Small-scale fisheries, food security, and the SSF Guidelines: value chain challenges in two community-managed fisheries in western Madagascar

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Word count: 6532 (+ abstract 180, references 1574)

2 Figures

0 Tables

Abstract

Madagascar, among the world's poorest countries, depends heavily on small-scale fisheries for food security and income. Many of its fisheries have transitioned from subsistence- to market-oriented in recent decades, driven by the emergence of new export markets. In this chapter we consider the *Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication* ('SSF Guidelines') in light of experiences from two small-scale fisheries in Madagascar: for octopus (*Octopus cyanea*) and mud crab (*Scylla serrata*). We focus on articles related to value chains, post-harvest and trade. The dispersed nature of the fisheries means fishers rely on private sector collectors to access markets. Post-harvest actors hold disproportionate negotiating power, with benefits from management initiatives accruing mainly to actors high in the value chain rather than the fishers who implement them. To address these imbalances and increase the contribution of these fisheries to poverty reduction and food security, it is critical to empower fishers and improve their representation in management processes. Data deficiencies must also be tackled, to enhance transparency and provide an evidence base for decision-making.

Keywords: Community-based natural resource management; Locally Managed Marine Area (LMMA); Market-based approaches; Mud crab; Octopus

Introduction

Small-scale fisheries (SSFs) directly or indirectly support the livelihoods of over 500 million people worldwide (Béné et al. 2007; FAO 2016), so ensuring that they are managed sustainably is critical to food security and poverty reduction efforts (FAO 2005; Bell et al. 2009; Garcia & Rosenberg 2010; Smith et al. 2010). They are particularly important in tropical developing countries where the majority of the world's fishers live (Pomeroy and Andrew 2007), but where productivity and sustainability are often threatened by a suite of factors including competition with industrial fleets (Pauly 1997; 2006), climate change (Allison et al. 2009; Hoegh-Guldberg and Bruno 2010), inadequate environmental governance (Allison et al. 2012; Garcia & Rosenberg 2010), and the marginalisation of small-scale fisheries in policy and planning (Andrew et al. 2007; Mills et al. 2011). As a result, many such fisheries are "failing to fulfil their potential as engines of social and economic development" (Andrew et al. 2007).

Recognising that a lack of policy guidance was hindering the sustainable development of the sector, in 2015 the Food and Agriculture Organisation of the United Nations (FAO) published the *Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication* ('SSF Guidelines', FAO 2015), the first internationally agreed instrument focusing on small-scale fisheries. Developed through a bottom-up, participatory process involving over 4000 fishers, academics, government and civil society stakeholders from over 120 countries (da Silva 2015), the guidelines are viewed as a potential turning point for small-scale fishers worldwide (Jentoft 2014). However, the impact of the SSF Guidelines will depend entirely on their implementation, and this should be a "cyclical, interactive, and iterative process, where original objectives are subject to repeated questioning, debate, evaluation and reformulation" (Jentoft 2014).

In this chapter, we contribute to this refinement process by considering the SSF Guidelines in light of experiences from two small-scale fisheries in Madagascar, an island state with extremely high poverty (World Bank 2015) and high dependence on small-scale fisheries for both food security and income (Le Manach et al. 2012; Barnes-Mauthe et al. 2013). The two fisheries target reef octopus (*Octopus cyanea*) and mangrove mud crab (*Scylla serrata*). We focus specifically on Chapter 7 of the SSF Guidelines 'value chains, post-harvest and trade', since the isolated, dispersed nature of the fisheries, combined with their export-oriented

markets, mean that interventions centred on reducing value-chain inefficiencies have great potential to improve the economic returns received by small-scale fishers.

Study system

The fourth largest island on Earth, Madagascar spans 14 degrees of latitude and has more than 5500 km of coastline, along which over half the population is concentrated (WRI 2003). The third least food secure nation globally (GFSI 2015), Madagascar suffers absolute poverty rates of around 90 % (World Bank 2015). Its largely rural population depends heavily on renewable natural resources for subsistence and household income (Horning 2008), particularly in western coastal regions, where poor soils and climatic constraints impede agriculture (Razanaka et al. 2001), and where small-scale fisheries are concentrated (Harris 2011). This area is home to the Vezo, a semi-nomadic ethnic group of traditional fishers (Astuti 1995). Traditionally subsistence dominated, the Vezo economy has become increasingly trade-oriented since the 1970s, and has focused on export markets for octopus, sea cucumbers and shark fin since the turn of the 21st century (Iida 2005; Muttenzer 2015; Cripps and Gardner 2016). However, several stressors threaten the safety net provided by small-scale fisheries in this region, including reef sedimentation (Maina et al. 2012; Sheridan et al. 2015), coral bleaching (McClanahan et al. 2009), destructive capture techniques (Andréfouët et al. 2013), and overfishing driven by increases in fisher populations, improved technologies and new or growing markets (Bruggemann et al. 2012; Grenier 2013; Muttenzer 2015). In addition the State continues to promote access to its fisheries by foreign fleets (Le Manach et al. 2013), despite evidence that this may damage the sector's productivity (Le Manach et al. 2012), and lacks the capacity to regulate the small-scale fisheries sector effectively (Harris 2011).

Given the lack of central fisheries management capacity, management initiatives in the country's small-scale fisheries sector are largely driven by non-governmental organisations (NGOs), often with assistance from international development agencies. Blue Ventures (BV), a British environmental conservation NGO working with communities to rebuild tropical fisheries, has been supporting local fisheries management and conservation initiatives in Madagascar since 2003. From its initial experience with octopus fishery management and community-managed protected area development, the organisation now implements diverse programmes in community health, education, aquaculture and mangrove-based carbon emissions reductions, and contributes to the management of several fisheries.

Octopus fishery

The octopus fishery of south-west Madagascar targets three species, although *Octopus cyanea* makes up 95 % of landings (Raberinary and Benbow 2012). Octopus is harvested by all sectors of Vezo society and is either gleaned from coral reef flats during low tides, or caught by free divers in deeper waters (Westerman and Benbow 2013). Traditionally of minor local importance, the fishery expanded at the turn of the 21st century, when private sector export companies started to send trucks carrying ice buckets to remote villages along the coast, buying octopus from intermediaries and transferring them to processing facilities and the export cold chain (L'Haridon 2006).

In order to improve the productivity of the fishery, in 2004 a trial closure was implemented over 150 ha of reef flat near the village of Andavadoaka by the local community with support from BV and several private sector, NGO and government partners (Harris 2007). The perceived success of this approach stimulated adoption of the periodic closure system by neighbouring villages, and in the decade since, more than 200 hundred closures have been implemented along 500 km of coastline in south-west Madagascar, as well as others in northern Madagascar, Pemba (Tanzania), Cabo Delgado (Mozambique) and Bahia de los Angeles (Mexico). Recent evaluations have demonstrated that well-managed closures create net economic benefits for fishers (Oliver et al. 2015). The periodic closure system has also influenced national fisheries policy, with the introduction of a minimum catch size of 350 g and an annual national fishery closure for 1.5 months in 2005. National closures have also been adopted by Mauritius and Rodrigues in the Western Indian Ocean as a result of this work.

