilus leucogaster* (Chiroptera: Vespertilionidae). Biotropica 15, 2: 129–132.

Golden, C. D. 2009. Bushmeat hunting and use in the Makira Forest, north-eastern Madagascar: A conservation and livelihoods issue. Oryx 43, 3: 386–392. (doi:10.1017/S0030605309000131)

Goodman, S. M., Andriafidison, D. Andrianaivoarivelo, R., Cardiff, S. G. Ifticene et al. 2005. The distribution and conservation of bats in the dry regions of Madagascar. Animal Conservation 8: 153–165. (doi:10.1017/S136794300500199X)

Goodman, S. M., Chan, L. M., Nowak, M. D. and Yoder, A. D. 2010. Phylogeny and biogeography of western Indian Ocean *Rousettus* (Chiroptera: Pteropodidae). Journal of Mammalogy 91, 3: 593–606. (doi:10.1644/09-MAMM-A-283.1)

Hodgkison R., Balding S. T., Zubaid A., and Kunz T. H. 2003. Fruit bats (Chiroptera: Pteropodidae) as seed dispersers and pollinators in a lowland Malaysian rain forest. Biotropica 35, 4: 491–502. (doi:10.1646/03043)

Jenkins, E. V., Laine, T., Morgan, S. E., Cole, K. R. and Speakman J. R. 1998. Roost selection in the pipistrelle bat, *Pipistrellus pipistrellus* (Chiroptera: Vespertilionidae), in northeast Scotland. Animal Behaviour 56, 4: 909–917. (doi:10.1006/anbe.1998.0858)

Jenkins, R. K. B. and Racey, P. A. 2008. Bats as bushmeat in Madagascar. Madagascar Conservation & Development 3, 1: 22–30.

Jenkins, R. K. B., Keane, A., Rakotoarivelo, A. A., Rakotomboavonjy, V., Randrianandrianina, F. H., Razafimanahaka, H. J., Ralaiarimalala, S. R. and Jones, J. P. G. 2011. Analysis of patterns of bushmeat consumption reveals extensive exploitation of protected species in eastern Madagascar. PLoS ONE 6, 12: e27570. (doi:10.1371/journal.pone.0027570)

Kofoky A., Andriafidison D., Ratrimomanarivo F., Razafimanahaka H. J., Rakotondravony D., Racey P. A. and Jenkins R. K. B. 2007. Habitat use, roost selection and conservation of bats in Tsingy de Bemaraha National Park, Madagascar. Biodiversity & Conservation 16, 4: 1039–1053. (doi:10.1007/s10531-006-9059-0)

Mackinnon, J. L., Hawkins, C. E. and Racey, P. A. 2003. Pteropodidae, fruit bats. In: The Natural History of Madagascar. S. M. Goodman and J. P. Benstead (eds.), pp 1299–1302. The University of Chicago Press, Chicago.

Racey, P. A., Goodman, S. M. and Jenkins, R. K. B. 2010. The ecology and conservation of Malagasy bats. In: Islands Bats: Evolution, Ecology, and Conservation. T. H. Fleming and P. A. Racey (eds.), pp 369–404. The University of Chicago Press, Chicago.

Rakotoarivelo, A. R. and Randrianandrianina, F. H. 2007. A Chiropteran survey of the Lac Kinkony-Mahavavy area in western Madagascar. African Bat Conservation News 12: 2–5.

Rakotoarivelo, A. R., Razafimanahaka, H. J., Rabesihanaka, S., Jones, J. P. G. & Jenkins, R. K. B. 2011. Lois et règlements sur la faune sauvage à Madagascar: Progrès accomplis et besoins du futur. Madagascar Conservation & Development 6, 1: 37–44.

Rakotonandrasana, E. N. and Goodman, S. M. 2007. Bat inventories of the Madagascar offshore islands of Nosy Be, Nosy Komba and Ile Sainte-Marie. African Bat Conservation News 12: 6–10.

SUPPLEMENTARY MATERIAL.

AVAILABLE ONLINE ONLY.

TABLE S1: Summary of hunting evidence, habitats and conservation action at six *Rousettus madagascariensis* roosts from 2006 to 2010.

SHORT NOTE

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Preliminary fish survey of Lac Tseny in north-western Madagascar

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ABSTRACT

We surveyed the fish fauna of Lac Tseny, in the Sofia Region of northwestern Madagascar, during October 2010 by observing commercial catches and targeted netting of areas used by endemic species. We recorded seven native fish species at the lake, including three endemic cichlids, a herring and a catfish. We confirmed the continued survival of the Critically Endangered *Paretroplus menarambo*, as well as the presence of a *Paretroplus* taxon that may be new to science. The commercial fishery in the lake is sustained by introduced tilapiines and the native *Sauvagella robusta*. The three endemic cichlids (*Paretroplus* spp.) were not targeted by commercial fishermen, but when caught in small numbers were retained for domestic consumption. Submerged trees in the west of the lake restrict fishing with nets and probably provide important habitat for *P. menarambo*. Priority next steps at the lake include (i) additional surveys and biological studies of the endemic fish species and the Critically Endangered Madagascar big-headed turtle, *Erymnochelys madagascariensis*, (ii) clarification of the taxonomic status of *Paretroplus* cf. *kieneri* and, should it prove a new taxon, its formal scientific description, and (iii) continued engagement with fishing communities and authorities to promote practices that benefit livelihoods and the survival of threatened fish species.

RÉSUMÉ

La composition spécifique de l'ichtyofaune du lac Tseny, dans l'ouest de Madagascar (région de Sofia) a été inventoriée au cours du mois d'octobre 2010, en observant les prises des pêcheurs et des pêches ciblées sur les espèces endémiques. Sept espèces de poissons indigènes ont été observées, dont trois cichlidés endémiques (*Paretroplus menarambo*, *Paretroplus lamenabe* et *Paretroplus* cf. *kieneri*), un hareng indigène (*Sauvagella robusta*) et un poisson-chat (*Arius madagascariensis*). Deux de ces espèces sont classées comme Menacées dans la Liste Rouge de l'UICN : *P. menarambo* est une espèce en Danger Critique d'Extinction qui n'est connue que du lac Tseny et *A. madagascariensis* est une espèce en Danger d'Extinction et endémique de la région de Sofia. Un des poissons que nous avons inventorié dans le genre *Paretroplus* semble être une forme non décrite. Les pêcheurs ont indiqué que *P. menarambo* est associé à des arbres immergés le long de la rive occidentale du lac qui offrent un habitat propice à la reproduction et à l'alimentation. Ces arbres immergés empêchent l'utilisation des filets pour la pêche et limitent ainsi la pression de pêche qui s'exerce sur cette espèce. Les trois espèces endémiques de *Paretroplus* sont prisées par les pêcheurs qui les gardent pour leur consommation personnelle plutôt que de les vendre. La pêche commerciale pratiquée dans le lac semble pérenne grâce à la présence de tilapias allogènes et du hareng indigène (*Sauvagella robusta*) qui approvisionnent les marchés de poisson local (Tsaratanana), régionaux (Boriziny et Mandritsara) et national (Antananarivo). Les populations locales ont rapporté que la surpêche, l'immigration, l'utilisation illégale de filets à petit maillage et le non respect de la saison de fermeture de la pêche étaient les principales menaces pesant sur l'ichtyofaune du lac Tseny. Une baisse de la pêche commerciale pourrait entraîner une ruée vers les espèces endémiques et l'ouverture des zones d'arbres immergés pour la pêche. Le lac Tseny abrite un assemblage unique de poissons qui doivent être protégés dans leur habitat qui est essentiel aux cichlidés endémiques par le maintien d'une pêche commerciale pérenne. Les prochaines étapes à mener en priorité pour le lac incluent : (i) des études supplémentaires sur la biologie des poissons endémiques et de la Podocnémide de Madagascar (*Erymnochelys madagascariensis*), une tortue en Danger Critique d'Extinction, (ii) la clarification du statut taxinomique de *Paretroplus* cf. *kieneri* qui pourrait être une nouvelle espèce et sa description, le cas échéant, et (iii) l'engagement continu avec les communautés de pêcheurs et les autorités locales pour promouvoir des pratiques équitables en faveur des populations riveraines et pour la survie des espèces de poissons menacées.

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INTRODUCTION

Freshwater fishes and their habitats are severely threatened in Madagascar (Benstead et al. 2003) because of over-fishing, exotic species and deforestation (Reinthal and Stiassny 1991, Sparks and Stiassny 2003, Irwin et al. 2010). Many endemic fish species are now restricted to a tiny proportion of their original range and are on the verge of extinction (Reinthal and Stiassny 1991, Benstead et al. 2003, Sparks and Stiassny 2008, Irwin et al. 2010). The pinstripe damba, *Paretroplus menarambo*, was described in 1996 from Sarodrano in western Madagascar (Allgayer 1996). This population of *P. menarambo* subsequently became threatened by over-fishing and habitat degradation (Benstead et al. 2003, Sparks and Stiassny 2003) and was considered to be extinct in the wild by 2003 (Loiselle and de Rham 2003). It is currently listed as Critically Endangered (CR) on the IUCN Red List of Threatened Species (Loiselle 2008), and is only reported to occur in Lac Tseny, although populations are maintained in captivity in five institutions (ISIS 2011). In October 2010 we conducted a rapid ichthyological assessment of Lac Tseny to provide additional information on the conservation status of *P. menarambo*.

METHODS

STUDY SITE. DA visited Lac Tseny in July 2010 for a preliminary meeting with fishermen to inquire about *P. menarambo*. A five-person survey team (DA, AS, TM, JR, AAR) then visited Lac Tseny between 14 and 16 October 2010. The lake is located within the Port Bergé District of the Sofia Region and is 26 km straight-line distance from Lac Sarodrano (Figure 1). Lac Tseny is located within a wetland complex in the lower catchment of the Sofia River. It undergoes major fluctuations in water level in accordance with the rainy (January-April) and dry seasons (May–December) in western Madagascar. The villages of Anjia, Ambario, Ankazobe, Anjiajia and Antanankova are located on the lakeshore and the nearest town is Tsaratanana, which had an estimated population of 8,720 in 2001 (INSTAT 2001). No human census data are available for populations in these smaller villages.

