ARTICLE http://dx.doi.org/10.4314/mcd.v11i1.5

First records of illegal harvesting and trading of black corals (Antipatharia) in Madagascar

Gildas Todinanahary[I]*, Lucas Terrana[II]*, Thierry Lavitra[I], Igor Eeckhaut[II]

Correspondence:
Lucas Terrana
Marine Organisms Biology and Biomimetics, University of Mons, Belgium
E-mail: lucas.terrana@umons.ac.be

ABSTRACT

Black corals (Cnidaria: Antipatharia) have been used all around the world for a long time, whether as money or for medicinal purposes and jewellery manufacturing. Except in Hawaii where these fisheries are well known, black coral harvests are usually made without any control or any management. This is the case in many tropical islands and particularly in Madagascar, where the illegal trade is continually expanding. Since 2011, an illegal traffic of black corals has been occurring in the main cities of the southern and coastal regions of Ambovombe and Tolagnaro. In 2014 and 2015, hundreds of kilograms of black coral skeletons and a lot of diving material were seized by the authorities in the Anosy and Androy regions. Despite this and the continual harvesting of these natural resources, there has been no study of the excessive exploitation in this region. This paper is the first to talk about this new threat and to analyse and discuss the benefits of these fisheries. The first seizures and the efforts carried out on the island to stop the trade are explained. This paper highlights the urgency of studying these corals before making an appropriate conservation and management plan.

RÉSUMÉ

Le corail noir (Cnidaria : Antipatharia) est exploité dans le monde entier depuis très longtemps. Bien qu'inscrit à l'Annexe II de la convention sur le commerce international des espèces menacées d'extinction (CITES), le squelette du corail noir est utilisé sous forme de monnaie d'échange, à des fins médicinales ou pour être transformé en bijoux.Excepté à Hawaii où s'est développé une pêcherie durable, leur collecte s'effectue depuis toujours sans le moindre contrôle ni la moindre gestion. C'est le cas dans de nombreuses îles tropicales, et plus particulièrement à Madagascar où le commerce illégal se développe de plus en plus. Depuis 2011, un trafic se déroule dans les principales villes côtières du sud, Ambovombe et Tolagnaro. En 2014 et 2015, des centaines de kilos de squelettes de coraux noirs et une grande quantité de matériel de plongée furent saisis par les autorités dans les régions d'Anosy et Androy. Malgré cela, et pendant que les ressources naturelles s'épuisent continuellement, il n'existe aucune étude sur le déroulement d'une telle exploitation. Cette étude est la première à analyser et discuter des collectes ayant lieu à Madagascar. Les premières saisies ainsi que les efforts mis en place sur l'île pour stopper les collectes sont expliqués. L'étude met également en exergue l'importance et l'urgence d'accroître les connaissances sur les coraux noirs avant de pouvoir développer un programme de conservation durable de ces ressources.

INTRODUCTION

Antipatharians, called black corals, are marine organisms that have attracted people for a long time. Historically, they were used by religious people and for medicinal purposes (Bruckner et al. 2008). During the Paleolithic, some populations used them as money to trade (Tescione 1968) and from antiquity to the present, they have been used worldwide mainly for jewellery. Small black coral fisheries have always existed all around the world, but it increased with the development of scuba diving equipment and techniques until it became an important source of income in several regions and countries, such as Cayman Islands, Cuba, Mexico, Taiwan, the Philippines and the Dominican Republic (Castorena and Metaca 1979). The latter three were responsible for the trade and export of 72 metric tons and 7,400,000 pieces of black coral between 1982 and 1998. In 1996, 473,000 black coral pieces imported into the United States were reported to be worth $447,000 (Guitart et al. 1997).

At the moment, these fisheries are best known, managed and controlled in the Hawaiian islands. Grigg (1993) explains in detail the precious coral fisheries in the region. The black coral meadows located around them were discovered in 1958 at between 30 and 75 meters depth and 14 species were found within it, with 3 being harvested and exploited: *Antipathes dichotoma*, *A.grandis*, and *Myriopathes ulex*. The others are found at over 100 meters depth and their diameter is not sufficient to be profitable to fishermen (Grigg and Opresko 1977). In 1969, black coral fisheries and precious coral exports to Asia were worth $2 million in Hawaii. Quickly, population and stock management problems appeared and academic studies started in 1970 led to the development of a selective harvesting system utilizing a manned submersible

