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RESEARCH ARTICLE

The History of Makassan Trepang Fishing and Trade

Kathleen Schwerdtner Máñez , Sebastian C. A. Ferse

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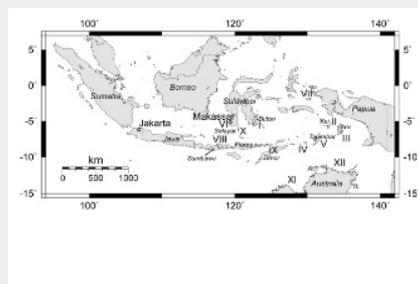
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Figures



Year	Amount in tons	Source
1910-11	175	Sum
1911-12	211	Sum
1912-13	247	Sum
1913-14	283	Sum
1914-15	319	Sum
1915-16	355	Sum
1916-17	391	Sum
1917-18	427	Sum
1918-19	463	Sum
1919-20	499	Sum
1920-21	535	Sum
1921-22	571	Sum
1922-23	607	Sum
1923-24	643	Sum
1924-25	679	Sum
1925-26	715	Sum
1926-27	751	Sum
1927-28	787	Sum
1928-29	823	Sum
1929-30	859	Sum
1930-31	895	Sum
1931-32	931	Sum
1932-33	967	Sum
1933-34	1003	Sum
1934-35	1039	Sum
1935-36	1075	Sum
1936-37	1111	Sum
1937-38	1147	Sum
1938-39	1183	Sum
1939-40	1219	Sum
1940-41	1255	Sum
1941-42	1291	Sum
1942-43	1327	Sum
1943-44	1363	Sum
1944-45	1399	Sum
1945-46	1435	Sum
1946-47	1471	Sum
1947-48	1507	Sum
1948-49	1543	Sum
1949-50	1579	Sum
1950-51	1615	Sum
1951-52	1651	Sum
1952-53	1687	Sum
1953-54	1723	Sum
1954-55	1759	Sum
1955-56	1795	Sum
1956-57	1831	Sum
1957-58	1867	Sum
1958-59	1903	Sum
1959-60	1939	Sum
1960-61	1975	Sum
1961-62	2011	Sum
1962-63	2047	Sum
1963-64	2083	Sum
1964-65	2119	Sum
1965-66	2155	Sum
1966-67	2191	Sum
1967-68	2227	Sum
1968-69	2263	Sum
1969-70	2299	Sum
1970-71	2335	Sum
1971-72	2371	Sum
1972-73	2407	Sum
1973-74	2443	Sum
1974-75	2479	Sum
1975-76	2515	Sum
1976-77	2551	Sum
1977-78	2587	Sum
1978-79	2623	Sum
1979-80	2659	Sum
1980-81	2695	Sum
1981-82	2731	Sum
1982-83	2767	Sum
1983-84	2803	Sum
1984-85	2839	Sum
1985-86	2875	Sum
1986-87	2911	Sum
1987-88	2947	Sum
1988-89	2983	Sum
1989-90	3019	Sum
1990-91	3055	Sum
1991-92	3091	Sum
1992-93	3127	Sum
1993-94	3163	Sum
1994-95	3199	Sum
1995-96	3235	Sum
1996-97	3271	Sum
1997-98	3307	Sum
1998-99	3343	Sum
1999-00	3379	Sum
2000-01	3415	Sum
2001-02	3451	Sum
2002-03	3487	Sum
2003-04	3523	Sum
2004-05	3559	Sum
2005-06	3595	Sum
2006-07	3631	Sum
2007-08	3667	Sum
2008-09	3703	Sum
2009-10	3739	Sum

Abstract

The Malayan term *trepang* describes a variety of edible holothurian sea cucumbers. Although found in temperate and tropical marine world, the centre of species diversity and abundance are the shallow waters of Southeast Asia. For at least 300 years, trepang has been a high-value commodity in the Chinese market. Originally, its fishing and trade was a speciality of the town of Makassar in South Sulawesi (Indonesia). The rise of the East India Company in the 17th century added valuable export merchandise to the rich shallow waters of the islands of Southeast Asia. This enabled local communities to be integrated into global trading networks and greatly supported their economic development. We follow Makassar trepang fishing and trading from its beginning until the decline of the fishery and worldwide depletion of sea cucumbers in the 20th century. We identify a number of characteristics which trepang fishing shares with other marine resources, including (1) a strong influence of international trade, (2) the role of patron-client relationships which heavily influence the resource use, and (3) the roving-bandit-syndrome, where fishermen exploit local stocks until they are depleted, and then move to another area. We suggest that understanding the similarities and differences between historical and recent exploitation of marine resources is an important step towards effective management solutions.