SURVEY. The team conducted interviews with local authorities and five fishermen in the village of Ambario (E47° 59,591', S15° 39,752'; 45 m a.s.l.) to obtain a description of the fishery and discern the main issues concerning the management of the lake. We also surveyed the composition of the catch by talking with fishermen and inspecting their catches as they landed their pirogues. In addition, because fishermen would not normally set nets to capture native cichlids, we occasionally employed them to fish in areas that they identified as of potential importance for *P. menarambo*. The communities around the lake consist of part-time fishermen who also tend their farmland nearby, and professional fishermen who are predominantly recent immigrants. Approximately one third of all fishermen from the four villages we visited are members of a cooperative funded by IFAD (International Fund for Agricultural Development) to promote sustainable fishing and improved marketing.

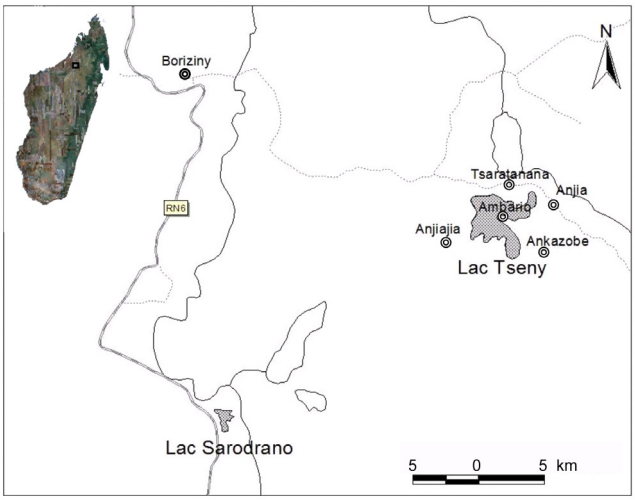

FIGURE 1. Map showing Lac Sarodrano and Lac Tseny in northwestern Madagascar. Route National 6, and Boriziny are also shown.

REFERENCE COLLECTION. We photographed each species encountered. Voucher specimens of the endemic species were taken and deposited in the Department of Animal Biology, University of Antananarivo (within the reference collection they only have been stored, not accessioned). Voucher specimens were identified by using morphological characteristics and available reference materials at the University of Antananarivo and at the American Museum of Natural History (AMNH). Tissue samples of the *Paretroplus* spp. were also collected and sent to the AMNH for DNA analysis.

RESULTS

We found seven native species in Lac Tseny: Three endemic Cichlidae (*Paretroplus menarambo* (Figure 2a), *Paretroplus lamenabe* (Figure 2b), *Paretroplus* cf. *kieneri* (Figure 2c)) and *Arius festinus* (Ariidae, Figure 2d), *Megalops cyprinoides* (Megalopidae), *Sauvagella robusta* (Clupeidae, Figure 2e) and *Glossogobius giuris* (Gobiidae, Figure 2f). We also confirmed the presence of the following non-native species in the lake: *Heterotis niloticus* (Cuvier 1829) (Arapaimidae), *Channa maculata* (Bloch 1793) (Channidae), *Cyprinus carpio* (Linnaeus 1758) (Cyprinidae) and three tilapiine species (Cichlidae) *Oreochromis n. niloticus* (Linnaeus 1758), *O. mossambicus* (Peters 1852) and *Tilapia zillii* (Gervais 1848).

Paretroplus menarambo (Allgayer 1996)
Menarambo (vernacular name)
IUCN Red List: Critically Endangered (Loiselle 2008)

An endemic species with an extant distribution restricted to Lac Tseny (Loiselle 2008). This species was caught by local fishermen using seine nets, known locally as *koka*, set in a wide arc and pulled to shore by a team of two to four people. It was present in many of the catches we inspected but always in small numbers, generally two to four individuals. In total, we observed sixteen individuals and three voucher specimens were taken. Fishermen reported *P. menarambo* are frequently found in or around submerged wood but could also sometimes be netted in other areas. The best fishing areas for this species are reportedly in the vicinity of the sunken trees along the southwestern shore. Fishermen reported that the species breeds during October and November and that it is caught in the highest numbers between October and December.

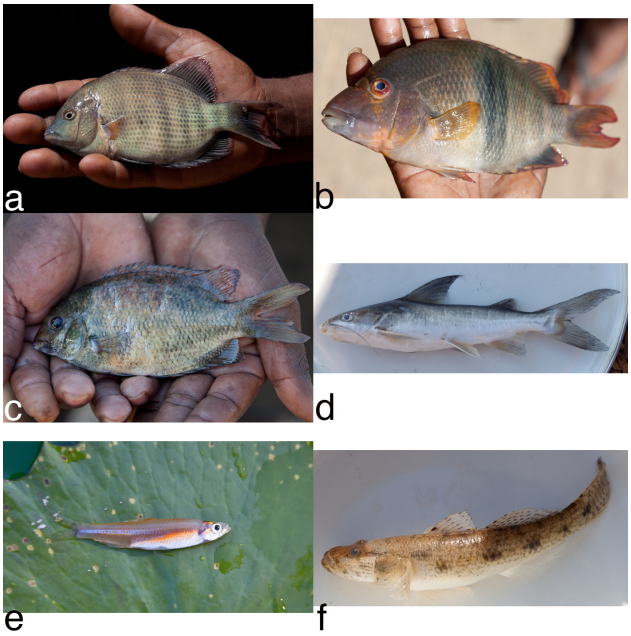

FIGURE 2. (a) *Paretroplus menarambo,* (b) *Paretroplus lamenabe,* (c) *Paretroplus* cf. *kieneri,* (d) *Arius festinus*, (e) *Sauvagella robusta,* (f) *Glossogobius giuris*. All photos taken at Lac Tseny by A. Saunders.

Paretroplus lamenabe (Sparks 2008)
Lamena (vernacular name)
IUCN Red List: Not Evaluated
This is an endemic species that was previously known only from the lower reaches of the Mahajamba River in northwestern Madagascar (Sparks 2008). This species was also caught by local fishermen using *koka*. It was present in many of the catches we observed, but always in small numbers (one to two individuals). In total, we observed nine individuals and two voucher specimens were taken. This species was caught less frequently than *P. menarambo*, although fishermen report that *P. lamenabe* is actually more abundant in Lac Tseny than *P. menarambo.* Fishers reported catching this species in the south and west of Lac Tseny and that it breeds during the months of October and November.

Paretroplus cf. *kieneri*
Kotsovato (vernacular name)
IUCN Red List: Not Evaluated
This taxon shared affinities with *P. kieneri*, such as the absence of any traces of vertical banding, and the presence of blotchy orange, grey, and brown pigmentation, but may warrant species status because of its small size and unusual rostral profile (de Rham and Nourissat 2003). This species was caught using *koka* set in a wide arc and pulled to shore by teams of two to four people. This taxon appeared as frequently as *P. menarambo* in the catches that we inspected.

Arius festinus (Ng and Sparks 2003)
Gogo (vernacular name)
IUCN Red List: Endangered (Loiselle et al. 2004a)
This endemic catfish species is only known from the Sofia Region, where it has been collected from the Amboaboa River, a tributary of the Mangarahara River, itself a left bank tributary of the much larger Sofia River (Ng and Sparks 2003). This species was caught using the *doboka* method, which consists of setting a gill net either at the mouth of a small bay or around submerged trees and smacking the water surface to scare fish out of cover and into the net. Our team was never present during the capture of *A. festinus* and specimens were always brought to us as single individuals. In total, we observed three individuals and two voucher specimens were taken.

Sauvagella robusta (Stiassny 2002)
Varilava (vernacular name)
IUCN Red List: Data Deficient (Loiselle et al. 2004b)
This native species is a freshwater herring only known from the Mangarahara tributary of the Sofia River in northwestern Madagascar (Stiassny 2002). The Lac Tseny population therefore represents a range extension. This was the predominant fish species observed in commercial catches from the east of the lake.

Megalops cyprinoides (Broussonet 1782)
Besisika (vernacular name)
IUCN Red List: Not Evaluated
This native species is widespread in coastal northern Madagascar (Sparks and Stiassny 2003) and elsewhere in the Indo-Pacific region. This species was also caught using the *doboka* method as well as by setting gill nets in deep water at night. We observed two individuals, but fishermen reported that this species was frequently netted.

Glossogobius giuris (Hamilton1822)
Amborodoa (vernacular name)
IUCN Red List: Not Evaluated
This native species is widespread in Madagascar and occurs in other parts of Africa and Asia (Sparks and Stiassny 2003). This species is caught using both gill and seine nets throughout the year. It was present in all of the catches we observed, in small numbers from gill nets (two to three individuals) and in the thousands from seine nets.

All fishermen reported that the endemic cichlids were harvested accidentally as by-catch and were not of commercial importance. The fishermen seemed to appreciate the taste of these species, however, and kept these fish for their own domestic consumption. Commercial catches, based on fishermens' reports and our observations, consisted of mainly tilapiines, *Sauvagella robusta* and *Glossogobius giurus,* which supply local markets as well as Boriziny, Mandritsara and the capital city of Antananarivo.

A number of bays that we visited on the western shore of the lake contained permanently submerged trees, which provide habitat for the aquatic fauna of Lac Tseny. In some cases only the uppermost branches emerge from the water, whereas the tree trunks and associated debris are submerged. In other areas the entire tree is underwater. The submerged trees hindered fishing access to certain areas and fishermen refrained from setting nets in these areas because of the risk of damage from

underwater snags. These areas are therefore subject to minimal fishing pressure, although fishermen sometimes set nets in the open water adjacent to the sunken forest and attempt to scare the fishes into the nets. The fishermen reported that the sunken forests are used by endemic fishes as breeding sites and also by the endemic Madagascar big-headed turtle (*Erymnochelys madagascariensis*). Interviewees cited over-fishing, immigration, illegal (small) mesh sizes and fishing during the closed season as the main threats to the Lac Tseny fishery.

