

In the Spermonde Archipelago, Indonesia, demand for valuable living marine resources has caused a number of sequential exploitation waves. The most recent is the catching of moray eels. Over recent months, this activity has been taken up on at least seven islands. The main target is Giant Moray *Gymnothorax javanicus*, but other spotted species are also collected. Moray eels have not been previously exploited in the area as their flesh is considered locally to be non-palatable. Fishing started in February 2012 in order to satisfy a new demand from mainland China, where the species is used in traditional medicine. At present, several hundred kilogrammes of moray eels are caught daily, filleted and exported to mainland China and Taiwan for such purposes. Fishermen targeting moray eels either use spear guns and cyanide or place baited fish traps in the coral reefs. These activities are putting additional pressure on Spermonde's coral reefs, which are already suffering from over-exploitation and from the widespread use of cyanide and dynamite to capture fish. But the fishing of moray eels might also have other consequences. As top predators, they influence the reef fish community structure. The low abundance and strong site-affinity of moray eels makes them extremely vulnerable to over-exploitation. According to fishermen involved, a number of reefs have already been depleted, forcing them to move to new reefs within and out of the archipelago to collect eels.

FIRST EVIDENCE OF TARGETED MORAY EEL FISHING IN THE SPERMONDE ARCHIPELAGO, SOUTH SULAWESI, INDONESIA



BACKGROUND

Indonesia's vast coral reefs are some of the most species-rich ecosystems in the world. Their abundant marine resources provide primary livelihoods for millions of coastal inhabitants, who exploit them both for subsistence and as valuable commodities, including some species exclusively targeted for distant markets. For centuries, large trading networks have connected some of the remotest areas with markets in Asia, Europe and the USA. Mainland China has long played a key role in this maritime trade. At least since the early 18th century, Indonesian sea cucumbers were exported to meet the increasing Chinese demand that could no longer be satisfied by the country's own stocks (Schwerdtner Máñez and Ferse, 2010). Indonesia is also the world's leading shark fin supplier (Tull, 2009), and provides a significant part of the market supply in live reef food fish for Singapore and Hong Kong (Radjawali, 2011).

The Spermonde Archipelago in South Sulawesi hosts one of the largest coral reef fisheries in Indonesia. The archipelago is part of the Coral Triangle (a specific area encompassing the tropical marine waters of Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor Leste and recognized as the global centre of marine biodiversity), and has long been known for its enormous abundance in marine resources. Spermonde lies in close proximity to Makassar, a major trading hub for maritime resources. The approximately 70 tiny coral atolls provide hardly any land-based alternatives (Schwerdtner Máñez *et al.*, 2012), such that the majority of Spermonde's households strongly depend on marine resource exploitation (Deswandi, 2012).



PHOTOGRAPHS: K. SCHWERTNER MÄNEZ



Since the 1970s, a combination of population growth, technological developments and emerging preferences for specific commodities has led to the development of consecutive waves of marine resource exploitation in the area (Ferse *et al.*, 2012). There are increasing signs of over-exploitation, notably the disappearance of high value species such as the sea cucumber *Holothuria nobilis* or the Humphead Wrasse *Cheilinus undulatus* (Johannes and Riepen, 1995; Massin, 1999).

Alternatives to fishing are currently largely absent. Many fishermen are also involved in so-called patron-client relationships, in which patrons provide credit, fishing gear and social security to their clients who in return fish exclusively for their patrons. Demand for particular resources is communicated from outside the country through fish trader to patrons, who pass this information on to their clients

(fishermen). Upcoming exploitation waves are mostly unpredictable, can spread quickly and might lead rapidly to local over-exploitation. This seems to be the case for the most recent exploitation wave in the Spermonde Archipelago: the targeted fishing of moray eels.

METHODS

First observations of moray eel landings were made by the authors during a ten-day field expedition to the Spermonde Archipelago in October 2012. The expedition took place in the frame of the joint Indonesian-German research project SPICE III (Science for the Protection of Indonesian Coastal Ecosystems). A boat landing moray eels was observed on the island of Langkai during two consecutive days. Each catch consisted of between 30 and 40 specimens, including some large individuals of nearly two metres in length. The fish were cleaned and

filleted on the shore. Several other boats were also observed returning to the shore with buckets of moray eels, and remains of the cleaning were found along the shore.

A follow-up study to investigate moray eel catching was undertaken between October and November 2012, and continued in February 2013. During this time, fishermen, patrons and traders involved in moray eel catching and trade were identified and interviewed. Interviews initially took place with four traders in the fish market in Makassar; further interviews were conducted during three visits to three islands: on Barrang Lompo Island, three traders and five fishermen were interviewed; two traders and six fishermen were interviewed on the island of Langkai; and one trader was interviewed on the island of Bone Tambung. People were asked how long they had been involved in this activity, how they found out about the demand for moray eels, where and to whom they sell their fish, how and where morays eels are caught, how much they catch, and what they earn from their catch. These visits were also used to observe moray eel landings.