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Introduction

Living in a trader's house everything is brought to me as well as to the smoked tripang, or beche de mer, looking like sausages which have and then thrown up the chimney... Alfred Russel Wallace [1:329]

The term trepang derives from the Malayan word *teripang* and describes holothurians commonly known as sea cucumbers. Sea cucumbers are found in tropical marine waters all over the world, but the centres of species abundance are the shallow coastal waters of Island Southeast Asia. In this region, some 80–100 species are known, up to half of which are of high value. Along with other marine resources such as pearls, mother-of-pearl, tortoiseshells, trepang has exclusively been harvested as a high-price commodity on the international market. Historically, trepang trade was a specialization completely in the hand of Makassarese, Bugis, and Bajau [2]. Because of its value as an item of trade, and certainly also because of its unusual appearance, trepang attracted travellers, there are a number of historical sources available allowing reconstruction of the history of trepang fishing and trade in Island Southeast Asia, with Makassar (Makassar Pandang) in South Sulawesi as a major trading hub.

The consumption of trepang is almost entirely restricted to the Chinese, for whom it is a culinary delicacy and an aphrodisiac. Together with similarly valued commodities such as shark fins and bird nests, trepang belongs to a group of commodities that are so valuable that “distant seaside cliffs and seemingly peripheral sea islands become after destinations” [3:138]. Trepang fishing and trade thus was exclusively driven by the strong demand from China, and quickly generated new sources of supply. China has a long history in Southeast Asia, reaching back several centuries, and resulting in the development of large trading networks that involved the region and extended into remote areas such as Eastern Indonesia by the time of the late Ming period [4]. The shallow seas of Island Southeast Asia suddenly became a valuable export commodity enabling local communities to contribute to the regional economy.

Authors such as Macknight [5], Sutherland [3] and Dai [6] agree that trepang trade first derived from Hainan and Japan, before Southeast Asia became a major source of exploitation. The region not only possessed what seemed like an unlimited supply of trepang, it offered virtually ideal conditions for exploitation and trade.

Makassar had long been known as a central point of seaborne commerce. Its location at the southwest peninsular of Sulawesi made the town an important hub, being at the crossroads of local coastal movements as well as in international trade among Java, Kalimantan, Maluku, Nusa Tenggara and the Philippines. Trepang trade with Europe, India and China [7]. The town also provided political stability, which further increased after its conquest by the Dutch in 1669. In addition, the withdrawal of the Malays from Makassar after 1669, thereby leaving room for other groups to exploit the trepang resources.

Three ethnic groups were involved in the exploitation and trade of trepang in this region. The Bajau people originally were sea nomads, travelling in search of valuable collecting grounds and thereby opening many trading routes. They have often been described as the only people engaged in commercial trepang collecting resources along the shores in Sulawesi [8]. They added trepang fishing and turtle hunting as a means of obtaining goods for exchange.

group are the Bugis, traders from the mainland of Sulawesi, which E as "... the chief and almost sole carriers of the Archipelago, collectir various islands..." Bugis were also well-known and feared as pirate slave trade [10]–[11]. Together with the Makassarese, the tradition coastal Southern Sulawesi and also well-known as traders, the Bug involved in the trepang trade.

Similar to other products, trepang flowed through a shifting hierarc where cargoes were assembled. Many Bugis traders paid dues to t who could also be their creditors, while the Bajau were often tied to tributary relationships [3].

