Wild sea cucumber fishery in southwestern Madagascar

Olivier Maka,[1,*] Benjamin Pascal[2] and Gildas Todinanahary[1]

Abstract

Sea cucumbers have been overexploited in southwestern Madagascar, and some measures have been established for sustainably managing them. Since these management measures have been in place, however, very few assessments of the holothurian fishery have been made. From January to December 2018, we performed an assessment of fishery activities (fishing effort, catches, processing and marketing of products), and governance analysis at three main holothurian fishing villages (Sarodrano, Ankiembe and Andrevo). The results show that 12 species of sea cucumbers are collected by fishers in the study area. Compared to previous studies (Rasolofonirina and Conand 1998; Rasolofonirina et al. 2004), catches have increased, although these mainly comprise *Holothuria notabilis* (95.4% of catches for Andrevo, 95.4% for Ankiembe and 60.2% for Sarodrano), which have a low commercial value. Three forms of holothurian commercial chains were identified involving fishermen, middlemen, fishmongers and private operators. Fishmongers and/or fishermen take care of the first part of the processing (evisceration, first cooking, salting and second cooking), and operators complete the process to obtain exportable trepang. The holothurian fishery in southwestern Madagascar is developing but some of the established measures for their management and governance are poorly applied. Thus, it is recommended to improve aspects of their governance and to reinforce and renew existing management systems.

Key words: sea cucumber fishery, management, governance, southwestern Madagascar

Introduction

In Madagascar, sea cucumber exploitation provides income-earning potential for a portion of the coastal population, particularly near coral reefs (McVean et al. 2005). Trepang production in this country has increased exponentially over the last three decades**, from** 118 tonnes in 1988 to 890 tonnes in 2011 (Andriantsoa and Randriamiarisoa 2013). There are three major trepang-producing regions in Madagascar: the north, around Nosy Be Island; the centre of the west coast, around Mahajanga city; and the southwest around Toliara city, which is the largest producer on the island (Conand 1996; Andriantsoa and Randriamiarisoa 2013).

After the overexploitation of holothurians in Madagascar between 1990 and 1994 (Rasolofonirina and Conand 1998), studies were carried out on exploitation activities and sustainable management (Rasolofonirina 1997; Mara et al. 1998; Conand et al. 1998; Rasolofonorina et al. 2004; McVean et al. 2005). Today, holothurian fishery management measures are in place, and the aquaculture of these animals has been suggested as an alternative solution to be implemented for their sustainable management (Conand 1996; Rasolofonirina et al. 2004). However, since then, holothurian farming has developed in southwestern Madagascar to an industrial scale (Robinson and Pascal 2009), and the wild exploitation of holothurians in the region, as well as the effectiveness of management measures, has not been assessed.

The aim of this study is to assess activities related to the exploitation of wild holothurians in southwestern Madagascar, assess the existing management system for these animals, and analyse the governance of this fishery.

Methodology

Study sites

This study was carried out in three fishing villages, Sarodrano, Ankiembe and Andrevo, located on the coast of southwestern Madagascar (Fig. 1).

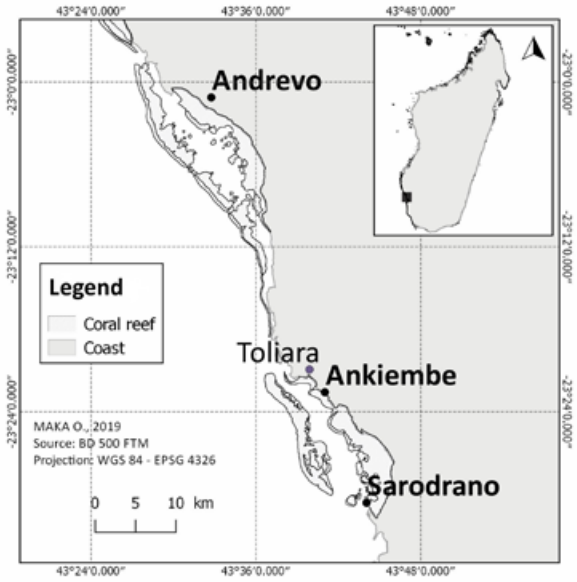

Figure 1. Location of the study villages.

[1] Institut Halieutique et des Sciences Marines, University of Toliara, BP 141, Rue Dr Rabesandratana Mahavatse II, 601-Toliara, Madagascar
[2] Indian Ocean Trepang, Enclosure of the Port - 601 Toliara, Madagascar
* Author for correspondence: dimaolivier@gmail.com

Surveys

Surveys were carried out with public authorities (fishery services, environment department, department of interior, and their local representatives in the villages) to collect administrative data concerning the exploitation of sea cucumbers in the region. Stakeholders (e.g. fishermen, middlemen, fishmongers and exporters) were also surveyed in order to know the organisation of this fishery, its socioeconomic aspects, its management methods and governance. These surveys were conducted by means of pre-established questions.

Individual interviews (semi-directives) were carried out with key informants from each village, followed by a focus group discussion. These forms of interviews were necessary not only to complete the information but also to explore new issues through discussions.