Thirty-seven people participated in a two-day meeting held in Boriziny on 3 and 4 February 2011 to discuss the results of the ichthyological survey at Lac Tseny. A day was devoted to discussing fish and a half-day to freshwater turtles. The participants included the Regional Director and Representative of the Ministry of Environment and Forests, Regional Director and Representative of the Ministry of Fisheries and Aquatic Resources and representatives from Conservation International and communities around the lake (e.g., Ambanjabe, Tsarahasia and Tsaratanana). The objective of the workshop was to inform stakeholders about the results of the fish survey and discuss future options for managing the lake.

Priority research activities over the next two years at Lac Tseny include (i) biological studies on *Paretroplus menarambo* and *Sauvagella robusta*, (ii) assessment of major seasonal variation in the lake's habitats and fish stocks and (iii) evaluation of the taxonomic status of *P.* cf. *kieneri*. Activities orientated towards conservation include (iv) occasional bans on the use of seine nets, (v) awareness raising campaign about fishery laws, (vi) limiting the expansion of new human settlements near the lake and (vii) mapping to identify key conservation, fishery and cultural features. There was also consensus to (viii) provide more training and equipment to fishermen to encourage adoption of improved techniques and (ix) more support for fishermen's cooperatives. An assessment of the other lakes within the Port Bergé wetlands is also needed to identify any other nationally important sites. Future surveys at Lac Tseny, and elsewhere in the region, should also focus on assessing the conservation status of the Critically Endangered Madagascar big-headed turtle (*Erymnochelys madagascariensis*).

DISCUSSION

Lac Tseny is a wetland of considerable importance for both people and biodiversity. It has a unique assemblage of endemic and threatened fish species and sustains an important commercial fishery. The submerged trees along the western shore appear to be a key feature of the lake, and the presence of this refugium probably supports substantial recruitment of endemic cichlids. Tangled roots and branches provide predator-free and competitor-free space for these species, and dendrophilous algae and bacteria may support large populations of invertebrate prey for juvenile and adult *Paretroplus* (Kiener 1963, Catala 1979). *Paretroplus* species are substratum spawners and require a firm surface upon which to lay their eggs (de Rham and Nourissat 2003). The sunken wood along the western shore of Lac Tseny therefore appears to represent essential habitat for fish concealment, foraging and breeding.

Fishing pressure on the main commercial species probably has little impact on the endemic cichlids. The main *Sauvagella robusta* fishery is located along the eastern shore and is spatially isolated from the submerged trees on the western shore. The gill nets used to target the tilapiines in deep open water throughout the lake are unsuitable for catching the largely bottom-feeding endemic cichlids. A potential concern for the future, therefore, is that major declines in the commercial fishery for either *S. robusta* or tilapiines might lead to fishermen targeting endemic cichlids and clearing areas within the submerged wood fishing with nets. It is therefore important from a conservation perspective to maintain the Lac Tseny commercial fishery as well as the endemic fish populations.

Although some freshwater habitats are included within Madagascar's network of strict protected areas, only Lac Tsimanampetsotsa in southern Madagascar is protected primarily for its aquatic ecosystem (ANGAP 2003). In the last twenty years, greater conservation attention has been given in Madagascar to freshwater lakes, primarily because of their importance to birds, and seven are now listed as Ramsar sites and subject to conservation management (Ramsar 2011). There have been few direct attempts to conserve rivers, with the only reported conservation efforts occurring in eastern Madagascar (for the Nosivolo River, which was granted Ramsar status in 2007 mainly because of its importance to endemic fishes (Ramsar 2011)). Lac Tseny is included in the Port Bergé Wetlands, an area of 80,279 km^2, which was identified as a national biodiversity conservation priority during a review conducted in 2005 (MEF 2011). However unlike other sites, it never received further consideration as a new protected area. It is evident from this survey that Lac Tseny is of national importance because it supports apparently viable populations of endemic fish as well as a commercial fishery, and is one of the few remaining examples of its kind in Madagascar.

Priority action in the short term at Lac Tseny should focus on obtaining more information about the state of the commercial fishery and endemic fish populations. Although Stiassny (2002) stated that there is no commercial or artisanal *Sauvegella* fishery in Madagascar, *S. robusta* is a major component of the fishery in Lac Tseny. Additional surveys of the endemic cichlids should focus on confirming the role of the submerged trees as key habitats for conservation. Conservation organizations, government and local stakeholders should continue to collaborate because Lac Tseny needs to function as a commercial fishery whilst maintaining populations of its unique assemblage of endemic fishes.

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REFERENCES

Allgayer, R. 1996. Description d'une espèce nouvelle du genre *Paretroplus* Bleeker (Teleostei: Cichlidae) de Madagascar. Revue Française des Cichlidophiles 159: 6–20.

ANGAP 2003. Madagascar Protected Area System Management Plan. ANGAP, Ministry of the Environment, Water and Forests. Antananarivo, Madagascar.

Benstead, J. P., de Rham, P. H., Gattolliat, J.-L., Gibon, F.-M., Loiselle, P. V., Sartori, M., Sparks, J. S. and Stiassny, M. L. J. 2003. Conserving Madagascar's freshwater biodiversity. Bioscience 53, 11: 1101–1111. (doi:10.1641/0006-3568(2003)053[1101:CMFB]2.0.CO;2)

Catala, R. 1979. Poissons d'eau douce de Madagascar (suite). Revue Française d'Aquariologie 6: 125–128.

de Rham, P. H. & Nourissat, J.-C. 2003. Les Cichlidés Endémiques de Madagascar. Publication Association France Cichlid, Solliès-Pont, France.

INSTAT 2001. <http://www.ilo.cornell.edu/ilo/data.html> accessed 27 October 2011.

Irwin, M. T, Wright, P. C., Birkinshaw C., Fisher, B. L., Gardner, C. J., Glos, J., Goodman, S. M., Loiselle, P., Rabeson, P., Raharison, J.-L., Raherilalao M. J., Rakotondravony, D., Raselimanana, A., Ratsimbazafy, J., Sparks, J. S., Wilmé, L. and Ganzhorn, J. U. 2010. Patterns of species change in anthropogenically disturbed forests of Madagascar. Biological Conservation 143, 10: 2351–2362. (doi:10.1016/j.biocon.2010.01.023)

Kiener, A. 1963. Poissons, Pêche et Pisciculture à Madagascar. Publication Centre Technique Forestier Tropical 24: 1–244.

ISIS (International Species Information System). 2011. <www.isis.org> accessed 25 October 2011.

Loiselle, P. V., and participants of the CBSG/ANGAP CAMP «Faune de Madagascar» workshop 2004a. *Arius festinus*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2010.4. Available at <http://www.iucnredlist.org/apps/redlist/details/44461/0>

Loiselle, P. V., and participants of the CBSG/ANGAP CAMP «Faune de Madagascar» workshop 2004b. *Sauvagella robusta* In: IUCN 2011. IUCN Red List of Threatened Species. Version 2010.4. Available at <http://www.iucnredlist.org/apps/redlist/details/44661/0>

Loiselle, P. V. 2008. *Paretroplus menarambo*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. Available at <http://www.iucnredlist.org/apps/redlist/details/44461/0>

Loiselle, P. V. and de Rham, P. 2003. *Paretroplus*, Damba. In: The Natural History of Madagascar. S. M. Goodman and J. P. Benstead (eds.), pp 877–878. The University of Chicago Press, Chicago.

MEF (Ministère de l'Environnement et des Forêts). 2011. <http://www.meeft.gov.mg/index.php?option=com_sapm&task=RESULTPOTENTIEL> accessed 10 November 2011.

Ng, H. H. and Sparks, J. S. 2003. The ariid catfishes (Teleostei: Siluriformes: Ariidae) of Madagascar, with the description of two new species. Occasional Papers of the Museum of Zoology, University of Michigan 735: 1–21.

Ramsar 2011. <http://www.ramsar.org/cda/en/ramsar-pubs-annolist-anno-madagascar/main/ramsar/1-30-168%5E16534_4000_0> accessed 1 November 2011.

Reinthal, P. N. and Stiassny, M. L. J. 1991. The freshwater fishes of Madagascar: A study of an endangered fauna with recommendations for a conservation strategy. Conservation Biology 5, 2: 231–243. (doi:10.1111/j.1523-1739.1991.tb00128.x)

Sparks, J. S. 2008. Phylogeny of the cichlid subfamily Etroplinae and taxonomic revision of the Malagasy cichlid genus *Paretroplus* (Teleostei: Cichlidae). Bulletin of the American Museum of Natural History 314: 1–151. (doi:10.1206/314.1)

Sparks, J. S. and Stiassny, M. L. J. 2003. Introduction to freshwater fishes. In: The Natural History of Madagascar. S. M. Goodman and J. P. Benstead (eds.), pp 849–863. The University of Chicago Press, Chicago.

Sparks, J. S. & Stiassny, M. L. J. 2008. Les poissons d'eau douce. In: Paysages Naturels et Biodiversité de Madagascar. S. M. Goodman (ed.), pp 283–309. Publications Scientifiques Muséum national d›Histoire naturelle (MNHN), Paris.

Stiassny, M. L. J. 2002. Revision of *Sauvagella* Bertin (Clupeidae; Pellonulinae; Ehiravini) with a description of a new species from the freshwaters of Madagascar and diagnosis of the Ehiravini. Copeia 2002, 1: 67–76. (doi:10.1643/0045-8511(2002)002[0067:ROSBCP]2.0.CO;2)

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Stocks de bois précieux de Madagascar - quelle voie emprunter?

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Après avoir culminé en 2009 et 2010, l'exploitation de bois de rose a ralenti suite à une interdiction d'exportation adoptée par le gouvernement de transition de Madagascar (HAT) en réponse à la pression internationale croissante se référant au trafic illégal de bois de rose causant la destruction des forêts officiellement protégées. Le principal de ces bois précieux illégaux était destiné à la Chine. À la suite de l'interdiction d'exportation, un volume conséquent de bois de rose est à présent stocké dans les villages et les ports le long de la côte nord-est de Madagascar, sachant cependant que le volume exact n'est pas bien défini dans la mesure où l'inventaire est en cours et que le processus ouvre ainsi la possibilité d'ajouter de nouveaux bois fraîchement exploités aux stocks anciens. Cela signifie qu'il n'existe pour le moment aucune estimation précise du volume de bois précieux exploités sous un permis (et à l'extérieur des limites des aires protégées) ou de manière illégale à l'intérieur des limites des aires protégées.