At present (2016), periodic octopus closures form the bedrock of broader marine resource management initiatives centred on Andavadoaka. Twenty-five villages are grouped into a local marine environmental management association named Velondriake, governed by an elected committee. The association is legally empowered to set and enforce resource use rules using a form of by-law known as *dina* (see Article 7.4; Andriamalala and Gardner 2010), and manages over 600 km^2 of shallow coastal seas as Madagascar's first Locally Managed Marine Area (LMMA). In addition to periodic closure sites, the LMMA incorporates permanent reserves in reef and mangrove areas, and in 2015 was officially gazetted as an IUCN category V protected area, co-managed by the Velondriake Association and Blue Ventures.

Mud crab fishery

Madagascar's mud crab (*Scylla serrata*) fishery is based on traditional methods using simple gears, with fishers operating on foot or from small dugout canoes in the mangrove forests of the west and north-west coasts. Small-scale collectors and sellers operate locally, often within informal markets, and sell their produce to seafood export companies. Market demand has grown significantly in recent years, particularly for live crabs for export to China, leading to price increases of 500% since 2011 and subsequent pressure on wild stocks. In 2014 national production reached 3087 T of which 75% was exported to China (Fisheries Hygiene Authority statistics, 2015).

Since 2011, local communities and the Ministry of Fisheries and Marine Resources have implemented management measures, including 3-5 month periodic closures. National legislative changes in 2014 set a minimum catch size of 11 cm, an annual quota of 5000 T (4250 T for export), and an annual nationwide fishery closure from July to October (Arrêtés 37206/14 and 32101/14). Management priorities include stock management through further periodic closures, decreasing post-harvest losses, developing crab aquaculture and/or fattening to reduce pressure on wild stocks, and improving monitoring, transparency and regulation along the value chain.

Application of SSF Guidelines chapter 7: value chains, post-harvest and trade

The bulk of BV's management interventions in Madagascar's small-scale fisheries were implemented prior to 2015, thus their success or otherwise cannot be linked to the SSF Guidelines. Nevertheless, experiences in Madagascar's SSF sector over the last decade offer valuable insights that can contribute to their iterative improvement, particularly on account of the public-private partnership-based approaches to fisheries management and post-harvest value chain improvement that has been developed in these fisheries. The lessons learnt from our experiences may prove instructive to other parties – be they State, private or civil society – seeking to implement the SSF Guidelines in similar socio-ecological contexts. Here, we discuss our experiences of value chain interventions in Madagascar's small-scale octopus and mud crab fisheries using the framework of the SSF Guidelines Chapter 7 on 'value chains, post-harvest and trade'.

Article 7.1 *All parties should recognize the central role that the small-scale fisheries post-harvest subsector and its actors play in the value chain. All parties should ensure that post-*

harvest actors are part of relevant decision-making processes, recognizing that there are sometimes unequal power relationships between value chain actors and that vulnerable and marginalized groups may require special support.

Both the octopus and mud crab fisheries occur largely in isolated locations lacking transport infrastructure or cold chains, but are primarily export-oriented. As such, post-harvest actors are particularly important for economic productivity, providing collection, processing, and access to markets (Oliver et al. 2015; Smartfish 2015). BV's actions in both fisheries integrate post-harvest actors in all management activities, but focus predominantly on traditional small-scale fishers, the most vulnerable and marginalised actors in the supply chain (see Article 7.4).

The seafood export company Copefrito, one of two main collectors operating out of the city of Toliara (SW Madagascar), has been a key partner in the development of periodic fishery closures for octopus since initial trials in 2004 (Harris 2007; Oliver et al. 2015). By coordinating collections on closure openings and offering a price premium of 15-20 % for octopus at openings, as well as a premium for larger octopus, the partnership contributes to the economic incentive for good closure management. This move by a key commercial actor has since been followed by the region's other principal buyer, Murex, as well as by some smaller collectors.

All octopus fishery stakeholders (including fisher associations and collectors/export companies as well as the Ministry of Fisheries and Marine Resources, marine research institute (IHSM) and supporting NGOs) convene quarterly within the octopus fishery management platform (*Comité de Gestion de la Pêche aux Poulpes* (CGP)). An informal platform with no official fisheries management mandate, the CGP nonetheless serves as an effective forum for engaging stakeholders. Decisions made by the body mostly relate to the management of periodic closures, negotiation of prices, and implementation of the south-west Octopus Fishery Improvement Project (FIP) – an action plan intended to move the fishery towards certification by the Marine Stewardship Council's (MSC) ecolabel.

In the mud crab fishery, buyers are, whenever possible, involved in decisions over the timing of periodic closures, or notified of opening dates, in order to ensure prompt collection following openings. There is some evidence from the Smartfish project (see Article 7.3) that

buyers catalysed adoption of improved storage and transport technologies, since they valued healthier crabs (Smartfish 2015). To identify the key actors in the value chain to be integrated into management activities, a stakeholder analysis for this fishery will be completed in 2016.

Challenges

Within the octopus fishery, the development of effective partnerships between private sector buyers, fishers and NGOs is threatened by rivalry and mistrust, particularly between those operating without the necessary authorisations. While illegal, such informal trade is practically unavoidable, given the country's vast coastline, poor transport and communications infrastructure, and limited central fisheries management capacity. While the CGP helps to engage community representatives in an open forum, it lacks the legal authority to bring about necessary but unpopular actions, and as such, currently operates based on cross-party consensus. Even within the CGP, fishers have limited negotiating power over prices as they remain heavily dependent on post-harvest actors for access to markets.

Madagascar's mud crab fishery lacks a coordination platform and thus the negotiating power of fishers is even more limited. There is no fixed price for mud crab, and buyers are in a strong position to dictate prices since fishers have little capacity for post-harvest conservation of their produce and remain unorganised. Coordination efforts are more complex than in the octopus fishery, since there are more buyers, collaboration is lower, and the market is much more dynamic.

Article 7.2 *All parties should recognize the role women often play in the post-harvest subsector and support improvements to facilitate women's participation in such work. States should ensure that amenities and services appropriate for women are available as required in order to enable women to retain and enhance their livelihoods in the post-harvest subsector.*

Women play a key role in both fisheries, as fishers and in the immediate post-harvest sub-sector. Between 2004 and 2011, 58% of recorded octopus fishing outings in 14 villages were by women (Westerman and Benbow 2013). Women comprise the majority of local intermediaries employed by export companies to buy octopus from fishers at the village level. Nevertheless, men tend to dominate discussions and decision-making related to octopus closures (Westerman and Benbow 2013), as well as the CGP.