I Polyaquaculture Research Unit, Institut Halieutique et des Sciences Marines, Université de Toliara, Madagascar
II Marine Organisms Biology and Biomimetics, University of Mons, Belgium
* These authors contributed equally to this work

Citation Todinanahary, G., Terrana, L., Lavitra, T. and Eeeckhaut, I. 2016. First records of illegal harvesting and trading of black corals (Antipatharia) in Madagascar. Madagascar Conservation & Development 11, 1: http://dx.doi.org/10.4314/mcd.v11i1.5 **// Early view**

(Grigg et al. 1973), allowing the development of the sustainable management of these resources. These selective fisheries and coral management are based on coral growth rates and reproductive cycles, which are supported and approved by the Western Pacific Regional Fisheries Management Council (Grigg 1976). Fishermen also need a license and an authorization to collect black corals around the Hawaiian islands (Bruckner et al. 2008). The Hawaiian islands make $50 million with the precious coral fisheries, with $33 million for black corals (Grigg 2010). These fishery industries employ about 1,000 people: the current wholesale value of unworked black coral being about $US 35 per pound, and the retail prices for manufactured black coral jewellery range from around $US 35 to $300 for earrings to over $US 3,000 for more ornate necklaces and bracelets (Grigg 1993, Kahng and Grigg 2005).

Elsewhere in the world, very little is known about black coral fisheries and management. At this time, the United States is the main importer, followed by Japan, but the USA is importing less than 1,000 pieces per year, which is a very small quantity of corals. The biggest provider of black corals is Taïwan, with more than 90 percent of the total of black coral legally sold, while the most harvested region is the Philippines. There is no official report of black coral trade in Africa nor in Madagascar but it is notorious that the illegal trade occurs without exportation control and management. In Madagascar this illegal trade involves fishermen, small collectors in villages, foreign scuba divers and exporters in big cities where a kilogram of black coral is bought for €50 from fishermen.

The global conservation status of black coral has not been evaluated, but they are protected by international treaties restricting their exploitation and exportation/importation. According to the CITES (Convention on International Trade in Endangered Species of wild fauna and flora), the main threats are harvesting and invasive alien species such as the octocoral *Carijoa riisei* (Kahng and Grigg 2005). Black coral exploitation generally occurs in different steps: seabed exploration, discovery of black coral meadows, exploitation and depletion (Grigg 1989). Their stocks gradually run out, and fishermen continually search for new meadows to maintain sales. Overexploitation of black coral quickly leads to local population extinctions causing a great loss of biodiversity without a proper management plan. Conservation plans for black coral are, however, difficult to establish because these organisms are characterized by a slow growth, a delayed first reproduction (after about 10 years), a long life, an annual release of gametes, a high colony fecundity, a low recruitment of larvae and a slow rate of recovery when individuals are damaged (Parker et al. 1997). Mortality often results from sediment covering and substrate erosion (Grigg 1993). At the moment, there is no integrative biological data on shallow-water black coral populations from the Indian Ocean and it is consequently not possible to properly manage their populations in this region.

BLACK CORALS: UNKNOWN RESOURCES IN MADAGASCAR

Research on coral reefs began in Madagascar in 1961 with the establishment of the first marine station of Toliara. French researchers from the marine station of Endoume in France studied the southwestern region of Madagascar, including the Great Reef of Toliara (GRT) (E043° 20', S23° 30'), and the coral reefs of the Bay of Ranobe (E042° 58', S23° 18'). The first published results describe the location and the physiography of these reefs (Clausade et al. 1971, Thomassin 1971, Battistini et al. 1975). Since this time, several research programs have been carried out on the coral reefs of the region (Pichon 1978, Laroche and Ramananarivo 1995, Salimo 1997, Vasseur 1997, Laroche et al. 1997, Gabrié et al. 2000, Bruggemann et al. 2012, Andréfouët et al. 2013), but none of these included black corals.

No scientific study on black corals has been made in Madagascar until now: their communities remain completely unknown. Moreover, there is no data available from the main fishery and marine science research centres of Madagascar (Fishery and Marine Science Institute - IH.SM and the National Centre for Oceanographic Research - CNRO), or from the National Environmental Research Centre (CNRE). This publication is the first to exclusively talk about antipatharians from Madagascar and the problems related to their illegal exploitation, with the lack of management.