Le 25 août 2011 une réunion se déroulant dans la région SAVA entre les représentants de la HAT et les trafiquants de bois de rose a révélé que le gouvernement voulait mettre un terme au trafic illégal et n'autorisait donc plus aucune exportation de bois de rose. Dans un avis du 12 juillet 2011, l'UNESCO a proposé d'éliminer tous les stocks dans un délai de 12 à 18 mois suivant leur saisie ; entre temps, la Banque mondiale cherchait comment vendre ces stocks de bois illégaux de façon responsable et transparente afin de financer les efforts destinés à protéger la biodiversité des forêts humides de Madagascar. À ce stade, on ne sait pas comment la HAT va gérer ce stock de bois précieux.

Le journal MCD observe le processus et voudrait donner la parole à quelques experts et praticiens impliqués dans cette crise du bois de rose.

MADAGASCAR'S ROSEWOOD STOCKS – WHICH WAY TO GO?

After peaking in 2009 and 2010, rosewood logging has slowed due to an export ban enacted by Madagascar's transitional government (HAT) in response to growing international pressure over the illegal traffic of rosewood causing the degradation of the country's formally protected forests. Most of the illegally sourced rosewood was destined for China. As a consequence of the export ban much of the rosewood is now sitting in villages and ports along the northeastern coast of Madagascar, and it is not clear how much of the rosewood stock has been inventoried by authorities given that it is an ongoing process, leaving open the possibility that newly-logged wood is being added to stockpiles. This means that currently there is no clear picture of how much of the rosewood is been harvested with permits (i.e., from outside protected areas) or illegally from within protected areas.

On 25 August 25 2011 a meeting in the SAVA region between HAT representatives and the rosewood traffickers revealed that the government wants to stop the illegal traffic and consequently will not allow any further exportation of rosewood. In a paper issued on 12 July, UNESCO proposed to eliminate all of the stocks within 12-18 months of the seizure of the wood; in the meantime, the World Bank is exploring a way to responsibly and transparently sell illegal timber stockpiles as a means to finance efforts for conserving Madagascar's rainforest biodiversity. At this point, it is not clear how the HAT may deal with the stocked rosewood.

The journal MCD is observing this process and would like to give voice to some of the experts and practitioners involved in this rosewood crisis.

HERY RANDRIAMALALA, Madagascar

Selon vous, que devrait faire le Gouvernement avec le bois de rose stocké, et pourquoi ?

Je n'ai pas varié depuis mes déclarations à tribune.com en août 2011 : le bois doit être détruit après sa saisie par l'État.

Toute opération d'alchimie qui consisterait à transformer le bois en argent (vente par appel d'offres, comme le veut actuellement le gouvernement ou stockage de longue durée puis vente ultérieure) relancerait la coupe immédiatement. En fait, ce phénomène a déjà commencé : des témoins ont rapporté récemment que la population coupe du bois de rose autour d'Ivohibe Bemangidy, en vue de le faire saisir par l'État et de déclarer ensuite que ce stock était ancien, donc légal. Les villageois ont anticipé qu'avec ce mensonge, ils allaient toucher une compensation de l'État après la saisie. L'ancien gouvernement, croyant bien faire avec sa saisie des stocks, a en fait involontairement relancé la coupe car les coupeurs ont toujours l'espoir de gagner quelque chose. En outre, le gouvernement actuel n'a pas les moyens de déplacer les 17 000

rondins de bois de rose qu'il a saisis : cela coûterait environ trois milliards d'ariary et il ne les a pas. La volonté politique aussi fait défaut. Selon le Ministre de l'Environnement, « la résolution de la crise politique est la priorité actuelle et la forêt passe après » (l'Express, 28/11/11). Et il y aurait encore 280 000 rondins non saisis, pour lesquels les trafiquants font obstruction... En outre, le temps qui passe facilite l'écoulement silencieux, à l'insu des médias. Pourquoi y a-t'il aux Douanes de Toamasina une filière rapide, réservée aux exportateurs chinois, dans laquelle aucun conteneur n'est passé au scanner ? Culture du *fihavanana* [valeur culturelle régissant l'entraide et la solicarité, propre à Madagascar] pour satisfaire les exportateurs de bois de rose ou intérêt bien compris ?

Dans les années 80, un trafic similaire a été arrêté par la destruction des matières saisies : celui de l'ivoire, qui menaçait d'extinction les éléphants d'Afrique orientale et australe. Le braconnage avait réduit de moitié la population d'éléphants en moins de dix ans. Rien qu'en 1973, 160 millions de dollars d'ivoire avaient été exportés d'Afrique (soit 200 000 éléphants morts). L'ivoire se négociait au marché noir à 250 US$ le kilo. La plaque tournante en était Hong Kong, qui a vu passer l'ivoire de 500 000 éléphants tués entre 1979 et 1989. Certains pays (l'Afrique du Sud entre autres) voulaient légaliser ce commerce pour mieux le contingenter, espérant ainsi sauver l'espèce. Mais l'argent de la corruption avait déjà infiltré toutes les instances décisionnelles. Alors il a fallu un geste symbolique fort pour renverser le cours des événements : le 18 juillet 1989, le Président du Kenya, Daniel Arap Moi, a incendié devant les caméras du monde entier 2 500 défenses d'éléphants saisies par son administration. Plus de trois millions de dollars ont été détruits devant 850 millions de téléspectateurs. En octobre 1989, l'éléphant a été inscrit à l'annexe I de la CITES (donc sur la liste des espèces interdites au commerce). En 1990, le prix de l'ivoire était divisé par 30, le commerce était stoppé et l'espèce sauvée, au moins pour un temps. Cette opération de communication a réussi et les touristes sont revenus dans les parcs kenyans.

Mais à Madagascar, qui a assez de force de caractère, de sens politique et d'autorité pour oser une telle opération ici et maintenant ? Je dis aux élites de ce pays : « Réveillez-vous avant qu'il ne soit trop tard ! Maintenant ! »

La coupe illégale et le trafic de bois précieux à Madagascar peuvent-ils être arrêtés et comment ?

La seule façon d'empêcher cette essence de disparaître totalement de nos forêts, car nous n'en sommes maintenant plus très loin, est de rendre la coupe stérile : une bille de bois précieux ne rapporte rien à personne (sauf peut-être de la prison) quelles que soient les circonstances. Mais la Justice ne suit pas : le 9 juillet 2011, six conteneurs de bois de rose ont été saisis à Vohémar. Ils étaient au nom de Gilbert Randrianasolo, directeur de la société Mamilaza. La déclaration douanière mentionnait du quartz industriel, mais en réalité ils étaient chargés de bois de rose. Le procès s'est tenu à Antalaha le 12 septembre 2011. Vingt-et-une personnes étaient inculpées et ont été placées en détention préventive pendant deux mois, parmi lesquelles seules 17 étaient réellement coupables. Verdict : Randrianasolo a été condamné à cinq mois fermes (mais il n'a pas passé un seul jour en prison), quatre prévenus ont été condamnés à de la prison avec sursis (entre deux et quatre mois), un a été acquitté, tous les autres ont été relaxés au bénéfice du doute. La vraie propriétaire du bois, épouse et sœur d'un trafiquant, n'a jamais été citée ni inquiétée. Ce procès sous influence a valu leurs mutations hors d'Antalaha à la Présidente du Tribunal ainsi qu'au Procureur, avant même que le jugement n'ait pu être signé !

Cette stérilisation de la coupe devrait durer jusqu'à la mise en place d'une exploitation durable, un jour peut-être, quand les exploitants forestiers feront des investissements sur 400 ans en ensemençant des parcelles avec du bois de rose à exploiter par la 8e génération de leurs descendants...

Mais je comprends la frustration de la population qui, en cas de destruction des stocks, verrait partir en copeaux des millions de dollars alors qu'elle a bien du mal à acheter son riz quotidien. Je propose donc que l'État saisisse le patrimoine des trafiquants, immobilier et financier, sur le territoire national comme à l'étranger, et ainsi l'argent du bois de rose déjà vendu depuis 2009 reviendrait à la communauté nationale. Il est facile de montrer que ce bois est d'origine illégale : il suffit d'inspecter les lots forestiers des exportateurs et d'y compter les souches de bois de rose. Il apparaîtra clairement qu'ils ont exporté plus de bois qu'il n'en poussait sur leur lot, la différence étant alors forcément illégale. Quant à ceux qui n'ont pas de lot forestier, tout leur bois est illégal. Plus de trafiquants, plus de trafic !

Au-delà de la politique du tout répressif que je prône actuellement, la solution à long terme serait de faire disparaître la demande : l'offre disparaîtra également et la paix reviendra alors dans les forêts, ainsi que les éco-touristes. La demande, c'est la Chine et rien que la Chine. Ce pays n'a qu'un appétit limité pour le bois de rose, qui est un produit de luxe et non une matière première stratégique. Elle a surtout un appétit insatiable pour le commerce. Madagascar a fait inscrire le 28 septembre 2011 ses espèces de bois précieux en annexe III de la CITES, la convention internationale sur le commerce des espèces menacées, également ratifiée par la Chine. Cette protection est insuffisante car les obligations de la Chine sont, d'après l'article 4, alinéa 3 de la CITES : « L'importation de spécimens d'une espèce incluse dans l'annexe III nécessite, sauf exceptions prévues à l'alinéa 4 du présent article, la présentation préalable d'un certificat d'origine et, quand l'importation se fait depuis un État qui a inscrit cette espèce en annexe III, d'un permis d'exporter. » Cette procédure était déjà en vigueur à Madagascar en 2009 (présentation du certificat d'origine et du permis d'exporter) et elle n'a pas empêché les trafiquants d'extraire la majeure partie de leur bois des parcs nationaux, puis de l'exporter.