All of the information collected through they surveys was verified through direct observations, which allowed us to know what was happening on the ground with regard to stakeholders' activities in the sector.

Participatory monitoring of holothurian exploitation activities

Catch monitoring was carried out four days a week in each village. On each day of monitoring, a sample of 30 fishermen was randomly selected. This was done to estimate the catch composition and catch per unit effort (CPUE) at each site. Monitoring notebooks were set up to be filled out daily by fishmongers. This monitoring allowed us to observe the variation in the number of holothurian fishers who fished, and the price of fresh holothurian species. The price of semi-processed products was taken from the invoices received by the fishmongers after each sale to exporters in Toliara.

Participatory mapping

Participatory mapping was used to develop a map of the fishing sites frequented by sea cucumber fishermen. This method takes into account fishermens' knowledge and takes place in two stages: holding a community meeting, and recording the geographical coordinates of fishing sites.

A map was drawn by the fishermen with all of the information needed to make reference points on the marine and coastal environment of each village. During the community meeting, fishermen indicated on the map the location of their different fishing sites. Including both fishermen and fisherwomen in discussions was necessary in order to optimise the accuracy of these fishing sites' locations. Then, the geographical coordinates of the fishing sites on the map were taken *in situ,* with at least two fishermen who were present during the participatory mapping session.

Summary of the methodological approach

The approach of the methodology used for this research is summarised in Figure 2.

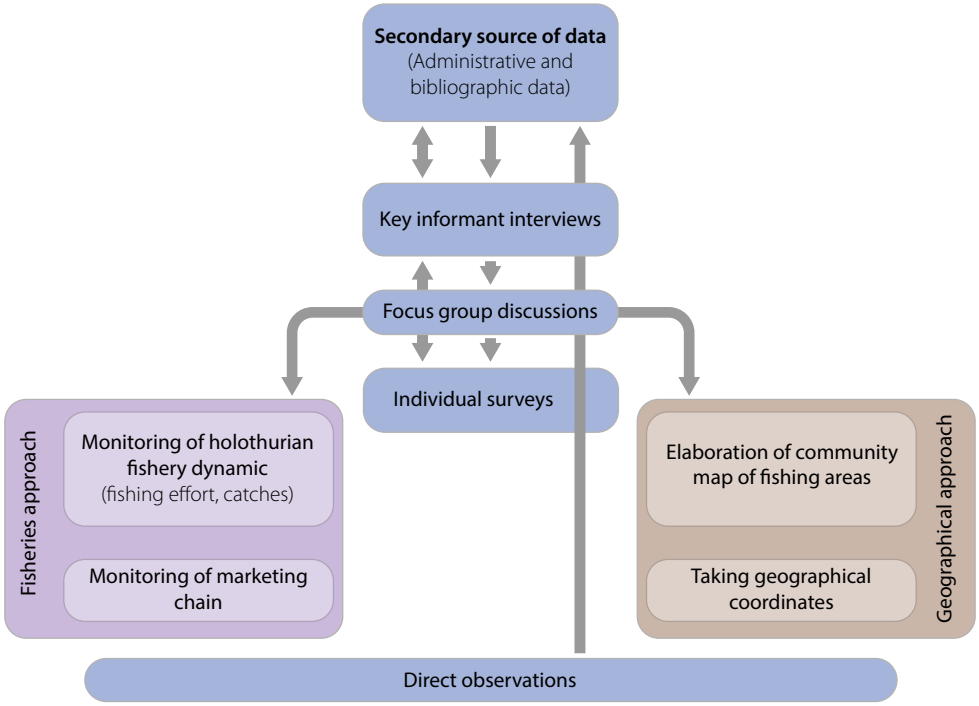

Figure 2. Summary diagram of the data collection technique used in this study.

Data treatment and statistical analysis

CPUE, expressed in kilograms per fisherman per day, is calculated using the formula:

$$CPUE = \sum_{1}^{ni} \frac{C}{ni}$$

C: daily catch of surveyed fishermen

ni: number of surveyed fishermen

The monthly production of each village was estimated by the product of CPUE and monthly fishing effort.

All of the statistical analyses were performed using the R software (R Core Team 2017). The Shapiro-Wilk's test was used to determine the normality of the data, and the Levene's test to calculate the homogeneity of variances. The significance (or not) of the difference in means was determined using ANOVA for normal data (followed by the Tukey Bonferroni post-hoc test to determine the source of the observed difference), and the Kruskal-Wallis test for data that did not follow the normal distribution (with the Wilcoxon comparison), at a level of 5%.

Results

The socioeconomic situation of fishermen

The population of each of the study villages is 1656 for Sarodrano, 5226 for Ankiembe and 2436 for Andrevo. Figure 3 shows the distribution of these populations according to age group. The main activity of the population of these villages is still traditional fishing: 89% of the population of Sarodrano are fishermen, 59% for Ankiembe and 83% for Andrevo (Fig. 4). Other activities in the villages are mainly agriculture, aquaculture and charcoal making.