THE FIRST OFFICIAL SEIZURE OF BLACK CORALS. In 2014, a total of 178 kg of illegally-harvested black coral was seized by the Fisheries Control Centre (Centre de Surveillance des Pêches - CSP, based in the capital Antananarivo), in the southern regions of Anosy and Androy (Figures 1 and 2). Samples of the seizure were sent to the authors. The diameter of the base of the samples and their length were recorded with their origin (Table 1). Most of the black coral samples were fragments with a branch diameter higher than 35 mm (Figure 2). The harvested corals seized in Tolagnaro were first branched corals with a bush-like shape before being cut into fragments. Our investigations have confirmed that the bigger the branches are, the more expensive the price is. Furthermore, during the 31st May 2015, a new official seizure of

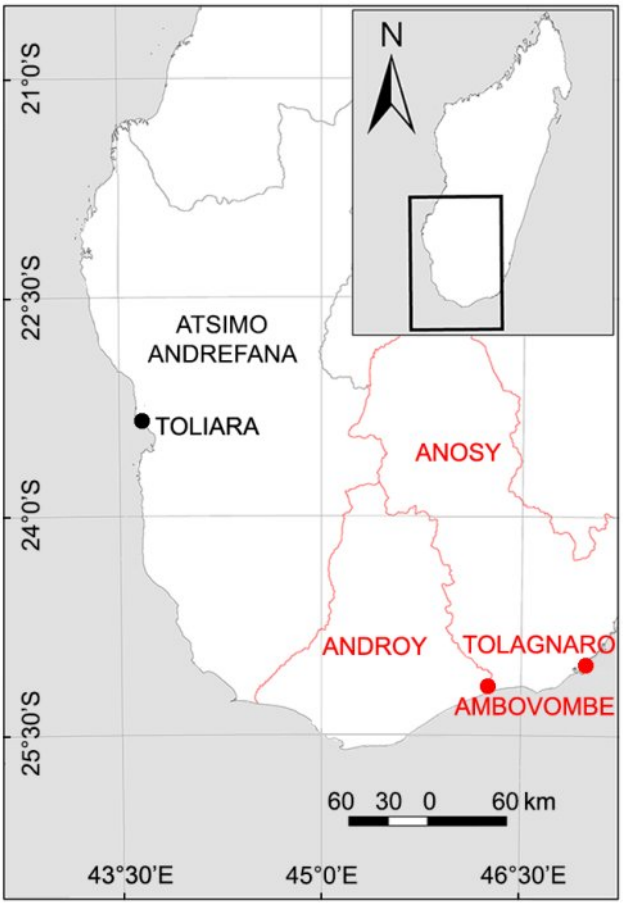

Figure 1. Southern coast of Madagascar. The two main regions concerned by the illegal harvesting of black corals, Androy and Anosy, are highlighted in red. Their capitals are respectively Ambovombe and Tolagnaro.