Et comme en Chine l'État est fort, en tout cas beaucoup plus qu'ici, je suggère que le gouvernement malgache signe avec son homologue chinois un accord qui interdirait l'importation de bois de rose malgache en Chine. Si nous avons du mal à contrôler nos ports et nos plages, nous devrions nous entendre avec les autorités chinoises pour qu'elles contrôlent les leurs et ne laissent plus notre bois y entrer. Après tout, nos forêts humides sont inscrites au patrimoine mondial de l'humanité et la Chine en fait partie. Et peut-être que la lutte contre la désertification du territoire chinois a une partie de sa solution chez nous. En attendant, la Chine devrait faire attention à la dégradation de son image internationale : elle apparaît pour beaucoup comme un pays qui n'a aucun respect pour l'environnement en Afrique. Pourquoi l'éléphant africain et le bois de rose malgache n'auraient-ils pas droit à la même protection que le panda chinois ? Les transporteurs maritimes, qui chargent le bois à Madagascar pour l'emporter en Chine, devraient aussi se

soucier de leur image « verte » et se montrer intransigeants en refusant toute cargaison de bois de rose de Madagascar, forcément illégale puisqu'elle provient des parcs nationaux, quels que soient les documents administratifs présentés.

Vos solutions aux problèmes précédents pourraient-elles s'appliquer aux autres ressources naturelles dans le contexte malgache ?

Qu'il s'agisse d'holothuries (concombres de mer consommés par les Chinois), d'ailerons de requins, de carapaces de tortues, de quartz à inclusion de titane, de cristaux, de pierres précieuses, d'extraction de minerais ou de pétrole dans des zones écologiquement sensibles, la problématique reste la même : c'est une question de mesure. Si, pour satisfaire les besoins budgétaires d'un gouvernement aux abois, on prélève une ressource plus vite qu'elle ne se reconstitue, ce n'est plus de l'exploitation mais du pillage. Nous vivons sur une terre nourricière, celle que nous laisserons à nos enfants sera stérile, privée de ce qui en faisait la beauté et surtout, la viabilité.

Avant d'accorder un permis d'exploiter, le gouvernement doit procéder à l'inventaire de la ressource, estimer sa vitesse de régénération et en déduire le quota annuel autorisé à l'exploitation. Mais il faut savoir résister aux différents lobbies intéressés par la ressource, ce qui n'est guère facile, tant la disproportion des moyens peut être immense entre l'État et l'industrie pétrolière, minière, alimentaire ou forestière.

Je crois qu'il serait bon de revenir à quelques fondamentaux simples, donc faciles à comprendre et à mémoriser par tous :

- Les parcs doivent être sanctuarisés. On n'y prélève rien. Les contrevenants doivent être faciles à identifier et les sanctions réellement dissuasives, c'est-à-dire que les amendes doivent être de plusieurs fois le montant de la marchandise extraite du parc (or, pierres précieuses, animaux ou plantes rares, bois précieux).
- L'exportation de ressources naturelles à l'état brut doit être interdite (pierres et bois précieux), de façon à créer ici des filières de transformation et les emplois correspondants.
- L'exportation de ressources vivantes (animaux, plantes rares, bois précieux) ne doit se faire qu'à partir de centres d'élevage ou de plantations.

ETIENNE RASARELY, Observatoire National de l'Environnement et du Secteur Forestier, Madagascar

Selon vous, que devrait faire le Gouvernement avec le bois de rose stocké, et pourquoi ?

Ces stocks de bois de rose ont été tous constitués de manière illégale, sans permis d'exploiter. Ils proviennent principalement, sinon même exclusivement des Aires Protégées, qui font partie du patrimoine de l'État. Le fait qu'ils aient été soustraits illicitement d'une propriété de l'État, en principe, autorise ce dernier à les récupérer comme un bien lui appartenant et qui lui a été volé. À ce titre, il doit donc être restitué de plein droit à son propriétaire. Si par ailleurs des délits avaient été commis dans les modalités d'octroi d'autorisation ou dans l'obtention des pièces justificatives de ces stocks, des sanctions correspondantes doivent être envisagées en toute équité à l'encontre de toutes les parties impliquées dans le délit. À travers les mesures d'interdiction qu'il avait prises jusque là, (notamment l'ordonnance 2011-001), le Gouvernement avait surtout comme objectif ultime d'arrêter le massacre, de geler et empêcher ce stock d'augmenter, en stoppant toute nouvelle coupe en forêt. Cependant, pour espérer gérer convenablement une ressource, il faut avant tout en connaître les caractéristiques (nature, quantité, qualité et configuration dimensionnelle, localisation, statut légal) et ceci pièce par pièce. D'où la nécessité d'inventorier systématiquement et de manière précise ces stocks de bois de rose, dont on ne doit plus voir la quantité augmenter, si les mesures prises sont effectivement et efficacement appliquées. Le Gouvernement ne peut y parvenir et maîtriser l'ensemble du processus sans procéder à la saisie systématique de tous les stocks et procéder à leur marquage et à leur lotissement, afin d'assurer la traçabilité qui doit être la règle principale et cruciale à respecter dans tout traitement ultérieur. Ceci suppose un fonctionnement normal de l'ensemble des rouages techniques, administratifs et légaux aux différents niveaux, ce qui dans le contexte actuel n'est malheureusement pas encore le cas.

L'option de vendre par appel d'offre international et en toute transparence ces stocks, via un processus piloté par le gouvernement mais ne l'impliquant pas directement, puis de fermer définitivement par la suite la filière, garantirait une certaine objectivité et préserverait l'administration de toute interférence liée au risque de conflit d'intérêts ou de reconstitution ultérieure de nouveaux stocks illégaux. Mais avant tout, il est crucial de disposer d'une connaissance précise et fiable de ce stock initial de départ que l'on se propose d'épuiser. Il faut en outre parvenir à ouvrir le marché en explorant les possibilités autres que les clients habituels, afin d'écouler la marchandise au meilleur prix. L'affectation judicieuse du fruit de la vente pour alimenter en continu des fonds destinés spécialement à financer des actions de reconstitution de la ressource, par le reboisement, reste par ailleurs une mesure primordiale à respecter par l'État, si celui-ci veut concrétiser sa volonté de gérer la forêt de manière rationnelle et durable.

La coupe illégale et le trafic de bois précieux à Madagascar peuvent-ils être arrêtés et comment ?

L'exploitation et le trafic de bois précieux à Madagascar sont le résultat combiné d'un dérèglement de différents ordres, qui s'est installé progressivement et insidieusement depuis plusieurs années. Si l'on souhaite réellement arrêter l'exploitation et le trafic de bois précieux, c'est tout le système devenu dans son ensemble corrompu, inapproprié et en tout cas inadapté pour assurer une vision de gestion à long terme rationnelle et durable de la filière, qu'il faut parvenir à corriger. Pour ce faire, un certain nombre de conditions et de préalables sont à remplir. Il faut ainsi et avant tout détecter, reconnaître sans honte, corriger et lever toutes les failles et blocages qui existent aux différents niveaux. Ainsi en est-il de la chaîne de contrôle : l'administration, habituellement confrontée aux problèmes chroniques de manque de moyens et d'effectifs, est le plus souvent dépassée par les évènements et manque d'efficacité. Il est temps d'examiner l'option d'instaurer un mécanisme d'implication des communautés et de la société civile, pour assumer certaines charges et responsabilités au sein d'un système de contrôle forestier de proximité. Il est clair que ce partage de responsabilités ne saurait se passer d'un transfert adéquat de compétences. Le réel engagement des parties concernées suppose entre autres l'acquisition d'une connaissance suffisante relative aux caractéristiques et à l'importance de la ressource (valeurs et intérêts

économique, biologique, écologique, génétique…), à son rythme de croissance et de reproduction, à son caractère renouvelable moyennant le strict respect des règles et principes de gestion rationnelle d'une ressource dotée de caractéristiques aussi exceptionnelles.

La chaîne de retombée économique rémunérant équitablement et aux différents niveaux tout effort fourni et consenti ne doit pas non plus être coupée ni négligée : ristournes pour motiver les communautés de base dans leur prise de responsabilité et système de fiscalité approprié redistribuant les recettes selon des critères objectifs ; alternatives économiques ; opportunités d'emplois et de sources de revenus décents : tant que celui qui est en face peine à trouver ce qu'il va mettre dans la bouche aujourd'hui, ça ne vaut même pas la peine de lui parler de quoi sera fait son lendemain, déjà incertain ; d'où l'importance cruciale d'aborder la précarité des conditions d'existence des populations riveraines des massifs, le plus souvent marginalisées ou spoliées par le système même. Quelle révision ou réparation apporter à ce dernier, quand on voit surabondance et surconsommation côtoyer effrontément une pauvreté extrême ?

Un certain degré de souveraineté sur les ressources doit être reconnu à ces communautés de base, pour en faire leurs véritables gardiens. Sans vouloir revenir à une économie de subsistance, qui du temps où elle était en équilibre avec la poussée démographique, permettait de préserver l'environnement, force est de constater que l'irruption brusque, voire l'agression d'un marché à satisfaire vis-à-vis d'une ressource donnée, est toujours à l'origine d'une rupture se traduisant par des ruées difficilement maîtrisables, qui déstabilisent profondément et de manière quasi irréversible le tissu socio-économique de la zone de production. Ce degré d'ouverture ou de fermeture de l'économie reste l'éternel dilemme que même les nations riches et dites développées gèrent encore de manière subtile, malgré le paradoxe de la mondialisation. C'est plutôt la qualité d'une croissance menant vers un réel développement qu'il faudrait chercher à gérer, et non seulement la recherche effrénée de plus value.

En termes beaucoup plus opérationnels et techniques, il faut remarquer que les opérations de répression et de sécurisation militaire ont toujours montré leurs limites. Faiblement appuyées par une logistique défaillante, incapables d'être présentes à temps et au bon endroit avec les moyens nécessaires. Dans des conditions de terrain très rudes, il s'avère difficile de maîtriser une troupe, sans que ses éléments aux abois ne sombrent dans des déviations de toute sorte, réduisant à néant les résultats et l'efficacité de l'exercice.

Toutes les règles, procédures, normes et modalités adoptées et instaurées par n'importe quelle administration forestière de par le monde reposent sur des principes et fondements scientifiques, et répondent généralement à des impératifs techniques à respecter, si l'on veut s'assurer d'une exploitation rationnelle et durable de la forêt. Déclinées en considérations d'ordres économique et commercial, somme toute très évolutives, elles se traduisent concrètement dans la catégorisation des essences forestières malagasy. Actuellement, les nouvelles tendances du marché conjuguées au progrès des connaissances scientifiques et techniques rendent cette catégorisation désuète. La Nouvelle Catégorisation des bois malgaches, ayant déjà fait l'objet d'une étude devrait aujourd'hui être validée et appliquée afin de réduire la pression qui s'exerce sévèrement sur les espèces habituellement connues, déjà l'objet de surexploitation.