Spatial distribution of holothurian stakeholders

Table 1 shows the number of stakeholders in the holothurian fishery, with the number of active participants in the three study villages.

None of the fishmongers in these villages are officially registered with the state. Middlemen go out to sea in a pirogue to buy sea cucumber catches from fishermen and sell them to fishmongers in the village itself.

Organisation of the fishery

Two holothurian fishing techniques were observed in the study villages: freediving and harvesting on foot. Free diving, which is practiced by men and very rarely by women (in the case of Andrevo). This fishing method is practiced every day except during bad weather (rainy periods or when the wind is blowing very strong) and requires a boat. Collecting sea cucumbers on foot is mainly done by women and children during a low spring tide. This method does not require a pirogue for travel.

Fishing sites

Sea cucumber fishing sites are located in the reef zone, and can only be accessed when the wind is moderate and blowing from the right direction because the sites that are very far from the villages are difficult to get to. In total, 15 fishing sites are frequented by fishermen in Sarodrano (Fig. 5), 20 in Ankiembe (Fig. 6) and 16 in Andrevo (Fig. 7).

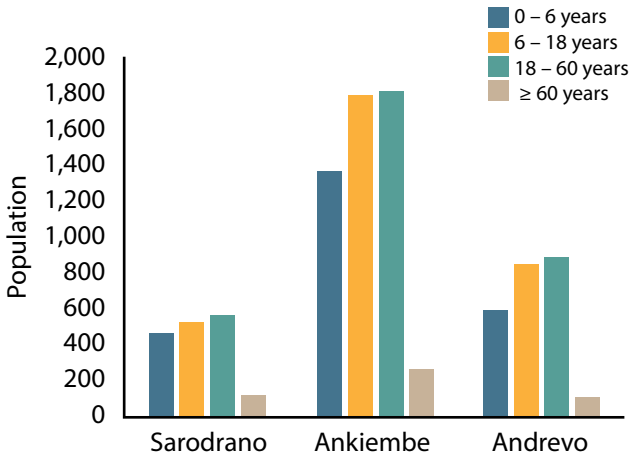

Figure 3. Population distribution at study sites by age group.

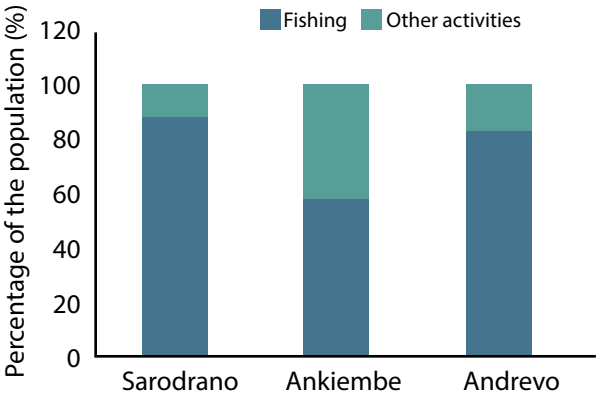

Figure 4. Population distribution at study sites according to villagers' main activities.

Table 1. List of stakeholders in the holothurian fishery in the study villages

Villages	Fishermen	Fishmongers	Middlemen
Sarodrano	216	4	0
Sarodrano	349	4	0
Andrevo	318	3	2

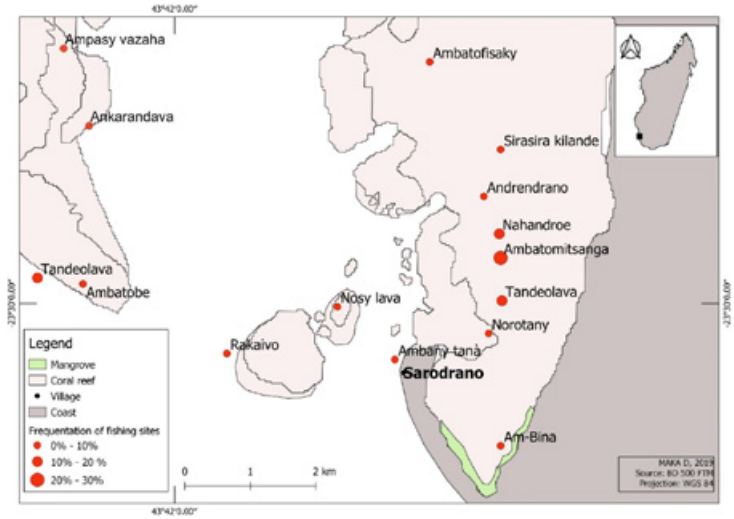

Figure 5. Fishing areas around Sarodrano and the frequency with which they are visited.