In Velondriake an awareness-raising campaign called *Ampela Tsy Magnavake* ('women not segregated') was launched in 2014, aimed at encouraging the participation of women in octopus fishery management and culminating in the establishment of women's fora in 19 villages. Each forum has two focal points participating in key meetings and relating news back to their group. The initiative has helped to increase the participation of women in meetings.

Challenges

The transition of octopus from subsistence food to valuable commodity over the last decade has increased the participation of men in the fishery, reducing the proportion of landings from women, and marginalising them from decision-making processes. While efforts are underway to address the latter issue, traditional Malagasy societies are strongly patriarchal, and women traditionally play only a limited role in collective decision-making (Gezon 2002). Although the *Ampela Tsy Magnavake* initiative has stimulated increased female participation in fishery management, an exclusive focus on women risks the disempowerment and disenchantment of male stakeholders. Further, while women's attendance has increased, many remain reluctant to actively participate and speak out in meetings.

Article 7.3 *States should foster, provide and enable investments in appropriate infrastructures, organizational structures and capacity development to support the small-scale fisheries post-harvest subsector in producing good quality and safe fish and fishery products, for both export and domestic markets, in a responsible and sustainable manner.*

State investment in post-harvest infrastructure was virtually non-existent until the launch of the African Development Bank-funded *Projet d'Appui aux Communautés de Pêcheurs* (PACP) in 2006. Project activities included the construction of fisheries landing and pre-processing stations ('*débarcadères*') in 20 octopus fishing villages in the south-west costing 1.5 million UC. The aim of the *débarcadères* is to ensure landings meet the hygiene standards expected of western markets, and their planning included provisions for solar power and ice production facilities. Unfortunately, the project failed to consult local fishers, and whilst facilities were completed in 2013, most remain locked and unopened (ICAI 2015). The poor planning and execution of this project has been highly controversial, making headlines in the British press as an example of wasted overseas aid money (Martin 2015; Parfitt 2015).

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Although there has been little State involvement in the mud crab fishery, the European-Union funded Smartfish programme has focused on reducing post-harvest mortality in the mud crab fishery since 2013. Initiatives have included the promotion of low-tech crab storage and transport equipment such as improved ox-carts and fishing vessels, fixed cages, tidal pens and storage sheds, as well as a multimedia campaign on mortality reduction. The project, which has been implemented in 33 villages across four regions has decreased post-capture mortality by about 15 %, benefitting all actors in the value chain (Smartfish 2015, Smartfish, unpublished data).

Challenges

State agencies are virtually absent through much of rural Madagascar, and major-donor-agency funded development interventions are not always well conceived, implemented or received. Consequently, there is widespread apathy amongst fishers and buyers regarding the State's capacity to mobilise support for infrastructure improvements in support of small-scale fisheries. The persistence of pre-existing collection stations for octopus, in which fishers sell catches to intermediaries in unsanitary conditions under a makeshift wooden shelter – often against a backdrop of a sophisticated yet securely locked and vacant landing station – provides a compelling illustration of the origin of such sentiment.

Article 7.4 *States and development partners should recognize the traditional forms of associations of fishers and fish workers and promote their adequate organizational and capacity development in all stages of the value chain in order to enhance their income and livelihood security in accordance with national legislation. Accordingly, there should be support for the setting up and the development of cooperatives, professional organizations of the small-scale fisheries sector and other organizational structures, as well as marketing mechanisms, e.g. auctions, as appropriate.*

As part of a broader initiative to devolve natural resource management rights and responsibilities to rural communities (Ferguson et al. 2014), in 1996 the Malagasy State permitted local social norms known as *dina* to be formalised and ratified as by-laws in the context of community forestry contracts (Antona et al. 2004). *Dina* have since been used to formalise resource use regulations in a range of community-based conservation and natural resource management initiatives, including community forestry contracts (Pollini et al. 2014),

LMMAs (Andriamalala and Gardner 2010), and new protected areas (Virah-Sawmy et al. 2014).

Periodic octopus fishery closures in Velondriake LMMA are regulated by the Velondriake *dina*, which specifies rules for each management zone, as well as penalties and enforcement mechanisms. Developed in a participatory process, it can be applied against offenders locally, but serious cases can be taken to a magistrate's court if required (Andriamalala and Gardner 2010). Similar *dina* have been developed with local communities in several LMMAs along the south-west coast to support octopus fisheries management efforts.

In the mud crab fishery BV has supported the creation of five fisher associations in the Menabe region, enabling a limited number of fishers to receive licenses to sell their products in urban markets, thus bypassing middlemen and gaining higher prices. It is anticipated that the associations will also empower fishers to negotiate better prices with collectors. These associations use *dina* to regulate their fisheries (including management measures such as periodic mangrove closures), although the *dina* have yet to be ratified in a District court and thus can only be applied at the local level without recourse to formal legal procedures.

Challenges

While *dina* have allowed the legal recognition of community-developed (or in many cases NGO-suggested, Pollini et al. 2014) rules over local resource use, in practice the Velondriake *dina* is rarely fully applied within the community because of strong social cohesion, and is difficult or impossible to apply against outsiders such as migrants, motorised artisanal fishers or illegal industrial fleets (Andriamalala and Gardner 2010; Cripps and Gardner 2016). In addition, although communities are legally empowered to manage the fishery, they have little capacity to influence the post-harvest value chain, since they are unable to transfer their product to market and thus remain entirely dependent on buyers to support their efforts. While the CGP provides an informal platform for price negotiations, buyers retain a position of disproportionate strength in discussions. This is compounded by a lack of awareness amongst fishers of their rights and ability to dictate terms, as well as by fisher poverty, which compels them to sell their produce daily. Further, all forms of formal social organisation within small-scale fisheries in Madagascar are hampered by very low literacy rates, high isolation and a lack of infrastructure, as well as by the costs and legal/administrative complexity of existing mechanisms. Training in collective bargaining is currently being trialled within BV's

aquaculture programme and may be extended to fisheries following evaluation. Fisheries management efforts for mud crab are further constrained by jurisdictional complexities regarding the mangrove habitats in which they live, since mangroves are legally considered terrestrial forests under national legislation and therefore do not fall under the remit of the Ministry of Fisheries and Marine Resources.