Le dispositif judiciaire montre encore quant à lui beaucoup de lacunes et d'imperfections, rendant non effective et inefficace l'application de la loi. Faut-il incriminer les textes ou bien ceux chargés de les appliquer, quand on assiste quasi indéfiniment à la relaxe des délinquants, situation qui entretient une culture et un climat malsain d'impunité ? Beaucoup de réformes de textes forestiers étaient à l'étude mais sont restées à ce stade, sans que les résultats aient encore été validés ni valorisés. Une forme de consultation et de participation des parties prenantes doit être prévue dans le processus d'élaboration des textes, et dans tous les cas, ceux-ci doivent être vulgarisés, mis à la connaissance, expliqués, appropriés et, compréhensibles, autant par les justiciables que par ceux chargés de les appliquer.

Tout ce qui a été dit repose bien entendu sur une action éducative efficace, qui doit intervenir à tous les niveaux et auprès de toutes les couches de la population dont on exige qu'elles n'ignorent pas la loi mais qui ne sont pas éduquées en conséquence. En dernier lieu, tout ce qui a été dit pourrait constituer en partie un véritable programme sectoriel de gouvernement. La volonté politique au plus haut niveau demeure à la base de l'instauration de l'ordre dans le secteur, et en particulier dans le problème d'exploitation et du trafic de bois précieux.

Vos solutions aux problèmes précédents pourraient-elles s'appliquer aux autres ressources naturelles dans le contexte malgache ?

Mines, pétrole, forêts, ressources halieutiques font actuellement l'objet de véritables ruées que l'Administration a le devoir de réguler, afin d'en limiter l'exploitation, d'en assurer de meilleures retombées économiques pour le pays, et de préserver l'environnement et la durabilité des ressources, pour celles qui sont renouvelables. L'instauration d'une politique de bonne gouvernance de ces ressources s'avère cruciale. Mais elle doit être soutenue par une politique d'éducation pour que l'ensemble de la population se prenne en charge, assume convenablement la responsabilité qui lui incombe dans sa sphère de compétence, refonde le pays, et surtout, s'occupe de la formation et de l'éducation des générations actuelles et futures pour en faire de bons citoyens.

JONAH RATSIMBAZAFY, Durrell Wildlife Conservation Trust, Madagascar

Selon vous, que devrait faire le Gouvernement avec le bois de rose stocké, et pourquoi ?

Avant toute chose, le gouvernement devrait commencer par annoncer publiquement la quantité des bois saisis ou stockés. La transparence est le premier défi que le gouvernement doit relever vis-à-vis du peuple malgache et de la communauté internationale compte tenu de ce qui s'est déjà passé car les gens ont du mal à croire qu'il y a de la transparence en ce qui concerne la gestion des bois de précieux saisis. Tout le monde sait qu'il y a des « grands bonnets » civils et militaires qui sont hors la loi mais intouchables et impliqués dans ces trafics, mais personne n'ose pas les dénoncer publiquement car ils font peur. Autrement dit, les voleurs sont récompensés. En second lieu, comme le gouvernement a déjà décidé qu'il faut vendre ces

stocks pour avoir des devises afin de construire des infrastructures pour la population, il faut que les acheteurs de ces stocks soient connus par tous, ainsi que le montant de l'argent obtenu par la vente. Un appel d'offre doit s'ouvrir aux acheteurs pour éviter les habitudes courantes « copains-copains ». Finalement, une commission spéciale composée de responsables de la justice, des forces de l'ordre, de la société civile, des ministères de l'environnement et des forêts, et du commerce et d'autres institutions ou ONG de conservation devrait être créée pour se charger de la vente de ces stocks de bois.

La coupe illégale et le trafic de bois précieux à Madagascar peuvent-ils être arrêtés et comment ?

Je puis affirmer sans l'ombre d'un doute que ces exploitations et trafics illicites des bois de rose pourraient être stoppés, et prétendre le contraire découragerait les meilleures. La tâche n'est pas facile mais le laisser-aller ne doit pas s'imposer pour permettre de mettre un terme au comportement des délinquants qui sont une honte pour toute la nation. Nous ne donnons pas de bonnes leçons à nos enfants et j'en arrive à douter que nous aimons notre cher pays. Dans un premier temps, il faut veiller que les lois qui protègent notre patrimoine existent et qu'elles soient respectées de tous, depuis le Président de la République jusqu'au simple citoyen. Compte tenu de la situation qui prévaut actuellement, Madagascar ne peut contrôler seule le trafic de bois précieux même si les premières actions doivent être entamées à Madagascar tout en offrant les moyens aux communautés locales de dénoncer les délits observés tout en protégeant les défenseurs du patrimoine. Pourquoi pas ne pas instaurer auprès de la Justice à Madagascar une commission spéciale qui jugerait les délits relatifs aux trafics de nos patrimoines ? Comment peut-on croire qu'il n'y a que deux ou trois hauts responsables qui soient impliqués dans ces fameux trafics ? Les citoyens malgaches n'ont pas confiance en leur justice de sorte qu'ils ont peur de dénoncer les responsables des trafics, même lorsqu'ils ont des preuves. Qui les protégerait ? Ils préfèrent donc le silence … Il devrait également exister une commission composée de Malgaches et d'Étrangers de bonne foi pour s'occuper de la surveillance et des enquêtes relatives aux trafics des bois de rose. Ainsi, en plus de l'emprisonnement et des amendes auxquels les coupables seraient contraints, leurs noms, quelle que soit leur nationalité, devraient figurer dans les annales des destructeurs des richesses naturelles du monde. Pour commencer, pourquoi ne pas publier les noms des pays qui acceptent d'importer les bois de rose qui sortent de Madagascar et pourquoi ne pas en discuter dans les réunions des Nations Unies ? Si les trafics de ces bois de roses se poursuivent à Madagascar, c'est aussi parce qu'il y a des pays qui les importent.

Vos solutions aux problèmes précédents pourraient-elles s'appliquer aux autres ressources naturelles dans le contexte malgache ?

Bien sur que oui, ces suggestions sont aussi valables pour les autres ressources naturelles de Madagascar. Le renforcement des lois et leur mise en application par une justice digne de ce nom est vitale pour remédier à ces problèmes. La sensibilisation à tous les niveaux et l'inscription de l'instruction civique dans le programme scolaire sont également nécessaires afin que les futurs gestionnaires et dirigeants de ce pays prennent conscience de leur devoir envers leur patrie car il faut que nous éduquions nos enfants. Et parallèlement à toutes ces activités, il faut lutter contre la pauvreté par l'amélioration de l'élevage et l'agriculture et de la santé publique.

ADOLFO BRIZZI, The World Bank, Madagascar

Selon vous, que devrait faire le Gouvernement avec le bois de rose stocké, et pourquoi ?

Aujourd'hui à Madagascar des opérateurs privés possèdent des quantités impressionnantes de rondins de bois de rose qui ont été coupés ces dernières années à cause d'une politique laxiste en matière de gestion des forêts. Les estimations font état de 200 000 rondins d'origine illégale qui ont certainement entamé le stock de capital naturel. Le gouvernement a décidé il y a un an d'interdire l'exportation du bois de rose, ce qui n'a pas entièrement stoppé les coupes dans la forêt, et plus récemment de saisir les rondins déjà coupés même si la grande majorité du bois reste dans les mains des opérateurs privés.

Le Gouvernement considère que maintenant que ces bois sont abattus, il convient de les vendre pour récupérer la plus grande partie de la rente. Certains acteurs sont contre une telle vente parce qu'elle pourrait constituer une incitation à la poursuite de l'exploitation illégale. Ils ont raison d'être inquiets, surtout si les opérateurs sont en fin de compte non seulement exemptés de poursuites judiciaires, mais également bénéficiaires de l'opération. Par conséquent, si le Gouvernement compte poursuivre cette option, il est indispensable de mettre en place un dispositif transparent au-dessus de tout soupçon, assorti de mesures complémentaires pour éviter que ce trafic illégal se poursuive. Une vente au plus offrant et le réinvestissement des revenus de la vente dans les infrastructures et les services sociaux permettraient de convertir ce capital naturel en capital humain (investissement dans l'éducation et la santé pour que la population soit productive) et capital productif (investissement dans les infrastructures – irrigation, transport, énergie, télécommunication). Quant aux risques, il convient, avant la vente, de mettre en place des mesures pour les minimiser, notamment en procédant au marquage génétique de chaque rondin saisi (y compris ceux entre les mains des opérateurs) de manière à éviter le blanchiment de nouveaux rondins. C'est une étape qui peut ralentir le processus de mise en vente, mais de notre avis, elle est indispensable pour que la vente n'ait pas d'effets pervers.

Il existe des exemples où de telles ventes de biens saisis se sont déroulées dans de bonnes conditions et au bénéfice du pays tout entier. Le principe général est qu'il faut que la vente et l'utilisation des revenus de la vente se fassent en suivant les principes de bonne gouvernance, et donc de transparence. Nous recommandons en plus du marquage génétique de suivre les trois principes suivant : premièrement, recruter une entreprise internationale pour organiser une vente aux enchères qui atti-rera des acheteurs sérieux et autoriser la présence d'un observateur autonome et indépendant pour suivre et documenter le déroulement de l'opération ; deuxièmement, verser les revenus de la vente dans un compte spécial doté d'un comité de pilotage et de fonctions d'audit financier ; et enfin, organiser un débat national avec la société civile et les communautés impliquées, sur une clef de répartition des revenus de la vente des stocks saisis.

Madagascar est un pays riche en ressources naturelles. Toute politique de croissance pérenne repose sur une exploitation rationnelle des ressources naturelles qui n'entame pas le capital afin de ne pas épuiser ces ressources. En plus de procéder à une exploitation qui ne prélève qu'une partie du stock, une politique de croissance pérenne nécessite également de capturer au moyen de taxes appropriées la plus grande partie de la rente dite naturelle qui correspond à la différence entre le coût d'exploitation et le prix du marché mondial pour réinvestir cette rente dans les infrastructures, l'éducation et la santé.