Gathering trepang neither required special skills nor a lot of equipr techniques ranged from simply collecting specimens by hand to the double-headed spears. In shallow water, trepang was located by fe feet and then brought to the surface. Women would also collect the on the reef flats at low tide, while men dived or used a weighted, thi which was lowered by rope from a boat to a point just above a trepa to the bottom, the weighted spear impaling the animal [12]. The sub required more attention, as this contemporary description explains caught, it is immediately boiled in sea-water, in which the leaves of steeped, to take off a thin skin which covers it. It is then placed in ba covered up with earth until the following morning, when it is washc it as much as possible of the disagreeable taste of coral which it po is spread out on mats, and dried." [13:174]. Sometimes, instead of p was used, and in some areas the trepang was also dried by smokir made to last, the trepang was either sold to the Chinese in Makassa to Singapore [10]. The mode of production has not changed over ti trepang fishers still process their harvest in basically the same way

Fishing and trading of trepang has a number of similarities with the exploitation of other marine commodities, such as live reef food fish major factor common to all is the strong influence of an outside der wealthy consumer class not only had a great influence on the Chin cucumbers in the late seventeenth and early eighteenth century [1 today's exports of live grouper to seafood restaurants in Hong Kon Similarly, fashionable trends greatly influence the demand for mari movie "Finding Nemo" significantly increased the demand for both s and clownfishes.

A second influential factor is the role of credit and debt, which is int relationships. The term describes a relationship between a political powerful patron and a weaker client. Clients and their families can k equipment or goods from the patron, in order to make it through ba regarded as benevolent, but also creates debts and dependency. I relationships have a significant influence on the exploitation of ma certain parts of Island Southeast Asia. In South Sulawesi, they deve systems of land tenure and agricultural production [15] and (2) crec common in Chinese business operations. *Punggawa*, the local term:

been used in the 19th century to describe elected leaders of the Bajau. In the eighteenth and nineteenth century credits were usually provided by the patron. Earl noticed: "Many of the Bajau ... are chiefly employed by the Chinese trepang ... and according to the policy invariably adopted by the latter with the natives, are generally involved in debt, from which extrication ... no instance is on record of ever having absconded to avoid the payment [9:335]. For a more detailed description of the role of credits and debt in trepanging activities, readers are referred to Sutherland [17].

Patrons react to market signals such as the desire for a new resource and recruit clients with the necessary equipment and announcing their will to buy. Clients—depending on the credits provided and often socially tied to their patron—move to a different target resource, if their patron demands them to do so. These relationships influence the choice of fishing strategies of individual fishermen.

Opportunistic behaviour is also quite common in the exploitation of marine resources. Fishermen exploit local stocks of valuable resources until they are depleted and then move to another area, a pattern Berkes et al. [19] have termed "bandit syndrome". This sequential exploitation of resources has been observed for a range of marine resources such as lobster and conch, sea urchins, ornamental fishes [20]–[22]. While the phenomenon has been linked to recent globalisation, the case of trepang shows that roving banditry is not a new phenomenon. Other historical accounts also give evidence of the depletion of marine resources, as in the case of the Atlantic cod in the 19th century and large green turtles before the 19th century in the Americas [24].

A current study by the FAO claims sea cucumber overexploitation to be the most significant cause of marine resource depletion [25]. This statement can only be revised by taking a historical perspective. The present amount of overfishing seems to largely exceed the historic level of fishing activity. While more ecological studies are needed to understand the impact of removing a large number of bioturbating organisms from tropical marine ecosystems, there also is a need to look at the similarities and differences between historic and recent exploitation of trepang in order to provide a knowledge base for sustainable management.

Therefore, the aim of this paper is to follow the trepang fishing and trade routes for the historical and current exploitation of marine resources in Indonesia. Our focus is on the trade which was started and is still handled by private traders and which had historically accounted for the largest amount of this important activity.

Results

The growth of the trade

While some authors stated that sea cucumbers have been harvested in the Indo-Pacific region [26 and references therein], documented trade is only available for the last 400 years. In China, written references to trepang first time under its Mandarin name *haishen* (sea ginseng) in a book

Five Items in 1602. It was described as an aphrodisiac. More frequently emerge in the late seventeenth century and indicate that trepang had been a common food at this time. According to Chinese literature, trepang was found along most of China's coastal areas, but the local production soon failed to meet demand. It was therefore first imported from Japan, and later from Southeast Asia. Documentary evidence from Island Southeast Asia confirms a time period between the seventeenth and the early eighteenth century as the date for the rise of trepang in this region, which is further supported by the fact that none of the earliest records of the sixteenth and early seventeenth century's trade mentions trepang. The earliest Dutch record that mentions trepang is the official diary (*dagboek*) from June 1710 that refers to trepang collection off Buton (I) in Southeast Asia. Boomgard [2:113] concludes that trepang seemingly "appears out of nowhere" in the records of the Dutch East India Company (*Vereenigde Oost-Indische Compagnie*). However, from the mid-eighteenth century on, there are frequent records of trepang collection and processing of trepang all over Island Southeast Asia, with South Sulawesi as the centre of trade.