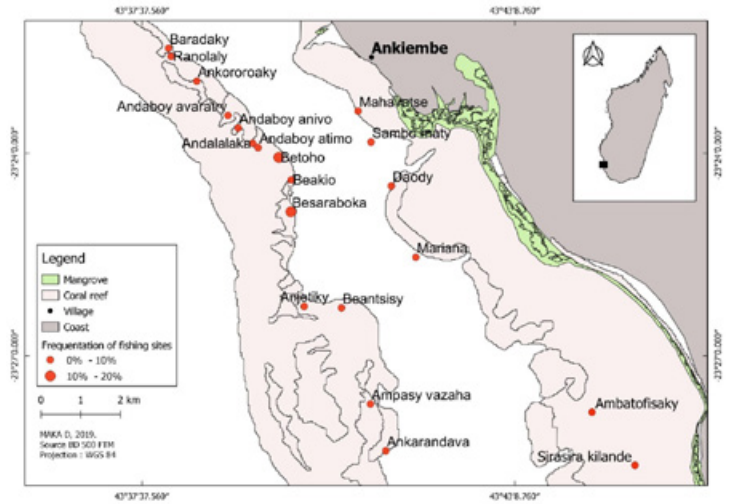

Figure 6. Fishing areas around Ankiembe and the frequency with which they are visited.

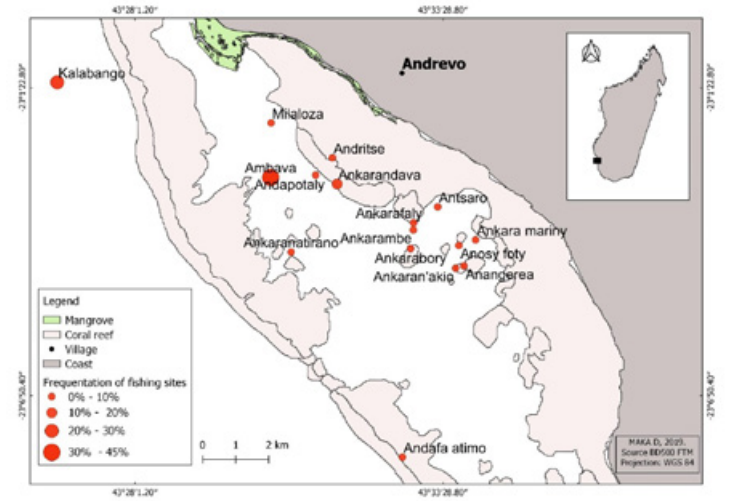

Figure 7. Fishing areas around Andrevo and the frequency with which they are visited.

Exploited species

Figure 8 shows that the accumulated number of sea cucumber species found in catches was stable from the 10th sampling for Sarodrano and Andrevo, at 11 and 10 species, respectively. For Ankiembe, the number of species found in catches was stable from the 8th sampling, with 10 species. *Holothuria cinerascens* was only found in Andrevo while *Actinopyga mauritiana* was not observed in this village. On the other hand, *Thelenota ananas* was only found in Sarodrano.

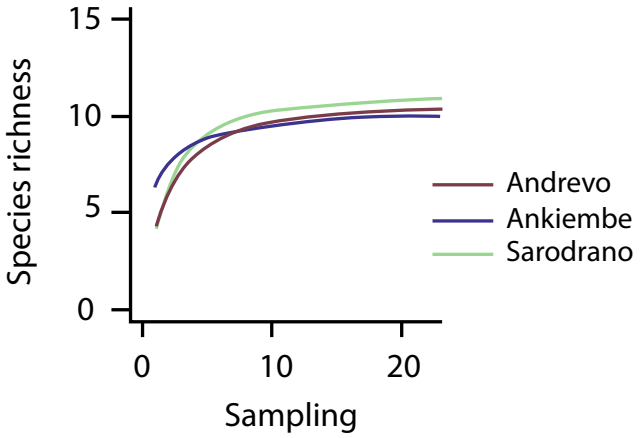

Figure 8. Trend line of sea cucumber species richness in the study villages.

The species observed in all three villages during this study are shown in Table 2. A species may have a different local name, depending on the village.

Fishing effort and catches

The average number of fishermen from Andrevo going out per month to harvest sea cucumbers is higher (804±332) than in Sarodrano (647±264) and Ankiembe (573±216) (Fig. 9), but there is no significant difference between these villages (p-value= 0.06).

The number of fishing days per month (Fig. 10) depends on weather conditions (wind and rain), sea conditions, and on events in the village (festivals or funerals).

Table 3 summarises the variation CPUE from January to December 2018 at the study sites. Andrevo's catches are significantly higher than those of Ankiembe (p-value=0.018) and Sarodrano (p-value=0.012). On the other hand, the difference between Ankiembe and Sarodrano catches is insignificant (p-value=0.99). Seasonality of catches is also observed because catches in all villages are significantly higher during the warm season than during the cold season (p-value<0.001).

Catch composition

Table 4 shows the specific composition of the catches from the study sites. Among the three villages, *Holothuria notabilis* is the most abundant species found in the catches (95.4% of the catches in Andrevo, 95.4% of those in Ankiembe and 60.2% of those in Sarodrano), followed by *Stichopus horrens* for Sarodrano and Andrevo (25.3% and 1.8%, respectively) and *Stichopus herrmanni* for Ankiembe (1.3%).

Commercial chain and holothurian processing

During this study, three sea cucumber marketing strategies were observed.

- Strategy 1: Fishermen sell freshly caught holothurians to the village fishmonger, who carrys out semi-processing before selling the product to exporters in Toliara;

Table 2. List of exploited species in the three study villages.