DISTRIBUTION AND STATUS

The family of moray eels Muraenidae contains around 200 species worldwide and approximately 150 species within the Indo-Pacific. Moray eels live as solitary predators in reef ecosystems. Top predators like moray eels have a strong influence on the reef fish community structure (Ruttenberg *et al.*, 2011). As poor swimmers, both juveniles and adults maintain high site fidelity (the tendency to return to a previously occupied location) to a few square metres of reef (Böhlke *et al.*, 1989). Particularly large species such as the Giant Moray *Gymnothorax javanicus* may reside in the same cave for several years. Although they are one of the most widespread and common groups of reef fishes, morays are still a poorly studied group of organisms (Reece, 2010). Information on most species is very limited. Fishbase holds information on only two of the species fished in Spermonde, and their IUCN Red List status has not been evaluated.

Photographs, top: a day's catch on Langkai Island; above, left: moray eel being cut, Langkai Island; above, right: moray eel traps, or bubu, on Bone Tambung Island.

LEGISLATION

Moray eels are not covered by CITES. There is also no specific Indonesian law dealing with their harvest or trade and the species is not listed by the Indonesian Nature Conservation Agency as a protected species. Indonesian companies holding an export permit for fish from the Ministry of Trade may trade morays without the need for an additional permit.

RESULTS

Most moray eels are considered to be non-palatable. The larger eels in particular have been found to contain ciguatera toxin, and can be highly poisonous if consumed (Withers, 1982; Allen and Erdmann, 2012). There are, however, some regions where morays are eaten, such as Papua New Guinea. In Indonesia, morays are usually not fished. If caught accidentally, they are used as bait. In mainland China, some species are used in traditional medicine (Sadovy and Cornish, 2000). Soup containing moray flesh is consumed to stop bleeding after physical injuries. Mainland China satisfies a significant part of its demand through imports (Tu-yin *et al.*, 2009).

Fish traders in Makassar reported that the demand for moray eels suddenly appeared in February 2012. It was first spread through a Makassar-based fish-exporting company that started to buy flesh and skin. Both are exported to mainland China and Taiwan, although it is currently unclear what the skin is used for. There are only four species in demand: the Giant Moray *Gymnothorax javanicus*, the Black-spotted Moray *Gymnothorax favagineus*, the Spotted Moray *Gymnothorax isingteena*, and the Peppered Moray *Gymnothorax picta*. Interviewed traders confirmed that they solely buy spotted species. This could mean that the pharmaceutical active ingredients are thought to appear in spotted specimens only. Given that the head and the tail of each fish are removed—which makes the identification of species difficult for non-specialists—all four species might be sold as one species.

Information about the demand for moray eels was quickly taken up by patrons on several islands in Spermonde and passed on to the fishermen they employ. In November 2012, fishermen on seven islands in and around the Spermonde Archipelago were involved in this activity: namely on Langkai, Barrang Lompo, Barrangcaddi, Bone Tambung, Kodingareng Pajenekang, Tana Keke, and Dewakkang. Morays are fished by compressor divers who use a spear gun with an extra-large arrowhead. The fish are sometimes also stunned with cyanide otherwise used to capture live reef fish or ornamental species. Cyanide fishing had been brought to Spermonde by fish traders from Hong Kong in the early 1980s. Although its use is now prohibited because of the damage cyanide causes to corals, it is still widely used throughout the archipelago. In order to retrieve the dead moray eels, divers using metal bars sometimes break open coral crevices in which the fish are hiding. Often two people are necessary to pull large individuals from the reef. On the island of Bone Tambung, baited fish traps—known as *bubu*—are used for moray eel catching. In order to place the trap in a certain spot, fishermen may destroy corals. According to the interviewees, a single boat with

two to three fishermen using spear guns can catch between two to seven morays per day, with an overall weight of between 20–70 kg. The authors have also observed larger catches, with more than 30 individuals and an approximate total weight of more than 100 kg. Information on catches from *bubu* traps is lacking. Fishermen report that their daily catches have decreased, both in numbers and in weight and that, as a consequence, they have moved to new reefs. This could indicate that moray eel numbers are already declining in some locations. According to interviewees, the reefs around the islands of Langkai and Lanyukan, where the photos for this article were taken in October 2012, are now largely fished out.

PRICES

Catches are sold on a daily basis to patrons and traders on the islands, or directly to Makassar. Traders reported daily purchases of up to 500 kg of fish. During February 2013, export numbers decreased because unusually difficult weather conditions did not allow for regular fishing activities. If the morays are already cleaned and filleted, fishermen can fetch between Indonesian Rupiah (IDR) 9000–12 000 (USD0.94–1.25), Makassar-based traders pay from IDR12 000 to 14 000 (USD1.25–1.45), and companies are paying traders between IDR14 000 and 20 000 (USD1.45–2.08) per kilogramme.