Article 7.5 *All parties should avoid post-harvest losses and waste and seek ways to create value addition, building also on existing traditional and local cost-efficient technologies, local innovations and culturally appropriate technology transfers. Environmentally sustainable practices within an ecosystem approach should be promoted, deterring, for example, waste of inputs (water, fuelwood, etc.) in small-scale fish handling and processing.*

Post-harvest losses were identified as the key inefficiency in the mud crab value chain, with losses averaging 23 % (rising to 50 % in the rainy season) due to low investment in storage and transport materials by collectors (Smartfish 2015). The Smartfish project aims to reduce such losses through the spread of simple innovations made using readily-available local materials (see Article 7.3). These techniques reduce waste and ensure that crabs are kept in good condition, facilitating entry into more lucrative export markets for live, rather than frozen, animals. Independently of Smartfish, BV has launched a feasibility study into 'crab fattening' aquaculture, since the value can double from an 'empty' crab to a 'full' crab of the same size. Undersized and badly damaged crabs are consumed by fishers or sold locally, thus waste during immediate post-harvest stages is low, though losses during onward transportation may be significant.

Waste in the octopus fishery is minimal. Undersized octopus and those not processed to export standards are dried for sale in the domestic market, thus contributing to domestic food security, while ink sacs are used as bait to fish rabbitfish (*Siganus* spp.) (Gough et al. 2009). Because current harvesting methods (spearing) damage the product and reduce its value, the possibility of introducing alternative methods (e.g. traps) is being investigated. However, these may trigger overfishing, for example by allowing the harvesting of octopus from deeper waters than can currently be fished. Post-harvest inputs are low in both fisheries, and we do not believe that they generate serious environmental impacts.

Challenges

The octopus fishery suffers from overwhelming dependence on a small number of buyers with exclusive access to the cold chain for preservation. Although some commercial operators are sensitive to fishers' needs and interests, fishers remain entirely distinct from collection businesses, and have little negotiating power.

Article 7.6 *States should facilitate access to local, national, regional and international markets and promote equitable and non-discriminatory trade for small-scale fisheries products. States should work together to introduce trade regulations and procedures that in particular support regional trade in products from small-scale fisheries and taking into account the agreements under the World Trade Organization (WTO), bearing in mind the rights and obligations of WTO members where appropriate.*

There is no regional cooperation between Western Indian Ocean coastal states with regards the octopus or mud crab trade. Existing trade regulations relating to the mud crab fishery work against the interests of small-scale fishers since quotas are based on vague and obsolete mangrove productivity studies and are likely to have overestimated productivity of stocks, potentially stimulating overfishing. Further, by requiring all collector-exporters to have an aquaculture pond of at least 1500 m^2, new export regulations discriminate against small collectors seeking to export live crabs.

Article 7.7 *States should give due consideration to the impact of international trade in fish and fishery products and of vertical integration on local small-scale fishers, fish workers and their communities. States should ensure that promotion of international fish trade and export production do not adversely affect the nutritional needs of people for whom fish is critical to a nutritious diet, their health and well-being and for whom other comparable sources of food are not readily available or affordable.*

The impacts of octopus and mud crab export markets on the food security of small-scale fisher communities, as well as of inland communities they may previously have traded with, have not been investigated. Many Vezo fishers now prioritise fishing for trade (i.e. sea cucumbers, shark fin) over fishing for subsistence (Muttenzer 2015; Cripps and Gardner 2016). There is also some anecdotal evidence that Vezo communities consume more octopus during the national closure (when buyers are not operating) than during other periods, suggesting that octopus which is usually traded may otherwise have been consumed. Trade is

additionally likely to reduce the amount of protein locally available, with children the most liable to suffer as a result. Conversely, by providing a ready source of cash in isolated communities that largely rely on subsistence fishing, export markets offer a rare opportunity for fishers to earn income to purchase foodstuffs, as well as invest in fishing equipment. The question of whether these markets serve to alleviate or reduce poverty and food security in participating fisher communities would certainly benefit from additional research.

Blue Ventures supports MIHARI, a national peer-to-peer learning network of more than 150 community associations working on LMMAs. The network gives small-scale fishers increased capacity to reach and influence policy makers (Mayol 2013), and is currently raising the profile of the small-scale fishing sector in discussions around Madagascar's plan to triple the total coverage of its marine protected areas, with a focus on LMMA-based approaches (Rajaonarimampianina 2014).

Challenges

International trade remains very lightly regulated but can have rapid and profound impacts on both small-scale fisher communities and the resources/ecosystems they exploit. For example, fishing intensity in the mud crab fishery strictly follows international demand and is now leading to overexploitation in the most accessible areas (Blue Ventures, unpublished data). While there is chronic food insecurity in south and south-west Madagascar, there is little understanding of the impacts of international trade on such issues and the resilience of small-scale fisher communities. Beyond the local point of collection, small-scale fishers have no representation in trade or related decision-making processes, and because trade monitoring systems are very poor, existing data may not be reliable. Small-scale fishers need to be better represented in national-level decision-making, and an improved understanding of the importance of small-scale fisheries to food security and local resilience is an urgent research priority (Le Manach et al. 2012).

Article 7.8 *States, small-scale fisheries actors and other value chain actors should recognize that benefits from international trade should be fairly distributed. States should ensure that effective fisheries management systems are in place to prevent overexploitation driven by market demand that can threaten the sustainability of fisheries resources, food security and nutrition. Such fisheries management systems should include responsible post-harvest*

practices, policies and actions to enable export income to benefit small-scale fishers and others in an equitable manner throughout the value chain.

The impact of new and growing export markets on the sustainability of octopus and mud crab fisheries remains poorly understood, in part due to a lack of monitoring systems and reliable data. However, effective fisheries management systems (i.e. periodic closures) have been developed and are spreading rapidly amongst small-scale fisher populations (Mayol 2013). LMMAs focused on ensuring resource productivity and sustainability are likely to play a key role in Madagascar's plans to triple marine protected area coverage, greatly increasing the proportion of small-scale fisheries managed through community-based mechanisms. While many initiatives that reduce fishing effort may favour some institutions or segments of society over others, octopus closures do not impose differential access restrictions and so theoretically avoid the issue of elite capture: all community members may access closure areas following their opening, whether or not they are members of the management association. That said, there is some evidence that arrangements like LMMAs may favour wealthier resource users (Cinner et al, 2012). Notions of equity have received little research attention in this context, and could benefit from further study.

Challenges

The dispersed nature of the fisheries and existence of a strong informal trade sector hinders the development of effective stock and trade monitoring systems, thus the data required for adaptive management of the fisheries are lacking. At the national level, State policies to ensure that maximal additional value from export trade filters down to small scale fishers are required to provide strong management incentives and promote poverty reduction.