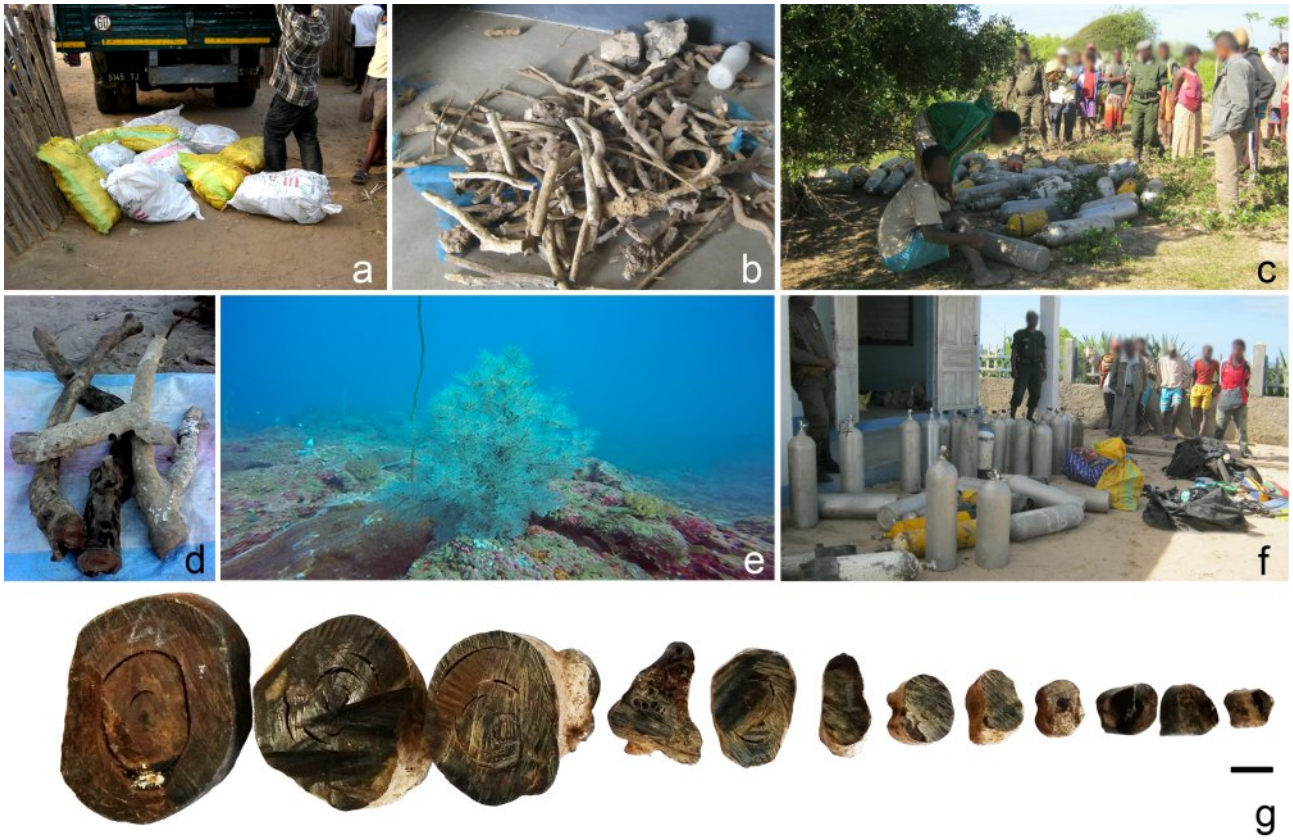

Figure 2. (a) Large bags containing dried black coral skeletons in Ambovombe, Androy. (b,d) Details of black coral skeletons collected. (c,f) Pictures of diving tanks used by poachers seized by the authorities in Kotoala, in the Ambazoa municipality of Ambovombe. (e) A branching black coral belonging to the Myriopathidae family photographed off the southwestern coast of Madagascar at approximatively 20 meters deep. This coral has the same shape and belongs to the same family as the corals harvested in Tolagnaro. (g) Pieces of black corals collected in the Anosy region showing the scale of corals that are harvested. (scale bar: 1cm)

100 kg of black coral was made in Andranobory, in the municipality of Analapatsy (Anosy region), bringing the number of official arrests in the Malagasy territory to four.

Dry tissues from these samples were also collected and fixed in 100% ethanol for DNA analysis. The primers LCOant forward and HCOant reverse were used to flank the CO-1 barcoding region (see Wagner et al. 2013 for the PCR conditions) and the same primers were used for DNA sequencing. Sequence analyses showed a high similarity with *Myriopathes* sp. and *Tanacetipathes* sp., two branched species belonging to the Myriopathidae family (Figure 2, unpublished data).

BLACK CORAL HARVESTING: AN ILLEGAL BUT LUCRATIVE BUSINESS. From the start of the operations in 2010 to today, it is known that antipatharians are collected from two regions of Madagascar: Anosy and Androy. These neighboring regions are located in the deep south of the country. They are famous for the aridity of their climate (especially in the Androy region) and the important richness of their marine resources (Bemiasa 2009). However, it is likely that harvesting of these marine resources occurs in other regions of the country. For example, in March 2012, a private operator officially requested an authorization to the Malagasy Ministry of Fishery and Aquatic Resources to collect black corals in four regions of Madagascar. The region of Androy was not targeted.