DISCUSSION AND CONCLUSIONS

Fishing of moray eels is the most recent development in a series of consecutive exploitation waves in the Spermonde Archipelago. In all cases, the resources exploited are destined for distant markets. This makes it extremely difficult to predict the future development of trade in valuable marine resources because the demand changes in response to societal and political trends outside Indonesia. Patron-client networks play a critical role in this respect. Through well-established trading networks, patrons receive information concerning particular resources in demand, which they then pass on to their clients. Patrons also lend money and equipment, and thereby create a financial and social dependency that gives their clients little room for making their own decisions. Fishing continues as long as there are resources to be taken, and patrons to buy the catch.

A comparative analysis of exploitation patterns over time indicates that consecutive peaks in fishing activities become shorter with each new activity (Ferse *et al.*, 2012). Technical developments, such as the use of diving compressors, enable the exploitation of areas that used to be ecological refugia, for example deeper waters. Others, for example special arrowheads or cyanide, allow fishing for species that are otherwise difficult to obtain, such as moray eels.

The moray eel fishery is highly problematic. Morays are vulnerable to overfishing due to their low abundance and strong affinity to certain sites. Their depletion can have demographic consequences on the fish community structure in coral reefs, for example changes in size and abundance of herbivorous fish. Furthermore, the continuous use of cyanide and the breaking of corals are placing additional pressure on Spermonde's already degraded habitats.



FISHERMAN ON LANGKAI ISLAND
CARRYING CLEANED MORAY EELS.

K. SCHWERTNER MÁÑEZ

RECOMMENDATIONS

The problem of export-oriented fisheries is that management and policy measures are usually developed as *ex-post* responses. Authorities and institutions react after problems appear, once overfishing has taken place and species are already under threat. This is often caused by the fact that little information is available for decision-makers on which they could base their evaluation of a species's status. However, research alone might not be sufficient. There are simply too many species that are exploited. An alternative would be the use of a precautionary approach in the sense that specific permission has to be given for the export of any species. In the case of the moray eel, little knowledge is needed to foresee the potentially detrimental impacts of fishing. Strong limitations need to accompany any request to fish and export these species.

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REFERENCES

- Allen, G.R. and Erdmann, M.V. (2012). Reef fishes of the East Indies, Vol. I, Moray eels (*Muraenidae*) 74–100.
- Böhlke, E.B., McCosker, J.E., and Böhlke, J.E. (1989). Family Muraenidae. In: Böhlke, E.B. (Ed.). *Fishes of the Western North Atlantic*. New Haven (CT): Sears Foundation for Marine Research. Pp.104–206.
- Deswandi, R., (2012). Understanding Institutional Dynamics. PhD thesis, University of Bremen.
- Ferse, S.C.A., Glaser, M., Neil, M., and Schwerdtner Máñez, K. (2012). To cope or to sustain? Eroding long-term sustainability in an Indonesian coral reef fishery. *Regional Environmental Change*. DOI 10.1007/s10113-012-0342-1.
- Johannes, R.E., and Riepen, M. (1995). *Environmental, Economic, and Social Implications of the Live Reef Fish Trade in Asia and the Western Pacific*. The Nature Conservancy, Arlington.
- Massin, C. (1999). Reef-dwelling Holothuroidea (Echinodermata) of the Spermonde Archipelago (South-West Sulawesi, Indonesia). *Zool. Verhandelingen Leiden* 329:1–144.
- Radjawali, I. (2011). Social networks and the live reef food fish trade: examining sustainability. *Journal of Indonesian Social Sciences and Humanities* 4:65–100.
- Reece, J. (2010). Phylogenetics and Phylogeography of Moray Eels (*Muraenidae*). Electronic Theses and Dissertations. Paper 290, Washington University.
- Ruttenberg, B.I., Hamilton, S.L., Walsh, S.M., Donovan, M.K., Friedlander, A., DeMartini, E., Sala, E., and Sandin, S.A. (2011). Predator-induced demographic shifts in coral reef fish assemblages. *PLoS ONE* 6:e21062.
- Sadovy, Y. and Cornish, A.S. (2000). *Reef Fishes of Hong Kong*, Hong Kong University Press, Hong Kong.
- Schwerdtner Máñez, K., Husain, S., Ferse, S.C.A., and Máñez Costa, M. (2012). Water scarcity in the Spermonde Archipelago, Sulawesi, Indonesia: past, present and future. *Environmental Science and Policy* 23:74–84.
- Schwerdtner Máñez, K., and Ferse, S.C.A. (2010). The history of Makassar trepang fishing and trade. *PLoS ONE* 5(6).
- Tull, M. (2009). *The History of Shark Fishing in Indonesia: A HMAP Asia Project Paper*. Working Paper No. 158, Murdoch University.
- Tu-yin, S., Hat, H., Shao-wu, Y., Guo-hua, C., and Shen, Z.B. (2009). Research status and utilization of *Gymnothorax*. *Modern Fisheries Information* 24(7):18–21 (in Chinese).
- Withers, N.W. (1982). Ciguatera fish poisoning. *Annual Review of Medicine* 33:97–111.

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