Scientific name	Local name (vezo)	Commercial code
Holothuria lessoni[3]	Zanga mena	ZM
Holothuria scabra	Zanga foty	ZF
Holothuria atra	Stylo	ST
Holothuria cinerascens	Folera	FL
Holothuria notabilis	Dôrlisy	DRL
Stichopus horrens	Jomely, Smurf, Crampon	CR
Stichopus herrmanni	Trakitera, Bengalo	TRK
Actynopyga echinites	Tronkena	TK
Actinopyga lecanora	Zangam-bato	ZB
Actinopyga mauritiana	Foty tsetsaky	FTSK
Thelenota ananas	Zanga borosy	BR
Bohadschia vitiensis	Kalalijaky, Falalijaky	KL

[3] *Holothuria lessoni* was previously known as *Holothuria scabra versicolor* (Purcell and al. 2012).

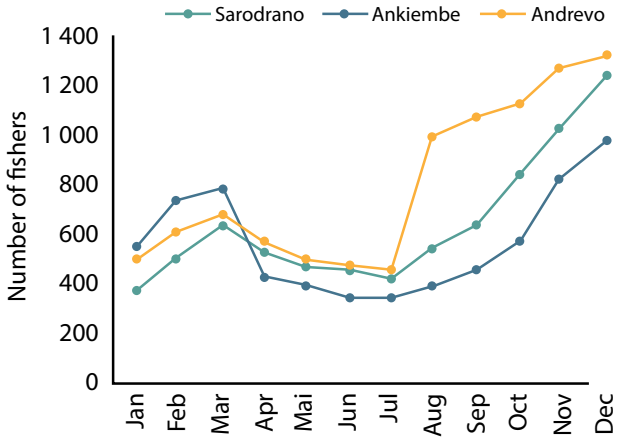

Figure 9. Monthly distribution of the number of fishermen going out to collect sea cucumbers in the villages

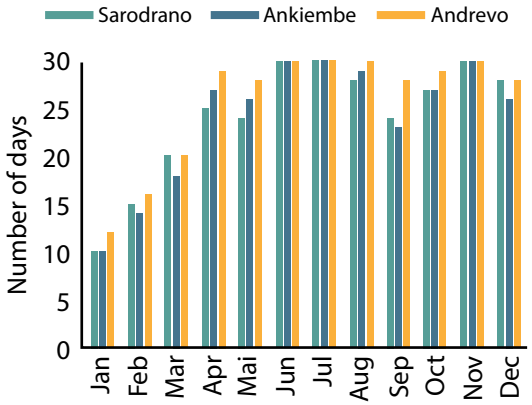

Figure 10. Number of sea cucumber fishing days per village.

Table 3. Monthly changes in catch per unit effort (CPUE) averages (in kilograms per fisherman per day) in the study villages.

CPUE	Sarodrano	Ankiembe	Andrevo
January	5.35	8.19	6.08
February	4.86	7.14	12.75
March	6.10	6.14	10.80
April	6.02	5.02	9.42
May	5.80	4.45	7.89
June	5.53	3.75	7.47
July	4.60	3.50	6.46
August	3.68	4.60	5.69
September	6.00	5.68	8.14
October	8.21	7.04	10.26
November	9.86	11.54	13.5
December	9.04	9.66	11.17
Average	**6.25**	**6.39**	**9.14**

Table 4. Composition of sea cucumber catches (in percent of total weight) from the three study villages.

Category	Species	Sarodrano	Ankiembe	Andrevo
1st	*Holothuria scabra*	2.62	0.92	0.55
	Holohuria lessoni	4.42	1.18	0.60
2nd	*Stichopus horrens*	25.31	0.24	1.84
	Stichopus herrmanni	3.23	1.27	0.63
	Actinopyga lecanora	1.16	0.003	0.002
	Actinopyga echinites	1.4	0.003	0.06
	Actinopyga mauritiana	0.41	0.030	
3rd	*Thelenota ananas*	0.02		
	Bohadschia vitiensis	0.93	0.74	0.02
	Holothuria atra	0.30	0.17	0.56
	Holothuria cinerascens			0.341
	Holothuria notabilis	60.20	95.44	95.38

- Strategy 2: Middlemen move to the fishermen's fishing areas to buy their catches and sell them, without any processing, to the fishmonger at the village, who then processes the sea cucumers in order to sell them to exporters in Toliara;

- Strategy 3: Fishermen process a part of their catch and sell directly to exporters in Toliara.

All marketing strategies of the commercial chain continue in the city of Toliara, where exporters complete the processing of products before reselling them. However, information on these exporters is very limited as they were not cooperative in this study.

Sea cucumbers are grouped into three categories according to their commercial value: high, medium and low (Table 5). Fishmongers buy fresh sea cucumbers per piece and resell them per kilogram to exporters after partial processing. The exporters complete the processing to obtain exportable trepang.

The processing of fresh holothurians is carried out by fishmongers at the villages. It generally consists of scraping, gutting, first cooking, salting, and then the second cooking, which is carried out before selling the products to exporters. But the processing steps varies depending on the species (Table 6).