Table 1. Description of the black corals seized by the authorities in southern Madagascar. (*: given as mean ± SD; **: not sampled given that the seizure happened after the sampling date)

Date of Seizure	Sample	Weight (kg)	Diameter of base (mm)*	Length (mm)*	Region
24 March 2014	10	5	19.3 ± 5.7	199.4 ± 71.7	Androy
15 May 2014	10	163	35.7 ± 6.6	395.5 ± 97.2	Anosy
15 May 2014	10	10	12.1 ± 2.6	247.5 ± 72.6	Anosy
31 May 2015**	NA	100	NA	NA	Anosy

Information from the CSP investigations were analyzed and cross-checked with interviews of local people (boat drivers, fishermen, fishing agent services and NGO staff) liable to fishing activities. Data obtained (Table 2) were used to estimate the average amount collected by each diver, each local fish trader (at the village level) and each seller (at the national level). According to all the people questioned, poachers come mainly from China with a lot of means, vehicles and diving materials (Supplementary Material, Table S1). It is estimated that a collection of 4-5 months could lead to the production of more than 5000 kilograms of black coral. At the same time, a few farmers and managers from different regions of Madagascar made contact with universities and local authorities to obtain either authorization or license to legally collect black corals (Supplementary Material, Table S2).

In Madagascar, black corals are so lucrative that local people have named them the "rosewoods of the sea". Fishermen claim that the value of unworked black coral sold from the villages is between 10,000 to 15,000 Ariary per kilogram from scuba divers/fishermen to local collectors and 15,000 to 20,000 Ariary from local collectors to national collectors. The price per kilo from the capital Antananarivo for international exportation, mainly headed to Asia, ranges between 500,000 to 700,000 Ariary. In a country where a worker earns an average of 120,000 Ariary per month, black coral harvesting represents an assured money supply. According to Table 2, a scuba-diver harvesting black corals can earn 750,000 Ariary per day, his monthly salary reaching more or less

Table 2. Estimations of the amount of black coral collected and sold by people involved in these fisheries. (*: scuba divers are professionals external to the villages)

Source of information	Scuba divers*	Fishermen	Local fishery service	NGO people
Rule in the harvesting	Dive, collect, sale	Dive, collect, boat driver, sale	Should control trade	Interactions with people
Estimation of black coral collected per day (kg)	50 ± 10	50 to > 300	> 100	> 40
Working day per week	4 ± 2	6 ± 1	5 ± 1	NA
Duration of a harvest season	26 weeks	84 weeks	72 weeks	NA
Estimation of total black coral collected (kg)	5,200			
Region	Anosy	Androy, Anosy	Anosy	Anosy

12 million Ariary. This is higher than the salary of a government official even when all costs related to the collection of corals are deducted. This income is a thousand times higher than the monthly revenue received by a traditional fisherman in Madagascar.

ALERTS, PETITIONS AND LOBBYING. People in Madagascar have became more and more interested in the harvest and sale of black corals, which are very lucrative. Fishermen and collectors from different regions of the country have tried to gather information about the geographical distribution and the available stock of black corals. As soon as researchers and students became aware of the fisher interest, alerts and lobbying have been launched with local authorities to inform them of the illegality of these banned fisheries.

A few months later, an alert about the illegal trade of black corals in Madagascar was launched by some students who took the initiative to start a petition. The purpose of this petition was to raise awareness and put pressure on government officials to promote the rational and sustainable management of fisheries resources. The petition, which was held in two stages, first invited the authorities to sign and publish laws prohibiting the exploitation of these resources. The second stage, which was launched after the release of a Ministerial Order, invited all administrative officials involved in the exploitation of these resources, including local authorities, the regional Director of fisheries, regions, gendarmerie and the national police, customs authorities and justice, to respect and apply the laws. The petition did not collect many signatures in three months, but the actions represented students, researchers and teachers from around the world (Madagascar, France, Norway, Belgium, United States, United Kingdom and Australia). The petition has become the forerunner of a wave of advocacy and lobbying conducted by environmental civil society organizations, such as FAMARI (*Ala Fatidràn'ny Maike sy ny Riake*), AVG (Alliance *Voahary Gasy*) and the Regional Platform of Civil Society Organizations of Atsimo Andrefana, which includes more than 250 associations and NGOs as members. These organizations are among the largest and most influential in Madagascar. All these actions have together led to the signature and publication of regional and national bylaws preventing and prohibiting any form of black coral exploitation.