Article 7.9 *States should adopt policies and procedures, including environmental, social and other relevant assessments, to ensure that adverse impacts by international trade on the environment, small-scale fisheries culture, livelihoods and special needs related to food security are equitably addressed. Consultation with concerned stakeholders should be part of these policies and procedures.*

All fisheries management measures supported by BV over the last 14 years have been developed through bottom-up, participatory processes that integrate marginalised members of small-scale fisher communities (e.g. women, migrants) as well as actors in the post-harvest

value chain. The spread of LMMAs and anticipated future recognition of them within Madagascar's protected area system should legally empower small-scale fisher communities to implement management initiatives and thereby minimise the adverse impacts of trade. The development of the MIHARI network of LMMA managers will also provide small-scale fishers with increased opportunities and power to reach and influence policy-makers (see article 7.7).

Challenges

There are currently no mechanisms through which concerned SSF stakeholders can reach policy-makers effectively, although the MIHARI network has been designed to address this deficiency. Existing fisheries legislation (i.e. minimum catch size and national closure period) for mud crab is inappropriate, not being based on our latest understanding of the species' biology and life cycle (Le Vay 2001; Leoville 2013). As a result the national closure does not correspond to the peak of reproduction, and minimum catch sizes are set too low, permitting the capture of sexually immature females (Blue Ventures, unpublished data). In addition the economic and social impacts of national and periodic fishery closures remain poorly understood.

Article 7.10 *States should enable access to all relevant market and trade information for stakeholders in the small-scale fisheries value chain. Small-scale fisheries stakeholders must be able to access timely and accurate market information to help them adjust to changing market conditions. Capacity development is also required so that all small-scale fisheries stakeholders and especially women and vulnerable and marginalized groups can adapt to, and benefit equitably from, opportunities of global market trends and local situations while minimizing any potential negative impacts.*

Participatory monitoring systems using locally trained data collectors and mobile technology to monitor landings are being developed for each fishery, though these cover only a small proportion of fishers. The CGP has implemented a dashboarding system to facilitate the communication of these landings data, but it remains insufficiently understood by stakeholders. Further, information on market conditions is not available to fishers, limiting their ability to adjust to market conditions or negotiate prices.

Challenges

Small-scale fishers have no access to market and price information other than the prices offered by local buyers. NGOs and partner fisher communities struggle to keep pace with the rapid expansion of fisheries improvement initiatives, to implement effective participatory monitoring systems at scale, and to find ways of effectively disseminating data back to communities and into local decision-making processes. Efforts to build management capacity within fisher communities have been launched in order to address these issues.

Lack of access to broader market information prevents identification and design of fisheries management interventions that may improve the value of the products at a local level, and in some cases reduce post harvest losses. For example, if trap-based fishing for octopus were viable, it could result in a product with the potential to meet quality standards of new higher value markets. There is thus an urgent need for a centralised and transparent monitoring and support system for small-scale fisheries landings and trade, one that includes broader market data.

Knowledge of international market-based initiatives to encourage sustainable fishing through ecolabel schemes is low among fisheries authorities and seafood exporters, and none of Madagascar's fisheries have yet been certified through the MSC standard. Given the lack of central management of the small-scale fisheries sector, as well as the high data deficiency and uncertainty around stock status, accessing such schemes – and thus potentially higher value export markets rewarding sustainable fishing practices – remains out of reach of this sector. Notwithstanding these limitations, south-west Madagascar's octopus fishery underwent pre-assessment against the MSC standard in 2010, and an ambitious FIP is being implemented by BV and the CGP with a view to potentially entering full assessment for the fishery. Notably this FIP is not being led by the collection and export companies that would have the most to gain from potential future certification, largely on account of scepticism of the likely future benefits of MSC certification within these businesses.

Discussion

The post-harvest subsector is critical to efforts to improve the capacity of Madagascar's small-scale fisheries to contribute to poverty reduction and food security, since the fisheries are widely dispersed around the country's 5500 km of coastline and fishers rely on post-harvest actors such as seafood export companies to reach markets and derive maximum revenues from their produce. However, to date most fisheries improvement initiatives have

focused on building local capacity for fisheries management and governance, and initiatives in the post-harvest subsector remain in their infancy.

At present the post-harvest value chains of both fisheries are opaque, poorly understood, and managed exclusively by commercial actors, notably private sector seafood collection and export companies. Beyond direct transactional relationships, these companies have little engagement with fishers, whose interests are not necessarily considered at higher levels of the supply chain. Moreover, commercial actors have little incentive to address imbalances in post-harvest power relationships or to maximise the value received by fishers for their fisheries management efforts. Given widespread poverty and low literacy among small-scale fishing communities, severe transport and communications challenges, and a general disregard of the small-scale sector by central fishing authorities, fishers remain particularly vulnerable to exploitation and unfair distribution of benefits by actors higher in the supply chain. Although communities have developed notable experience in local fisheries management efforts over the past decade, there is no history of formal fishers' organisations, cooperatives or trade associations representing the interests of these marginalised groups.

To improve the capacity of fishers to engage with, influence and benefit from post-harvest processes, greater fisher representation in national fisheries policy decision-making will be needed, for example through the establishment and formalisation of multi-stakeholder fisheries management platforms. It will also require the fundamental imbalances in bargaining power between actors to be addressed through capacity building of fisher communities and external pressure from civil society organisations. The vulnerability of small-scale fishers through these unequal power relationships notwithstanding, seafood collection and export businesses have a strong interest in ensuring a sustainable supply of high quality produce and have generally proved willing to collaborate on fisheries management initiatives. Indeed, such is their importance in providing access to markets that their partnership is considered indispensable.

While much of the SSF Guidelines focus on State parties, experience from the octopus and mud crab fisheries in Madagascar indicates that partnerships between the State, small-scale fisher communities, civil society organisations, academic institutions and private sector businesses provide the most realistic hope for rapid and far-reaching advances in the management of the Madagascar's small-scale fisheries. Like many tropical developing