For *Stichopus horrens*, the first cooking is obligatory before salting, otherwise the individual's body will deteriorate.

Management of the holothurian fishery

In 1992, the holothurian management method was based on fixing the commercial size (11 cm in fresh state and 8 cm in dry state), prohibiting the use of scuba gear, and monitoring the commercial strategy by means of compliance visas in order to collect statistical data. Since 1997, the administration's regulatory documents wanted to: 1) identify and list all of the stakeholders in the sector through fishermen's cards and registers, fishmonger's cards, collection permits, and exporter's cards; 2) require all stakeholders to provide information on their activities; and 3) require fees for col-

Table 5. The price range of species according to their commercial value (in Malagasy ariary, or MGA4).

Scientific name	Price of fresh product (ar./piece)	Price after semi processing (Ar./kg)
1st category: High		
Holothuria scabra	500–9000	20,000–30,000
Holothuria lessoni	1000–15,000	50,000–70,000
2nd category: Medium		
Stichopus herrmanni	500–4000	24,000
Stichopus horrens	500–3000	24,000
Actinopyga echinites	100–2000	15,000
Actinopyga mauritiana	500–4000	10 000
Actinopyga lecanora	500–3000	10 000
3rd category: Low		
Holothuria atra	100	1000
Holothuria cinerascens	100	4000
Bohadschia vitiensis	100	1000
Thelenota ananas	100	4000
Holothuria notabilis	20–40	4000

[4] 1 MGA = 0.00026 USD

Table 6. Summary of holothurian processing steps by species

	Holothuria scabra, H. lessoni	*Stychopus horrens*	Other[5]
Processing steps	Scraping		
	Gutting	Gutting	Gutting
	1st cooking	1st cooking (obligatory)	1st cooking (optional)
	Salage	Salage	Salage
	2nd cooking	2nd cooking	2nd cooking

[5] "Others" refers to species other than those listed in the preceding columns (*Actinopyga echinites*, *A. lecanora*, *A. mauritiana*, *Thelenota ananas*, *Holothuria atra*, *H. cinerascens*, *H. notabilis*, *Stichopus herrmanni* and *Bohadschia vitiensis*).

lection and export, which can be used to finance actions for fisheries management. In 2016, after an overexploitation of sea cucumbers, all forms of sea cucumber fishing and trepang processing were suspended in southwestern Madagascar, except for aquaculture. This interdiction, however, was lifted three months after the publication of the regulatory text.

However, several gaps are noted in the management of the sea cucumber sector, especially with regards to applying regulatory measures.

- During this study, none of the fishmongers in the three villages were registered with the Regional Fisheries Directorate (RFD). In addition, they continue to process sea cucumbers even when the law prohibits them to do so.
- The RFD states that fishmongers and collectors do not declare their products.
- The statistical data received by the RFD via the compliance endorsements of product shipments are not the same as those in the Fisheries Ministry's records. However, the current supply chain management system is totally dependent on these data.
- Concerning exports, there is also a big difference between the data at the Fisheries Ministry and those at the Fisheries Sanitary Authority; the latter agency issues sanitary certificates only on condition that it has seen the certificate of conformity endorsed by the Fisheries Ministry.

Problems with sector governance

The sea cucumber fishery has significant governance problems, and the main one is the lack of political will. There are delays in the design and implementation of strategies in policy framework documents. Moreover, these strategies generalise all resources exploited in the region concerned. However, certain species such as holothurians deserve specific strategies. The lack of government interest in fisheries management can also be seen in the persistence of a free-access regime to resources, and the weak will to enforce regulations.

As for the RFD, it faces serious budgetary problems, lack of material resources, and has limited functional and operational links with headquarters. As a result, its functions are limited to the collection of statistical data (particularly trade data). Collection and trading permits are issued by the administration, but this is carried out without any real link to the sea cucumber management plan. Indeed, there is little scientific advice within the authorisation procedure and little consideration of regulations.

Transparency in the activities of stakeholders and their data are should be part of good governance of the sector. Unfortunately, collectors and exporters consider their activities and data to be confidential so this information is generally inaccessible to everyone. Yet, such information would facilitate research on sea cucumber exploitation.

Finally, controlling and monitoring the exploitation of sea cucumbers (as with any resource) should be the role of the Fisheries Monitoring Centre. However, this branch has difficulty in fulfilling its role because informal actors (i.e. those who carry out their activities illegally) are not arrested or fined.

Discussion and conclusion

The number of sea cucumber species exploited in southwestern Madagascar is decreasing over time. Our results show that 12 species are currently exploited in the area, whereas in 2010, Madagascar still had the highest number of species fished in the entire western Indian Ocean at 30 species (Muthiga et al. 2010). Only two species have high commercial value in this study (*Holothuria scabra* and *Holothuria lessoni*) compared to four species from 1996 (Rasolofonirina et al. 2004) to 2007 (Lavitra et al. 2008). *Holothuria fuscogilva* and *Holothuria nobilis*, which were always present in fishermens' catches in the region until 2007, are no longer observed. This is due to the depletion of these species, which have been highly targeted by fishermen because of their high commercial value.