REGIONAL AND NATIONAL BYLAWS. Thanks to the willingness of leaders and managers of fisheries and marine resources service of the Region of Anosy, a regional bylaw suspending the collection of black corals in the region (*Région Anosy. 2013. Arrêté n° 336 REG /ANOSY du 12/12/2013 portant suspension de collecte de corail noir ou TANGOARAKY dans la Région Anosy*) was enacted. This attitude of the Anosy regional authorities was an example for all the coastal areas authorities, for the responsible management of the marine resources of Madagascar. Indeed, a few weeks after the publication of the bylaw, the presence of about 10 scuba divers and black coral collectors was confirmed by local NGOs in the Androy Region. Immediately, a regional bylaw was enacted to ban black coral harvesting in the whole region (*Région Androy. 2014. Arrêté n°021/14/REG/ANDROY/CR/Tangoharake du 5 Mars 2014 portant interdiction de collecte de corail noir ou "TANGOHARAKE" dans le littoral de la Région Androy*). However, these bylaws did not stop the illegal traffic in either regions. Scuba divers continued quietly to collect corals and civil society, including fishermen associations and NGOs, reported anonymously the arrival of professional divers in the area, with their diving materials. Nevertheless, the use of scuba is prohibited by the Article 10 of Ordinance No. 93-022 of 4 May 1993 on the regulation of fisheries and aquaculture in Madagascar. In June 2014, a ministerial decree prohibiting the exploitation of black coral at the national level was published by the ministry of aquatic resources and fisheries (bylaw No. 21816/2014 of 12 June 2014). This decree stipulates that all forms of exploitation including the extraction, collection, storage, transport, purchase and sale of black coral (Order: Antipatharia) is strictly prohibited in the whole country. The CSP and the competent fisheries authorities are empowered to note and pursue infringements.

APPLICATION OF THE LAWS: FRAGILITY AND CONSTRAINTS. The laws preventing the harvest of black coral in the natural environment constitute a tool for the government to better manage these resources. They allow local authorities and police to directly question any people whatever their role in the traffic: diver, collector, transporter or exporter. However, the traffic has not yet been affected by the publication of these laws. Indeed, anonymous informants from the Anosy and Androy regions were reporting the presence of black coral poachers. Every interviewed person refused to provide information on poachers for fear of being blackmailed or even condemned instead of them. These people included traditional fishermen, farmers, boat drivers, police, heads of regional or municipal services and researchers. Since the beginning of the traffic until June 2015, only four arrests and seizures were performed by the CSP. The most important seizure included 49 dive tanks, additional scuba equipment and an outboard engine for a speedboat (Table 2). The CSP also seized camp equipment, several saw blades used to cut the branches of corals and a weighing machine. Officially, no speedboat has been

seized. However, unofficial sources report that the arrest that led to the largest seizure also allowed the capture of two speedboats.

THE FUTURE OF BLACK CORALS IN MADAGASCAR

The efficient management of black coral is based on (1) the effectiveness of laws and rules that control the exploitation, (2) the protection of living stocks by the development of marine reserves, (3) the research on methods of transplantation in protected areas and reproduction in aquaria and (4) the awareness of populations especially via the education of children. The situation in the country since the beginning of the political and economic crisis in 2009 does not facilitate proper management. Black corals, among many other resources under CITES protection, have became indisputable objects of illegal harvesting and trade. At this time, the government of Madagascar cannot ensure the protection of these resources. The laws are not respected; and police and justice efforts are inefficient. The return of Madagascar to a constitutional political order in January 2013 constituted a new hope for the effective management of these natural resources. However, the situation has not improved. Indeed, several local sources, from the government, from NGOs or fishermen claim to be aware of several cases of law violation including the harvest, collection, sale and exportation of the resources mentioned above. Information about coral harvesting is growing over time. Corruption is one of the sources of the non-resolution of these problems of natural resource looting. Protection of black corals depends on the stability, independence and transparency of each concerned government entity, either directly or indirectly by the management of these natural resources, which are more and more in danger.

In Madagascar, the Decree No. 97-1455 of 18 December 1997, establishing general organization of maritime fishing, defines and clarifies the principles and guidelines set by Ordinance No. 93-022 of 4 May 1993 on the General regulation of fisheries and aquaculture. Figure 3 illustrates all the parts involved in the exploitation of the – unknown – natural stocks of natural resources, including black corals in Madagascar. Collection activities include purchase within a collection area, processing, storage, conditioning and/or transportation of fishery products, in order to sell them on the market, but they do not include fishing or direct capture in any form; or collection of animals from the aquatic environment. Any collecting authorization entitles the holder to the issuing of up to five collecting permits and is valid only in one zone as mentioned in the authorization. Furthermore, fishing activities are subject to the prior approval of the Ministry of Fisheries and Fish Resources. An industrial investment project (mining, fishing, production factory or else) that directly or indirectly affects the environment (including living natural resources) is subject to well defined rules. An environmental impact study is required for a large project, while for a small one, an environmental commitment program is enough. In any case, the decree of "compatibility of investments with the environment" (MECIE / Decree No. 2004-167 of 3 February 2004) governs all legal clauses that an operator must respect.