569 countries, Madagascar's State lacks the capacity to regulate its fisheries sector effectively and
570 has only recently recognised the importance of small-scale fisheries in meeting its domestic
571 food security and poverty reduction goals (Harris 2011). NGOs and fishers have played an
572 important role in bringing small-scale fisheries to the attention of policy-makers, and are
573 likely to remain at the forefront of fisheries improvement efforts, notably through the
574 innovation and adoption of appropriate, participatory management initiatives. However, the
575 State, international development actors and the private sector all have a crucial role in
576 popularising and scaling these initiatives, and enshrining them in policy.
577
578 Several key challenges remain for States and other SSF stakeholders to reduce value chain
579 inefficiencies and ensure maximum returns to fisher communities. Most importantly, data
580 deficiencies and the lack of transparency regarding market, catch and price information
581 throughout the supply chain should be urgently addressed. Knowledge of what and how much
582 fishers are catching, where they are catching it, how much they receive and how much is
583 consumed or traded locally, domestically and internationally is fundamental for understanding
584 the importance of the SSF sector for poverty alleviation and reduction. Such understanding
585 will help raise awareness of the importance of these 'not so small-scale' fisheries in the eyes
586 of decision-makers. Low-cost mobile technology-based approaches offer the potential to
587 collect the required data at scale.
588
589 Further regulation and professionalization is required of all steps in the supply chain,
590 including the registration of fishers, centralisation and sanitation of landing stations and the
591 supervision of middle-men and collectors, particularly those operating in the informal sector.
592 Such steps would promote improved quality standards and could thus increase the revenues
593 accruing to fishers, while facilitating the collection of data required to inform decision-
594 making.
595
596 Ensuring that the export of seafood products does not exacerbate food insecurity amongst
597 small-scale fisher populations or the populations they previously traded with will not only
598 require a better comprehension of the social impacts of decisions to fish for trade rather than
599 subsistence, but also the implementation of robust, science-based stock management to ensure
600 that existing fisheries can sustainably meet domestic fish protein needs. The allocation of
601 export quotas should be informed by the best available data and include the avoidance of food
602 insecurity as a guiding principle, while simultaneous mechanisms to promote sustainability,

such as the introduction or revision of minimum catch sizes and other harvest control rules should be included in legislation and enforced.

All proposed measures require substantial investment, particularly in building the capacity of central fisheries agencies. However, such investment would be modest relative to the importance of the small-scale fisheries sector from both a poverty and food security perspective. Alongside the implementation of improved fisheries management initiatives, structural investment in the post-harvest subsector will be key to maximising – and sustaining – the value that fishers are able to recover from these resources in the long term. As such the publication of the SSF Guidelines is particularly timely, providing a valuable starting point to raise awareness of small-scale fisheries among policy-makers and guidance to enhance their contribution to food security and poverty reduction. To maximise the impact of the Guidelines, and avoid the risk of them losing relevance over time, we need to continuously refer back to small-scale fisher communities throughout implementation. Improving the value of fisheries products such as octopus and mud crab is only one element; it is also critical to ensure that the added value is passed on to the fishers themselves, providing incentives to adhere to best practice in management, and develop socio-economic monitoring systems to enable the detection of any negative impacts arising from international trade. Independent organisations such as BV that have a permanent field presence and established, trusting relationships with fishing communities are in an excellent position to facilitate dialogue between fishers, other stakeholders and the SSF Guideline developers for the iterative, bottom-up improvement of the Guidelines, and thus help ensure their contribution to global food security and poverty eradication.

Acknowledgements

BV's efforts to support management of mud crab and octopus fisheries in Madagascar are supported by MacArthur Foundation, Helmsley Charitable Trust, DFID and Smartfish. We thank Leah Glass for the preparation of Fig. 1, the editors for the opportunity to contribute to this volume, and the reviewers for comments which greatly improved the manuscript.

References

Allison, E.H., Perry, A.L., Badjeck, M.-C., Adger, W.N., Brown, K., Conway, D., et al. (2009). Vulnerability of national economies to the impacts of climate change on fisheries. *Fish and Fisheries*, 10(2), 173–196.

637

638 Allison, E.H., Ratner, B.D., Åsgård, B., Willmann, R., Pomeroy, R. & Kurien, J. (2012).
639 Rights-based fisheries governance: from fishing rights to human rights. *Fish and Fisheries*,
640 13, 14–29.
641
642 Andréfouët, S., Guillaume, M.M.M., Delval, A., Rasoamanendrika, F.M.A., Blanchot, J., &
643 Bruggemann, J.H. (2013). Fifty years of changes in reef flat habitats of the Grand Récif of
644 Toliara (SW Madagascar) and the impact of gleaning. *Coral Reefs*, 32(3), 757–768.
645
646 Andrew, N.L., Béné, C., Hall, S.J., Allison, E.H., Heck, S., & Ratner, B.D. (2007). Diagnosis
647 and management of small-scale fisheries in developing countries. *Fish and Fisheries*, 8(3),
648 227–240.
649
650 Andriamalala, G., & Gardner, C.J. (2010). L'utilisation du *dina* comme outil de gouvernance
651 des ressources naturelles: leçons tirés de Velondriake, sud-ouest de Madagascar. *Tropical*
652 *Conservation Science*, 3, 447–472.
653
654 Antona, M., Biénabe, E.M., Salles, J.-M., Péchard, G., Aubert, S., & Ratsimbarison, R.
655 (2004). Rights transfers in Madagascar biodiversity policies: achievements and significance.
656 *Environment and Development Economics*, 9, 825–847.
657
658 Astuti, R. (1995). *People of the sea: identity and descent among the Vezo of Madagascar*.
659 Cambridge: Cambridge University Press.
660
661 Barnes, D.K.A., & Rawlinson, K.A. (2009). Traditional coastal invertebrate fisheries in south-
662 western Madagascar. *Journal of the Marine Biological Association of the United Kingdom*,
663 89, 1589–1596.
664
665 Barnes-Mauthe, M., Olesen, K.L.L., & Zafindrasilivonona, B. (2013). The total economic
666 value of small-scale fisheries with a characterization of post-landing trends: an application in
667 Madagascar with global relevance. *Fisheries Research*, 147, 175–185.
668
669 Bell, J.D., Kronen, M., Vunisea, A., Nash, W.J., Keeble, G., Demmke, et al. (2009). Planning
670 the use of fish for food security in the Pacific. *Marine Policy*, 33, 64–76.

Béné, C., Macfadyen, G., & Allison, E.H. (2007). *Increasing the contribution of small-scale fisheries to poverty alleviation and food security*. Rome: FAO.

Bruggemann, J.H., Rodier, M., Guillaume, M.M.M., Andréfouët, S., Arfi, R., Cinner, J.E., 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, 47. doi: 10.5751/ES-05300-170447.

Cinner, J.E., McClanahan, T.R., MacNeil, M.A., Graham, N.A.J., Daw, T.M., Mukminin, A., et al. (2012). Comanagement of coral reef social-ecological systems. *Proceedings of the National Academy of Sciences, USA*, 109, 5219–5222.

Cripps, G., Gardner, C.J., 2016. Human migration and marine protected areas: Insights from Vezo fishers in Madagascar. *Geoforum*, 74, 49–62.

Da Silva, J.G. (2015). Foreword. In FAO, *Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication*, p. v. Rome: FAO.

Epps, M.M. (2008). *A socioeconomic baseline assessment: implementing the socioeconomic monitoring guidelines in southwest Madagascar*. London: Blue Ventures.

FAO (Food and Agriculture Organisation of the United Nations) (2005). *Increasing the contribution of small-scale fisheries to poverty alleviation and food security*. Rome: FAO.