Sea cucumber fishing has continued to intensify over time. Indeed, snorkelling, which was rarely practised during neap tides (Rasolofonirina 1997), is now practised every day to get more catches. The results show that fishing effort in the region has quadrupled in 11 years compared to Ankiembe, which averaged 143 fishermen per month in 1997. This increase could be caused by a combination of factors such as the very rapid increase in the coastal (human) population, the lack of income-generating activities, and the growing demand for sea cucumbers. In addition, catches in the study villages are high compared to those in 1997, which averaged 4.9 kg per fisherman per day for Ankiembe (Rasolofonirina 1997). However, the difference can be explained by the intense exploitation of the low commercial value species *Holothuria notabilis*, which accounts for a very large proportion of the catches. The exploitation of this species has only been observed since the 1990s (Toral-Granda et al. 2008), and its exploitation is even more intense because many fishermen devote their effort to catching this species. Targeting low-value species is a sign of stock depletion, especially of high-value species (Rasolofonirina et al. 2004), which should normally be the main targets.

The trend in CPUE is similar in the villages studied and shows seasonal variation. The decrease in catches is due to the high turbidity observed every year in the study area resulting from the increased flow of the Onilahy River from November to December (due to heavy rains). This is also the case in this study because Sarodrano and Ankiembe are subject to hyper-sedimentation from the Onilahy and Fiherena rivers (Mahafina 2011). Heavy rains and especially cyclones limit the number of fishing days for fishermen.

In the villages, holothurians are processed by fishmongers and rarely by fishermen (e.g. Ankiembe); whereas in 1996, the majority of fishermen in the region processed their products themselves (Lavitra et al. 2009). Salting is widely used in holothurian processing in the region because it limits desiccation and reduces the loss of weight and length of processed sea cucumbers (Rasolofonirina et al. 2004; Lavitra et al. 2008).

Apart from the question about the effectiveness and consistency of sea cucumber management measures, their application is also very weak. Good management of the fishery requires production models that will be combined with data on fishing activity, population dynamics, and the socioeconomic aspects of fishers (Purcell and Pomeroy 2015). It is, therefore, essential for Madagascar to first conduct a sea cucumber stock assessment in order to subsequently define total allowable catch (TAC) by species and management area based on stock biomass. Spatialised management using TACs has positive biological (on the stock) and economic (on catches) effects, according to a study in New Caledonia (Léopold et al. 2015). Subsequently, the management measures established should be strengthened and/or revised. For example, the minimum commercial size of holothurians in Madagascar should be revised as it was based on the study of a single species (*Holothuria scabra*) and then generalised to apply to all other species (Andriantsoa and Randriamiarisoa 2013). It is also necessary to encourage fishermen to process their products. This will maximise their earnings because otherwise they receive only a fraction of the potential value of their resources (Friedman et al. 2008). Then, in the face of overexploitation, it is more effective to manage trade rather than fishing by freezing licensing and imposing export ceilings (Carleton et al. 2013). Finally, in order to be able to implement these measures, a specific national management plan for holothurians must be established. Three countries in Melanesia (Papua New Guinea, Solomon Islands and Vanuatu) have carried out a study to gain political and public support for sea cucumber fisheries management interventions. They demonstrated that enforcing the commercial size limit can increase fishing income by up to 144% (Lee et al. 2018). This is an example of how to convince the government to strengthen living resource management measures.

The solutions to the problems of sea cucumber fisheries governance in Madagascar are based on the application of several principles. The priority is the transparency of all aspects of the sector (stock state, regulations, exploitation of the resource, and the economic and social performance of the sector). Another principle is that of coherence, which refers to the correctness of public action in the sector according to the sectorial fisheries objectives (Breuil 2012). As in Vanuatu, Fiji and Tonga (holothurian producing countries), their sea cucumber stocks have been overexploited and they have first opted to rebuild stocks (by closing the fishery for years) and then setting a ceiling on exports (Carleton et al. 2013). The participation of stakeholders (fishermen, economic operators, civil society) in all steps of planning ensures the quality, effectiveness and efficiency of public action (Breuil 2012). This is the case of Vanuatu and New Caledonia, which have established a shared fisheries governance regime (Léopold et al. 2015). Finally, one aspect that should not be neglected is research, as it is the basis or reference point for decisions on resource management (Lee et al. 2018). In Madagascar, holothurians are among the resources that have been most studied. However, information is still lacking on the biology and ecology of sea cucumber species that are exploited, as well as the social and economic impacts (Anonymous 2014), in contrast to other trepang-producing countries.

Acknowledgements

This study was carried out, in part, with the financial support of the Indian Ocean Trepang company. We would like to thank Gabriel Donald, Joël Arnaud Masoava (SOAVATSARADIA), Romario Tsipy and his wife, as well as the fishmongers in the study villages who helped a lot with data collection.