At this time, not any conservation program for black coral can be established. A better knowledge of the biology and ecology of black corals is essential to ensure an effective management of these resources. The implementation of a conservation and management program is subject to major restrictions without a basis of reliable and updated scientific data.

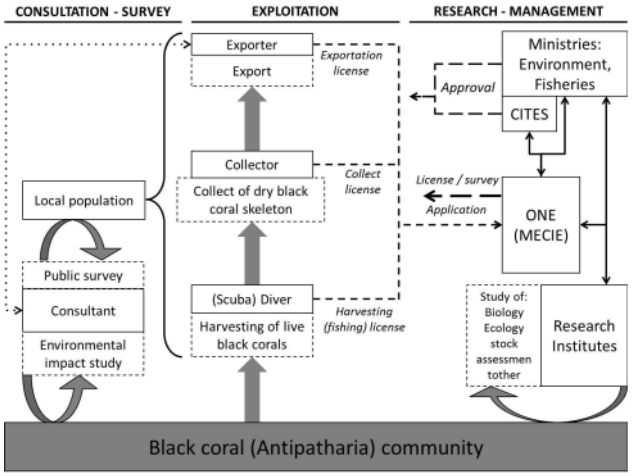

Figure 3. Diagram showing the normal procedures for black coral exploitation. The natural stock of antipatharians should be controlled through three clearly defined parts: research and management performed and ensured essentially by public centres and the government; consultation and surveys of exploitation impacts to the environment and local human societies; and exploitation itself, including harvesting, collect, transformation and exportation. Furthermore, the exploitation percentages of each part are not known yet for black corals. Meaning of the different arrows: 1- Black coral destination; 2- Application for license; 3- Approval, licensing and survey; 4- Consultancy for survey; 5- Interaction and data exchange; 6- Research and/or survey and consultation.

ACKNOWLEDGEMENTS

We thank all the officials from the Ministry of Fisheries and Fishery Resources of Madagascar, and especially from the CSP, who provided data and information about black corals harvesting and material seizure and allowed us to analyse seized black corals. We thank all the civil society actors in Madagascar who helped by sharing information about black corals harvesting in the country. The authors are thankful to the fishermen, divers and boat pilots who accepted to be interviewed, anonymously, about their former black corals harvesting activities. Thanks to Paubert Manhatante Tsiamanaorate and Sylvain Mahazotahy for their help and the pictures they allowed to be shared in this paper. The authors are thankful to the anonymous reviewers and the editors for their valuable comments that improved the manuscript.

REFERENCES

Andréfouët, S., Guillaume, M. M. M., Delval, A., Rasoamanendrika, F. M. A., Blanchot, J. and Bruggemann, J. H. 2013. Fifty years of changes in reef flat habitats of the Grand Récif of Toliara (SW Madagascar) and the impact of gleaning. Coral Reefs 32, 3: 757–768. (doi:10.1007/s00338-013-1026-0)

Battistini, R., Bourrouilh, F., Chevalier, J. P., Coudray, J., Denizot, M., et al. 1975. Éléments de terminologie récifale indopacifique. Téthys 7, 1: 1–111.

Bemiasa, J. 2009. Dynamique des Pêcheries Traditionnelles d'Anchois, de Calmars et de Poulpes du Sud-Ouest de Madagascar : Utilisation d'Outils Océanographiques pour la Gestion des Ressources. Unpubl. Ph.D Thesis, University of Toliara, Madagascar. Available at <http://archimer.ifremer.fr/doc/2009/these-6847.pdf>

Bruckner, A., de Angelis, P. and Montgomery, T. 2008. Case Study for Black Coral from Hawaii. International Expert Workshop on CITES Non-Detriment Findings, Cancun. Available at <http://www.conabio.gob.mx/institucion/cooperacion_internacional/TallerNDF/Links-Documentos/WG-CS/WG9-AquaticInvertebrates/WG9-CS1%20BlackCoral/WG9-CS1.pdf>

Bruggemann, J. H., Rodier, M., Guillaume, M. M. M., Andréfouët, S., Arfi, R., et al. 2012. Wicked social–ecological problems forcing unprecedented change on the latitudinal margins of coral reefs: the case of southwest Madagascar. Ecology and Society 17, 4: #47. (doi:10.5751/ES-05300-170447)

Castorena, V. and Metaca, M. 1979. El coral negro, una riqueza en peligro. Tecnica Pesquera 139: 22–27.