FAO (Food and Agriculture Organisation of the United Nations) (2015). *Voluntary guidelines for securing sustainable small-scale fisheries in the context of food security and poverty eradication*. Rome: FAO.

FAO (Food and Agriculture Organisation of the United Nations) (2016). Fishing People. FAO Fisheries and Aquaculture Department, FAO. http://www.fao.org/fishery/topic/13827/en. Accessed 9 February 2016.

Ferguson, B., Gardner, C.J., Andriamarovololona, M.M., Healy, T., Muttenzer, F., Smith, S., et al. (2014). Governing ancestral land in Madagascar: have policy reforms contributed to social justice? In M Sowman, R Wynberg (Eds.), *Governance for justice and environmental sustainability: lessons across natural resource sectors in Sub-Saharan Africa* (pp. 63–93). London: Routledge.

Garcia, S.M., & Rosenberg, A.A. (2010). Food security and marine capture fisheries: characteristics, trends, drivers and future perspectives. *Philosophical Transactions of the Royal Society B, Biological Sciences*, 365, 2869–2880.

Gezon, L.L. (2002). Marriage, kin, and compensation: a socio-political ecology of gender in Ankarana, Madagascar. *Anthropological Quarterly,* 75, 675–706.

Gough, C., Thomas, T., Humber, F., Harris, A., Cripps, G., & Peabody, S. (2009). *Vezo fishing: an introduction to the methods used by fishers in Andavadoaka, southwest Madagascar*. London: Blue Ventures Conservation.

GFSI (2015). *Global food security index 2015*. London: The Economist Intelligence Unit.

Grenier, C. (2013) Genre de vie vezo, pêche "traditionnelle" et mondialisation sur le littoral sud-ouest de Madagascar. *Annales de Géographie*, 693, 549–571.

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.

Harris, A. (2011). Out of sight but no longer out of mind: a climate of change for marine conservation in Madagascar. *Madagascar Conservation & Development*, 6, 7–14.

Hoegh-Guldberg, O., & Bruno, J.F.(2010). The impact of climate change on the world's marine ecosystems. *Science*, 328, 1523–1528.

Horning, N.R. (2008). Strong support for weak performance: donor competition in Madagascar. *African Affairs* 107, 405–431.

ICAI (Independent Commission for Aid Impact) (2015). *How DFID works with multilateral agencies to achieve impact*. London: ICAI.

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.

Jentoft, S. (2014). Walking the talk: implementing the international voluntary guidelines for securing sustainable small-scale fisheries. *Maritime Studies*, 13, 16.

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

Le Manach, F., Andriamahefazafy, M., Harper, S., Harris, A., Hosch, G., Lange, G.M., et al., (2013). Who gets what? Developing a more equitable framework for EU fishing agreements. *Marine Policy*, 38, 257–266.

Leoville, A. (2013). Diagnostic de l'état de la mangrove et de la pêche du crabe de mangrove (*S. serrata*) dans la région de Belo-sur-Mer, Menabe, Sud-Ouest de Madagascar. MSc thesis, Université du Littoral Côte d'Opale, Dunkerque.

Le Vay, L. (2001). Ecology and management of mud crab *Scylla* spp. *Asian Fisheries Science*, 14, 101-111.

L'Haridon, L. (2006). *Evolution de la collecte de poulpe sur la côte Sud Ouest de Madagascar: éléments de réflexion pour une meilleure gestion des ressources*. London: Blue Ventures Conservation.

Maina, J., de Moel, H., Vermaaqt, J.E., Bruggemann, J.H., Guillaume, M.M.M., Grove, C.A., et al. (2012). Linking coral river runoff proxies with climate variability, variability, hydrology and land-use in Madagascar catchments. *Marine Pollution Bulletin*, 64, 2047–2059.

772 Martin, D. (2015, June 11). Millions of UK aid 'being squandered': international agencies
773 failing to spend British money in ways that effectively help the poor. Daily Mail,
774 http://www.dailymail.co.uk/news/article-3119170/Millions-UK-aid-squandered-International-
775 agencies-failing-spend-British-money-ways-effectively-help-poor.html (accessed 11.02.2016)
776
777 Mayol, T.L. (2013). Madagascar's nascent locally managed marine area network.
778 *Madagascar Conservation & Development*, 8, 91–95.
779
780 McClanahan, T.R., Ateweberhan, M., Omukoto, J. & Pearson, L. (2009). Recent seawater
781 temperature histories, status, and predictions for Madagascar's coral reefs. *Marine Ecology*
782 *Progress Series*, 380, 117–128.
783
784 Mills, D.J., Westlund, L., De Graaf, G., Kura, Y., Willman, R., & Kelleher, K. (2011). Under-
785 reported and undervalued: small-scale fisheries in the developing world. In R.S. Pomeroy, &
786 N.L. Andrew (Eds.), *Small-scale fisheries management: frameworks and approaches for the*
787 *developing world* (pp. 1–15). Cambridge: CABI International.
788
789 Muttenzer, F. (2015). The social life of sea cucumbers in Madagascar: migrant fishers'
790 household objects and display of a marine ethos. *Etnofoor*, 27, 101–121.
791
792 Oliver, T.A., Olesen, K.L.L., Ratsimbazafy, H., Raberinary, D., Benbow, S. & Harris, A.
793 (2015). Positive catch and economic benefits of periodic octopus fishery closures: do
794 effective, narrowly targeted actions 'catalyze' broader management? *PLoS ONE*, 10,
795 e0129075.
796
797 Pauly, D.(1997). Small-scale fisheries in the tropics: marginality, marginalization, and some
798 implications for fisheries management. In: E.K. Pikitch, D.D. Huppert & M.P. Sissenwine
799 (Eds.), *Global trends: fisheries management* (pp. 40–49). Bethesda, Maryland: American
800 Fisheries Society Symposium.
801
802 Pauly, D., 2006. Major trends in small-scale marine fisheries, with emphasis on developing
803 countries, and some implications for the social sciences. *Maritime Studies*, 4, 7–22.
804