La coupe illégale et le trafic de bois précieux à Madagascar peuvent-ils être arrêtés et comment ?

Pour arrêter ce trafic il faudrait avant tout une forte volonté politique étant donné qu'il s'agit de réseaux qui ont des ramifications étendues et avec d'importantes capacités financières. Il faudra ensuite une combinaison d'éléments, notamment la capacité d'exercer le contrôle répressif et de poursuivre en justice ; la réglementation de l'exploitation de façon à créer une offre et une demande légales ; l'implication des communautés riveraines dans la protection et la gestion des aires protégées.

La simple interdiction s'est révélée peu efficace. De plus, un pays comme Madagascar dont le capital naturel constitue l'essentiel de la richesse, doit exploiter de façon durable ce capital naturel pour le transformer en capital productif et humain, en vue de se développer et d'assurer la croissance. Par ailleurs, la possibilité offerte aux opérateurs d'une exploitation forestière légale, réglementée et durable devrait en grande partie diminuer l'intérêt à pratiquer une exploitation illégale. Enfin, à terme, les communautés riveraines doivent être impliquées dans le contrôle offrant ainsi un service environnemental qui pourrait être rémunéré.

Au niveau de l'offre, la première étape consisterait à réaliser des inventaires forestiers et de déduire de ces inventaires des volumes maximums autorisés par régions et par essence. Ensuite, il convient de mettre en place un système de traçabilité (éventuellement accompagné d'une certification génétique). Il faudrait s'inspirer des expériences pilotes en cours et passer graduellement d'une échelle régionale à une échelle nationale.

Au niveau de la demande, il semble urgent de fermer l'accès aux marchés de tout bois en provenance de Madagascar non-issu de forêts exploitées durablement. Trois outils existent à cet effet : (i) le bois de rose a été inscrit en août 2011 par le Gouvernement malgache à l'annexe III de la Convention sur le commerce internationale des espèces de faune et de flore sauvages menacées d'extinctions (CITES). Cette inscription donne aux pays de consommation une base légale pour lutter contre le trafic ; (ii) certains pays come les États-Unis ont décidé de punir les consommateurs de bois de rose (*Lacey Act*) ; et (iii) certains pays pourraient autoriser l'accès à leur marché si Madagascar s'engageait officiellement dans des programmes de réformes en matière de gouvernance tels que *Forest Law Enforcement Governance* (FLEG) et *Forest Law Enforcement Governance and Trade* (FLEGT) ou encore l'initiative *Extractive Industry Transparency Initiative* (EITI++) que certains pays comme le Libéria ont décidé d'appliquer aux forêts.

Vos solutions aux problèmes précédents pourraient-elles s'appliquer aux autres ressources naturelles dans le contexte malgache ?

Oui, deux exemples.

Quand nous suggérons de transformer au moyen de la fiscalité le capital naturel en capital productif et humain, c'est l'exemple choisi avec succès par le Botswana qui a réussi à se développer durablement avec une économie entièrement fondée sur l'exploitation du diamant parce qu'il a correctement capturé et réinvesti sa rente minière. On parle, à propos de l'incapacité de nombreux pays en développement de capturer et réinvestir cette rente minière, pétrolière ou forestière à des fins de développement, de « malédiction » des ressources naturelles.

Quand nous suggérons de créer une offre légale, c'est la voie choisie par le Libéria pour exploiter ses mines et ses forêts en souscrivant à l'initiative EITI++. En particulier, le pays a mis en place un système de suivi et de communication publique des volumes de bois exploités et des revenus fiscaux engendrés par cette activité.

JÉRÔME BALLET, Fonds pour la Recherche en Éthique Économique, France

Selon vous, que devrait faire le Gouvernement avec le bois de rose stocké, et pourquoi ?

Face au problème de la gestion du stock de bois précieux, le gouvernement a trois solutions : 1) détruire le stock pour montrer que le pays ne veut plus de l'argent sal, 2) revendre le stock pour faire entrer de l'argent, 3) conserver et valoriser le stock par une production interne. Il me semble que la troisième solution reste la meilleure.

La première solution est la plus emblématique de la lutte contre les trafics mais se heurte au sentiment de perdre un montant de ressources considérable. Dans un pays où les ressources financières sont faibles, une perte monétaire si importante paraît peu décente. Une telle perte a de fortes chances d'être mal perçue par la population et ne paraît guère recevable pour le gouvernement.

La seconde solution ouvre des enjeux sur le mode de vente et l'utilisation de l'argent collecté. Ces deux enjeux sont à différencier. Le mode de vente peut être réalisé aux enchères ou de manière contractuelle en délimitant les acheteurs. Le mode de vente aux enchères est problématique car il laisse la possibilité à des personnes ayant fait usage illégalement de bois précieux d'en acheter. Il paraît donc préférable de procéder par une vente contractuelle à prix fixé à l'avance à des acheteurs devant prouver leur bonne foi passée en matière d'exploitation forestière. L'utilisation de l'argent peut aussi être diverse. Deux grandes options paraissent les plus tenables, soit une utilisation pour favoriser la conservation de l'environnement puisque les prélèvements illégaux ont affecté celui-ci, soit un usage destiné à la réduction de la pauvreté puisque la sensibilité de la population à l'environnement est aussi fortement liée à son niveau de vie. Cependant, cette solution pose un problème éthique majeur. Est-il légitime de légaliser ce qui est illégal ? Autrement dit, peut-on accepter de rendre légal le produit de prélèvements illégaux ? La revente du bois précieux se heurte à cette acceptation. Elle paraît suffisamment lourde de conséquences pour que cette solution ne soit guère satisfaisante. De plus, cette solution risque fort de provoquer un effet d'éviction des autres sources de financement. Autrement dit, les bailleurs de fonds pourraient

profiter de cette manne financière pour considérer que leur soutien financier peut être réduit. Cette solution n'apparaît donc elle aussi guère satisfaisante.

Reste la troisième solution, conserver et valoriser le stock de manière interne. Cette solution pourrait répondre à un autre problème auquel sont confrontés les artisans malgaches. En effet, pour eux, il est de plus en plus difficile de produire des objets artisanaux à partir de bois précieux, d'une part en raison de la raréfaction de la ressource, d'autre part en raison des difficultés que rencontrent leurs acheteurs à pouvoir désormais importer ces objets. Or ce stock pourrait permettre l'approvisionnement des artisans malgaches, et sous certaines conditions garantir aux acheteurs qu'ils peuvent repartir avec les produits acheter sur place. Cela suppose néanmoins qu'une traçabilité de la production puisse être réalisée, c'est-à-dire que l'usage du bois par des artisans puisse être suivi de manière sûre. Il importe pour cela qu'une entité soit identifiée par le gouvernement et les partenaires nationaux et internationaux et qui soit en charge de la distribution du bois précieux auprès des artisans. A ce titre on peut penser qu'une confédération des associations d'artisans pourrait jouer ce rôle sous le couvert d'un consortium de surveillance des ONG de conservation et de développement qui aurait droit de regard sur la gestion du stock. Cette solution pourrait aussi permettre de mieux canaliser la filière artisanale du bois et de poser enfin sérieusement la question de la valorisation du bois à travers cette filière.

La coupe illégale et le trafic de bois précieux à Madagascar peuvent-ils être arrêtés et comment ?

Le trafic doit être stoppé, mais comment est une autre affaire. L'interdiction complète d'exploitation est toujours difficile. L'interdiction du trafic d'ivoire a montré que les réseaux avaient tendance à se décomposer-recomposer suite à l'interdiction et que les flux prenaient d'autres chemins. Dans le cas du bois précieux, on peut penser que ce sera plus compliquer de construire de nouveaux réseaux et ce pour deux raisons. D'une part parce que Madagascar est une île et les possibilités de sorties de l'île sont par nature réduite, d'autre part parce que le bois précieux est plus encombrant que l'ivoire et que de fait les moyens de transports et les chemins pour le faire transiter sont là aussi réduit. Cependant, même si la volonté gouvernementale était là et qu'effectivement le trafic stoppait, combien de temps cela durerait ? Jusqu'à quand peut-on penser que cette interdiction tiendra étant donné le passé de Madagascar sur la question ? La pression nationale et internationale relâchée, le trafic pourrait reprendre aisément. Les risques d'instabilité politique pourraient aussi contribuer à des changements de politiques sur la question. Dans ces conditions, le moyen le plus adapté de faire cesser le trafic est de légaliser la filière bois précieux en l'encadrant fortement. Cela supposerait d'abord l'existence d'une filière certifiée locale. Cela supposerait ensuite une valorisation sur place afin d'éviter l'exportation de bois brut qui, elle, pourrait être totalement interdite. Au-delà de cette forme de légalisation de la filière, des modalités de sanction devraient être mises en place concernant aussi bien les compagnies d'affrètement maritime que les importateurs. La législation malgache devrait se doter d'instruments juridiques en mesure de permettre des poursuites judiciaires contre les transporteurs et les importateurs de bois précieux illégaux. Si la législation malgache ne peut pas se placer au-dessus de la législation internationale, elle devrait être en mesure néanmoins de prononcer des mesures d'interdiction d'activité sur son territoire envers certaines compagnies de transport et des importateurs qui seraient pris en situation de transporter et d'importer des bois précieux illégaux. De telles mesures obligeraient ces compagnies et importateurs à prendre au sérieux leurs responsabilités plutôt que de se dédouaner en rejetant la faute sur leurs clients.

Vos solutions aux problèmes précédents pourraient-elles s'appliquer aux autres ressources naturelles dans le contexte malgache ?

Oui les interdictions totales ont bien souvent du mal à être respectée. De nombreux exemples le soulignent (les œufs d'esturgeon par exemple). Les certifications sont la moins mauvaise solution. Même si cela ne veut pas dire qu'il s'agit toujours d'une excellente solution, car les fausses certifications existent aussi. Et par exemple, dans le cas du bois, les faux certificats sont légion courante (voir par exemple les problèmes en Afrique centrale). Mais là, il importe de responsabiliser les importateurs et de les pousser à mettre en place des systèmes d'audit et de vérification qui garantissent la réduction de la fraude. De tels systèmes sont d'autant plus aisés à mettre en œuvre que les filières de production sont sous contrôle des importateurs. On peut ainsi penser que les filières de production à l'étranger (principalement asiatiques) peuvent être remplacées par des filières de production nationales. Même si les commanditaires restent les importateurs étrangers. Cela implique seulement que les commanditaires acceptent de faire travailler des artisans locaux plutôt que des ouvriers de leurs pays. Il apparaît qu'il y a donc un enjeu majeur à développer une filière artisanale de qualité à Madagascar pour la valorisation du bois.