Clausade, M., Gravier, N., Picard, J., Pichon, M., Roman, M. L., et al. 1971. Morphologie des récifs coralliens de la région de Tuléar (Madagascar) : éléments de terminologie récifale. Téthys, Suppl. 2: 1–76.

Gabrié, C., Vasseur, P., Randriamiarana, H., Maharavo, J. and Mara, E. 2000. The coral reefs of Madagascar. In: Coral Reefs of the Indian Ocean. Their Ecology and Conservation. T. R. McClanahan, C. R. C. Sheppard and D. O. Obura (eds.), pp 411–444. Oxford University Press, Oxford.

Grigg, R. W. 1976. Fishery Management of Precious and Stony Corals in Hawaii. University of Hawaii, Honolulu. Available at: <http://nsgl.gso.uri.edu/hawau/hawaut76006.pdf>

Grigg, R. W. 1989. Precious coral fisheries of the Pacific and Mediterranean. In: Marine Invertebrate Fisheries: Their Assessment and Management. J. F. Caddy (ed.), pp 637–645. John Wiley and Sons, New York.

Grigg, R. W. 1993. Precious coral fisheries of Hawai'i and the U.S. Pacific Islands. Marine Fisheries Review 55, 2: 50–60. Available at <http://spo.nmfs.noaa.gov/mfr552/mfr5527.pdf>

Grigg, R. W. 2010. The Precious Corals Fishery Management Plan of the Western Pacific Regional Fishery Management Council. Western Pacific Regional Fishery Management Council, Honolulu. Available at <http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.365.841>

Grigg, R. W. and Opresko, D. M. 1977. Order Antipatharia, black corals. In: Reef and Shore Fauna of Hawaii. Section 1: Protozoa through Ctenophora. D. M. Devaney and L. G. Eldredge (eds.), pp. 242–261. Bishop Museum Press, Honolulu.

Grigg, R. W., Bartko, B. and Brancart, C. 1973. A new system for the commercial harvest of precious coral. University of Hawaii, Honolulu. Available at: <http://nsgl.gso.uri.edu/hawau/hawaut173001.pdf>

Guitart, B., Gonzalez, E. and Garcia, M. 1997. Evaluation of the Black Coral Populations in the Cuban West. Congreso De Ciencias Del Mar, Cuba 4: 74.

Kahng, S. E. and Grigg, R. W. 2005. Impact of an alien octocoral, *Carijoa riisei*, on black corals in Hawaii. Coral Reefs 24, 4: 556–562. (doi:10.1007/s00338-005-0026-0)

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

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

Parker, N. R., Mladenov, P. V. and Grange, K. R. 1997. Reproductive biology of the antipatharian black coral *Antipathes fiordensis* in Doubtful Sound, Fiordland, New Zealand. Marine Biology 130: 11–22. (doi:10.1007/s002270050220)

Pichon, M. 1978. Recherches sur les peuplements à dominance d'anthozoaires dans les récifs coralliens de Tuléar (Madagascar). Atoll Research Bulletin 222: 1–447. (doi:10.5479/si.00775630.222.1)

Salimo. 1997. Etude de la Pêche – Collecte à Pied sur les Platiers du Grand Récif de Tuléar (Sud-Ouest de Madgascar). Unpubl. DEA thesis, University of Toliara, Toliara.

Tescione, G. 1968. The Italians and their Coral Fishing. Fausto Fiorentino, Napoli.

Thomassin, B. 1971. Les faciès d'épifaune et d'épiflore des biotopes sédimentaires des formations coralliennes dans la région de Tuléar (Sud-Ouest de Madagascar). In: Regional Variation in Indian Ocean Coral Reefs. D. R. Stoddart and M. Yonge (eds.), pp 371–376. Symposia of the Zoological Society of London, 28. Academic Press, London and New York.

Vasseur, P. 1997. Ecosystèmes 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, Bordeaux.

SUPPLEMENTARY MATERIAL.

Available online only.

Table S1. Description of the material seized by the authorities that was used to collect black corals.

Table S2. Collection permits delivered by the ministry of fishery and aquatic resources in 2012.