805 Parfitt, T. (2015, June 11). Revealed: Britain 'wasted MILLIONS on foreign aid project that
806 was never used'. Daily Express, http://www.express.co.uk/news/uk/583652/foreign-aid-
807 government-African-Development-Bank-Madagascar-fishing (accessed 11.02.2016).
808
809 Pollini, J., Hockley, N., Muttenzer, F.D. & Ramamonjisoa, B.S. (2014). The transfer of
810 natural resource management rights to local communities. In I.R. Scales (Ed.) *Conservation*
811 *and environmental management in Madagascar* (pp. 172–192). Abingdon: Routledge.
812
813 Pomeroy, R.S., & Andrew, N.L. (2011). *Small-scale fisheries management: frameworks and*
814 *approaches for the developing world*. Cambridge: CABI International.
815
816 Rajaonarimampianina, H. (2014). 'Sydney Vision' Declaration. Speech presented at VIth
817 World Parks Congress, Sydney, 12-19 November 2014.
818
819 Razanaka, S., Grouzis, P., Milleville, P., Moizo, B., & Aubry, C. (Eds.). (2001). *Sociétés*
820 *paysannes, transitions agraires et dynamiques écologiques dans le sud-ouest de Madagascar*.
821 Antananarivo: CNRE-IRD.
822
823 Sheridan, C., Baele, J.M., Kushmaro, A., Frejaville, Y. & Eeckhaut, I. (2015). Terrestrial
824 runoff influences white syndrome prevalence in SW Madagascar. *Marine Environmental*
825 *Research*, 101, 44–51.
826
827 Smartfish (2015). Enhancing value-chain performance for mud crab in Madagascar.
828 http://commissionoceanindien.org/fileadmin/projets/smartfish/Fiche/FICHE3ENGLISH.pdf
829 (accessed 11.02.2016).
830
831 Smith, M.D., Roheim, C.A., Crowder, L.B., Halpern, B.S., Turnipseed, M., Anderson, J.L., et
832 al. (2010). Sustainability and global seafood. *Science*, 327, 784–786.
833
834 Virah-Sawmy, M., Gardner, C.J. & Ratsifandrihamanana, A.N.(2014). The Durban Vision in
835 practice: experiences in participatory governance of Madagascar's new protected areas. In
836 I.R. Scales (Ed.), *Conservation and environmental management in Madagascar* (pp. 216–
837 252). Abingdon: Routledge.

Westerman, K., & Benbow, S. (2013). The role of women in community-based small-scale fisheries management: the case of the south west Madagascar octopus fishery. *Western Indian Ocean Journal of Marine Science*, 12, 119–132.

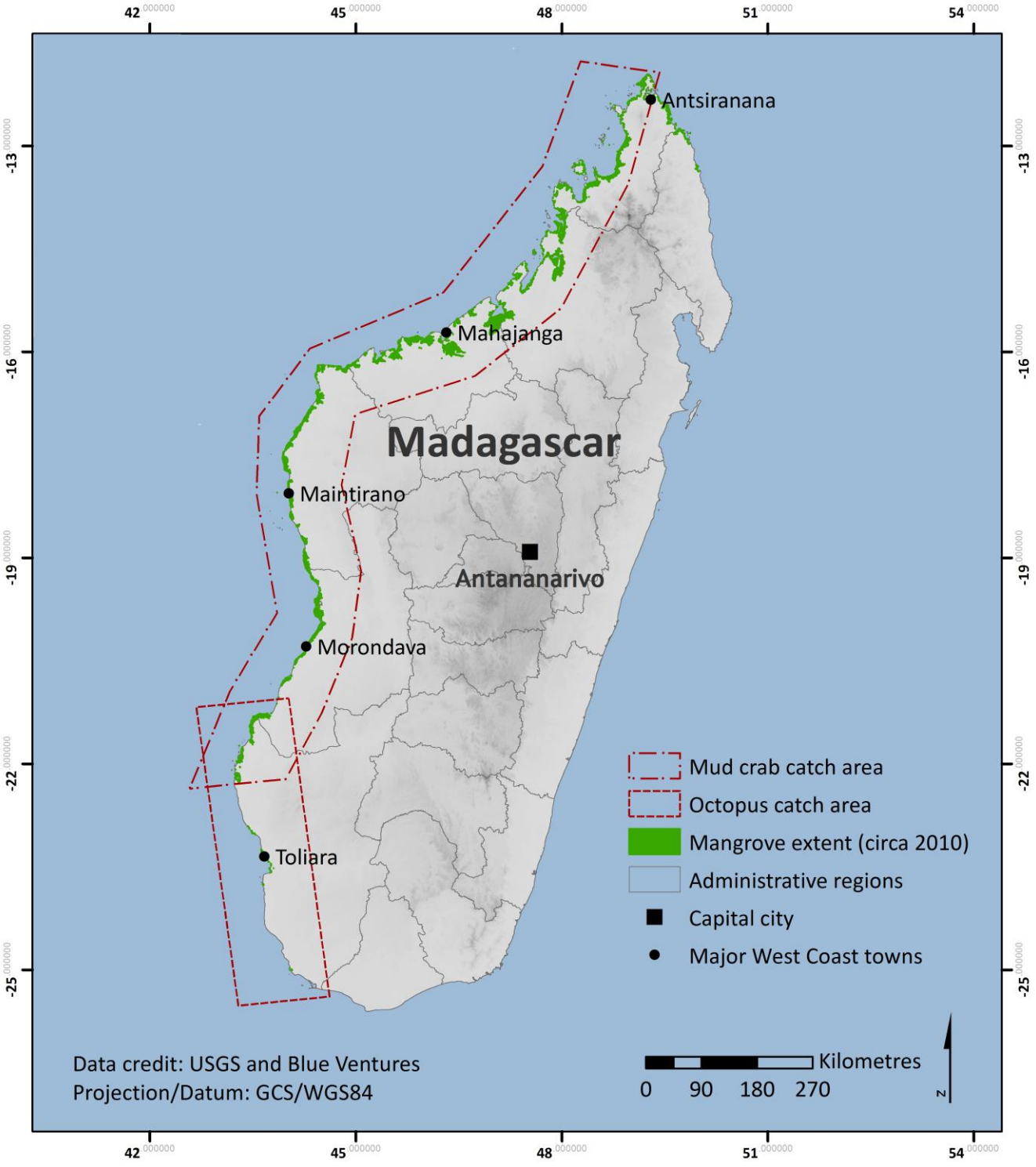
World Bank (2015). *Madagascar systematic country diagnostic*. Washington, DC: The World Bank Group.

WRI (World Resources Institute) (2003). *Earth trends: coastal and marine ecosystems, Madagascar*. Washington, DC: World Resources Institute.

849 **Figure Captions**

850

851 **Fig. 1** Map of Madagascar showing major towns of western regions and approximate extent
852 of octopus and mud crab fisheries.



853

854 **Fig.2** Images illustrating the fisheries and value chains of small scale octopus (*Octopus*
855 *cyanea*) and mud crab (*Scylla serrata*) fisheries in Madagascar. A, octopus are collected from

856 fishers by intermediaries in coastal villages; B, seafood export companies then transport the
857 octopus to export processing centres in ice buckets loaded on trucks; C, fishers collecting mud
858 crab from mangroves in northwest Madagascar; D, live mud crabs stored in rice sacks by
859 intermediaries, prior to transport to an export processing centre. Image credits: A, Xavier
860 Vincke; B, Alejandro Castillo Lopez; C and D, Adrian Levrel.

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