References

Andriantsoa M. and Randriamiarisoa. 2013. Caractérisation actuelle de la pêche maritime à Madagascar, les systèmes statistiques du MPRH et conception des activités pour le nouveau système de suivi des captures (Pêcherie Industrielle Nationale, Pêche Artisanale Nationale et Pêche Traditionnelle Nationale). Rapport du projet sur la Mise en œuvre d'une stratégie régionale de la pêche pour la région AOA-OI (IRFS) Intitulé : Renforcement des systèmes statistiques de la pêche maritime à Madagascar ; (FED/2009/021-330). 160 p.

Anonymous. 2014. Situation de référence. Lettre de politique BLEUE. 28 p.

Breuil C. 2012. Document de support à la formation sur la bonne gouvernance des pêches maritimes dans la sous-région AOA-OI, SmartFish Working Papers No 007. 34 p.

Carleton C., Hambrey J., Govan H., Medley P. and Kinch J. 2013. Effective management of sea cucumber fisheries and the beche-de-mer trade in Melanesia. SPC Fisheries Newsletter 140:24–42. https://purl.org/spc/digilib/doc/g2jdz

Conand C., 1996. Rationalisation des activités de collecte d'holothuries à Madagascar, Rapport d'intervention du COI/FED. 40 p.

Conand C., De. San M., Refeno G., Razafintseheno G., Mara E., Andriajatovo S. 1998. Sustainable management of the sea cucumber fishery sector in Madagascar. SPC Beche-de-mer Information Bulletin 10:7–9. https://purl.org/spc/digilib/doc/gaggg

Friedman K., Purcell S., Bell J. and Hair C. 2008. Sea cucumber fisheries: A manager's toolbox. ACIAR Monograph No. 135. Canberra: Australian Centre for International Agricultural Research. 32 p.

Lavitra T., Rachelle D., Rasolofonirina R., Jangoux M. and Eeckhaut I. 2008. Processing and marketing of holothurians in the Toliara region, southwestern Madagascar. SPC Beche-de-Mer Information Bulletin 28:24–33. https://purl.org/spc/digilib/doc/pmwuf

Lee S., Govan H., Wolff M. and Purcell S. 2018. Economic and other benefits of enforcing size limits in Melanesian sea cucumber fisheries. SPC Fisheries Newsletter 155:29–36.

Léopold M., Ham J., Kaku R., Gereva S., Raubani J. and Moenteapo Z. 2015. Spatial sea cucumber management in Vanuatu and New Caledonia. SPC Beche-de-mer Information Bulletin 35:3–9. https://purl.org/spc/digilib/doc/bmbw5

Mahafina J. 2011. Perception et comportement des pêcheurs pour une gestion durable de la biodiversité et de la pêcherie récifale : application au niveau des réserves marines du Sud-Ouest de Madagascar, Thèse de Doctorat, Université de la Réunion, France. Université de Toliara, Madagascar. 185 p.

Mara E., Rasolofonirina R., Rabesandratana H., RakotoarinivoW., Ravelo I. and Conand C. 1998. Étude de la pêcherie aux holothuries et propositions de mesures d'aménagement dans le Sud-ouest de Madagascar. Report IH.SM/ONE/BM, Toliara. 40 p.

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. https://purl.org/spc/digilib/doc/sz6v2

Muthiga N., Ochiewo J. and Kawaka J. 2010. Strengthening capacity to sustainably manage sea cucumber fisheries in the western Indian Ocean. SPC Beche-de-Mer Information Bulletin 30:3–9. https://purl.org/spc/digilib/doc/376xf

Purcell S.W. and Pomeroy R.S. 2015. Driving small-scale fisheries in developing countries. Frontiers in Marine Science 2:44. doi: 10.3389/fmars.2015.00044

Rasolofonirina R. 1997. Écologie, biologie et pêche de deux holothuries aspidochirotes, *Bohadschia vitiensis* et *Holothuria scabra* var. *versicolor* dans la Région de Toliara, Madagascar. DEA, IH.SM, Université de Toliara, Madagascar. 84 p.

Rasolofonirina R. and Conand C. 1998. Sea cucumber exploitation in the Toliara region of south-west Madagascar. SPC Beche-de-mer Information Bulletin 10:10–13. https://purl.org/spc/digilib/doc/494xf

Rasolofonirina R., Mara E. and Jangoux M. 2004. Sea cucumber fishery and mariculture inMadagascar, a case study of Tuléar, south-west Madagascar. p. 133–149. In: Lovatelli A., Conand C., Purcell S., Uthicke S., Hamel J. F. and Mercier A. (eds). Advances in sea cucumber aquaculture and management. Fisheries Technical Paper No. 463. Rome: FAO. 425 p.

Robinson G. and Pascal B. 2009. From hatchery to community – Madagascar's first village-based holothurian mariculture programme. SPC Beche-de-Mer Information Bulletin 29:38–43. https://purl.org/spc/digilib/doc/roo5p

Toral-Granda V., Lovatelli A. and Vasconcellos M. 2008. Sea cucumbers. A global review of fsheries and trade. FAO Fisheries and Aquaculture Technical Paper No. 516. Rome: FAO. 317 p.