NDRANTO RAZAKAMANARINA, Alliance Voahary Gasy, Madagascar

What do you think should the government do with its stockpiled rosewood, and why?

Firstly, absolutely no negotiations should be conducted with the 'timber barons' regarding the stockpiled rosewood. This is because all stocks of precious timber stocks are illegally sourced. There has been no issuing of permits since 2002. Most of the timber originates in protected areas, the majority of which falls under the endangered UNESCO world heritage site of the Atsinanana rainforests. It is imperative that the government officially declares the stocks as illegal, then seizes all the stocks and proceeds on one of the following alternatives without any compromises:

- Option 1: Burn the stockpiles, or sink them at a depth of six km depth far out at sea to avoid carbon emission. This would be similar to the cases of ivory in Africa or marijuana in Madagascar. Bear in mind that any financial transactions made with the wood is no better than money laundering.
- Option 2 (a more practical solution): Sell the timber by auctioning it through a completely transparent process during and after the transactions. Utilize the money transparently to enhance environmental governance in and outside of the affected regions, this being mainly to benefit the decentralized forest services, Civil Society and Community-based associations.

Can the illegal logging and traffic of precious wood in Madagascar be stopped, and how?

Of course, but not without a very strong willingness and show of integrity on the part of the Government. We need to stifle the traders in order to avoid further corruption and misuse of the Malagasy people, since these traders amassed their wealth by means of illegal products. Consistent and prolonged involvement of the government – in collaboration with the other stakeholders – is imperative:

- The Ministry of Environment and Forests (MEF) needs to be encouraged to stand firm on law enforcement, in tandem with other sectors (Justice, Customs and Security).
- Application of exemplary sanctions in accordance with the law and the last High Authority of Transition orders (Government Decree 2010-141 and Presidential Order 2011-001).
- Strengthen the Environmental Civil Society and implement more efficient organization within different facets of the environmental management network (Administration, Civil Society, regions and community-based organizations) assisted by Technical and Financial Partners (Donors and NGOs) to counter the destructive but influential network of timber barons.
- Continue aggressively integrating endangered precious woods within the international conventions (Wood Certification, CITES II, etc.).
- Assist the MEF and the government to effectively develop and implement sustainable logging programme (in parallel with Protected Areas and reforestation activities) and more appropriate codes: the environmental charter, forestry code, forest service reform (including the appropriation and the responsibility of decentralized authorities and communities), and a long-term vision for sustainable management of forest resources.
- Negotiate with the Chinese government, in partnership with other African countries, to develop a more sustainable utilization and fair trade when it comes to natural resources. The upcoming FOCAC (China Africa Trade platform) should be an opportunity to pledge such an initiative.

Could your suggestions for addressing these issues also be applied to other natural resources beyond the Madagascar context?

Madagascar is rich in natural resources but the country's economy is very weak and its population impoverished due to rife corruption since independence. All economic sectors lack long-term strategies and synergy with law enforcement. Strict implementation of the above-mentioned measures pertaining to natural resources can strengthen the economy in the short-term. These measures should be accompanied with improvement of civil servant wages in those departments and in the governance sector (Justice, Customs and Security forces).

NANIE RATSIFANDRIHAMANANA, WWF, Madagascar

What do you think should the government do with its stockpiled rosewood, and why?

The stockpiled rosewood should be seized, inventoried, each log individually stamp-marked and then it ought to be put on public auction by an independent organization, selected by international NGOs, donors and the Malagasy environmental civil society, along with the government. Benefits should be ploughed back into conservation programs to reinforce management – as well as the restoration – of affected national parks and other protected areas including Marojejy, Masoala and Mananara, and these funds should also be used to benefit local communities surrounding the affected rainforests. This needs to be conducted by means of a transparent system whereby revenue earned from sale of timber can be easily traced by the public.

Can the illegal logging and traffic of precious wood in Madagascar be stopped, and how?

Yes, but only by addressing both sides of the timber traffic. On the supplying side, strong governance including a clear political will in the highest levels of government to curtail the traffic is a necessity. This is so that laws and regulations are rigidly enforced. The traffickers must be stopped and corruption stamped out. There is an urgent need to develop a coherent plan to manage timber resources in a sustainable, well-regulated way. Unfortunately however, the current political situation is not conducive to this. On the receiving end/demand side, importing of rosewood and ebony needs to be discouraged in China and other countries by listing of all Malagasy rosewood and ebony species onto the CITES Appendix II. Somehow, links need to be forged with environmental groups in China in order to raise awareness among the Chinese authorities concerning the illegal nature of the timber and to ensure they understand the social and environmental impacts of the traffic on the majority of people of Madagascar. The traffic cannot be stopped just by dealing with it from the Madagascar/supplying side: as long as there is demand for timber, traders will find a way to respond to this demand.

Could your suggestions for addressing these issues also be applied to other natural resources beyond the Madagascar context?

It depends on the scale of the traffic and the natural resources at stake, but I think it is important to have both short-term measures (such as investigations, control and repression, a system to manage seized resources) and longer-term solutions (clear policies and adequate legislation, capacity for education and enforcement) in place. It is also very important to mediatize the traffic so that it becomes an issue for all stakeholders, not just conservationists. Today, the traffic of precious wood in Madagascar is closely related to the country's international political image. This is an important incentive for decision-makers to act. WWF is applying these suggestions to the current traffic of the endemic radiated tortoise of Madagascar, which is under heavy pressure both from international and national illegal trade.

DEREK SCHUURMAN, England

What do you think should the government do with its stockpiled rosewood, and why?

The trees have been felled illegally and the clock cannot be turned back. Due to multiple illegalities involved in the entire logging process – as carefully outlined in the Rosewood Chronicles

by Hery Randriamalala – the Malagasy government, in order to set a positive example and thereby perhaps start salvaging its appallingly tarnished reputation among the international community – should strictly forbid any dialogue or choice/negotiation with the 'rosewood mafia'.

Regardless of how unrealistic it may sound, I can think of only one viable alternative, following consultation with Greenpeace and sundry other conservationists. The existing stocks – known, and, undoubtedly vast quantities of unknown caches – should be seized with immediate effect and auctioned off in a completely transparent process, no exceptions granted. If the transparency is not adhered to, any revenue generated will smack of 'dirty' money. Because of its responsibility towards the citizens of Madagascar the government has to seize all timber stocks, and it also has to ensure that transparency is strictly adhered to and monitored. Unfortunately history has demonstrated that this process will require international involvement, for example by accredited watchdog organizations along with large NGOs, among other parties, in conjunction with the government.

Can the illegal logging and traffic of precious wood in Madagascar be stopped, and how?

One can but hope. At time of answering this interview (November 2011) things do not look good. I have been part of a small, loosely connected group of individuals who worked voluntarily since February 2009 on a difficult campaign against the illegal logging, so have insight into all levels of corruption involved in the illegal logging process. However, the cause of the problem is by no means unique to Madagascar. TRAFFIC for one, recently issued a statement following a meeting in Hong Kong, outlining how in the past 10 years, the economic boom in China (and Vietnam) resulted in a sharp increase in the demand for wildlife products, including ivory, rhino horn, pangolins, marine turtles and parts of big cats. In Madagascar the Chinese are predominantly after precious timbers (endemic rosewoods and ebonies) and also, as has lately been exposed in the media, human bones, which are stolen from burial tombs, then transported to China with the illegally sourced timber, to be ground and used in Chinese medicine. Steven Broad, TRAFFIC's Executive Director, admitted that thus far, efforts to curb these demands have "obviously fallen short of dissuading consumers, and the trade continues".

A very small group of people have amassed a fortune from the trade in illegally-sourced timber, while almost 20 million people live in poverty. It is now time for the Malagasy government to clean up its act, demonstrate some integrity and backbone, prosecute the 'timber mafia' and any of their associates, and among other measures, reinstate the many people in conservation organisations or legal personnel who lost their jobs as a result of confronting the criminal syndicate. Listing all Malagasy rosewoods and ebonies on CITES is a matter of urgency. Madagascar and other African countries need to establish dialogue in conjunction with the leading NGOs and watchdog organisations, and the Chinese government, concerning trade in natural resources.

Could your suggestions for addressing these issues also be applied to other natural resources beyond the Madagascar context?

I think this was partly answered in my reply to the previous question in that the problem is by no means confined to Madagascar. Yes, there has been corruption at all levels in the illegal logging process, and it continues apace, resulting in increased degradation of Madagascar's remaining forests and wetlands. Events since the political fallout in February 2009 have demonstrated that the timber (and now human bones) traders are relentless, and that they will get whatever they want, no matter what the cost to the population of the countries where the resources originate from. Every time a campaign against such traders succeeds, the success is short-lived, and the traders manage to work their way around whatever measures had been implemented to interrupt their activities. This is the case elsewhere, too: consider for example, the rhinoceroses in South Africa, which are now being airlifted by helicopter from one protected area to another. In South Africa, the web of corruption is similar to what it is in Madagascar, though perhaps marginally more covert. The main area which seems to require work, is on the 'demand' side: the enormous challenge lies in educating the burgeoning Chinese and Vietnamese populations when it comes to simple things, such as that powdered rhino horn is not going to give any man with erectile dysfunction a sudden erection. Perhaps they should consider trying medication such as viagra instead? Its cheaper and doesn't require the illegal slaughter of critically endangered animals. Or, that medicine made from hitherto common but fast declining Tokay geckos, is not going to cure HIV. Perhaps the pharmaceutical giants, which themselves have a lot to answer for and a less than savoury reputation, could step in and help fund environmental education programs in the countries where the demand for these resources are.

IMPRESSUM

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COVER PICTURE
Blue vanga (*Cyanolanius madagascarinus)* by Louise Jasper

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