Bugis had probably been visiting the Moluccas—namely the islands of the Lesser Sunda Islands since the sixteenth century [27] (see Figure 1), and there is evidence that trepang collection in this region actually started around this time. The first hint came from the fact that the Dutch navigator Pieter Pieterse visited the Aru Islands (III) in 1627 and reported that the trepang fishery then merely existed. One of the earliest sources is a VOC report from 1720, mentioning vessels from Sulawesi for trepang near the islands of Luang and Moea in the Southern Moluccas. The number was considerable, with 60 and 30 vessels, respectively [2].



Both Kei and Aru soon developed into major fishing grounds. While the Moluccan islanders originally sailed to Ambon in order to sell their commodities, the Bugis traders started to visit people directly in their villages [28]. Bugis, Makassar, and others brought rice and arak from Makassar and exchanged them for trepang, tortoise shells and other products. The trade greatly stimulated fishing in the Moluccas. "The islanders originally" did not embark on their fishing excursions until they had received advances from the traders, who had to await their return "whenever the weather permitted" whether traders were present or not. Kolff [13:175–176]; described the collection: "At low water hundreds

wives and children, may be perceived wading from Vorkay towards being only two or three feet deep,) carrying a basket at their backs, hands a stick provided with an iron point. When the water is deeper use of canoes. For fishing on the banks situated at a greater distance prahu, constructed for the purpose, in which they embark their entire party. In the 1840s, Chinese traders coming from Singapore through Makassar networks in Aru and ended the monopoly of the Bugis and Makassar.

The importance of trepang for the livelihoods of many people in the region is documented by the fact that institutions which governed the right to fish for trepang and other animals were developed [31]. Kolff (1840) reported that the people of the southern Moluccas claimed the exclusive privilege of fishing trepang in the coastal waters. He also described that in the islands of Tanimbar (V), the territory of a chief consisted of a portion of land and contiguous trepang banks, which were managed by the chief [13]. In the Moluccas, certain marine tenure rights and management practices were part of a culturally embedded institution known as *sasi*. *Sasi* encompasses related rights and rules, and is therefore commonly referred to as a marine management institution, even though it also has other functions and has changed through time [32]. The term signifies harvest restrictions and collection areas implemented by a local village council, the so-called *sasi* since the 18th century, a specific form of *sasi* was applied to trepang fishing. Some areas of the Aru Islands employed *sasi teripang* until recently [33], and commercialisation supported the establishment of traditional *sasi*. While *sasi* thus is a local institution, it has been suggested that Dutch administrators did assist local elites in recrafting and deploying *sasi* to control access to marine commodities [34].

At least since the 1720s, trepang was also fished in South Sulawesi (Spermonde Archipelago (VI) to the north and west of Makassar. Although the Spermonde islands were not yet inhabited, some already were settled. The island of Barrang Lompo [35] which still is a major trepang trading hub today. The trepang from Makassar during that time were about 84 *pikul* (1 *pikul* was equivalent to the amount a man could carry with a shoulder-pole [36]), a little more than the trepang came from Barru about 75 km north of Makassar, but since it arrived from Buton in Southeast Sulawesi, probably a transit point for trepang was collected around Aru, Tanimbar and Australia [37]. It is important to note that these figures are based on registered imports, which only provided a partial view of official exports. A significant amount of trepang probably arrived in Makassar from such as small coastal crafts fishing in the rich trepang grounds close to the coast.

In 1717–1718, 11 tons of trepang were exported from Makassar. In the following years the trepang trade started to grow. In 1725–1726, the amount rose to 301 tons, and in 1787–1788 to 512 tons, respectively (see Table 1). In the eighteenth century, trepang was the most important commodity in Makassar in value, both incoming and outgoing [38].



Table 1. Annual trepang exports from Makassar 1717–1917.

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Other important trepang collection areas during the eighteenth and nineteenth centuries were West-Papua (VII), Sumbawa (VIII), Timor (IX) and Selayar (X), as well as Northern Australia, namely Marege (XI) and Kayu Jawa (XII) (see Fig 1). The Sulu Archipelago remained an important collection site over time. In the nineteenth century, the best quality of trepang, the so-called *trepang pasir*, was found on the banks around the island of Kuding Aring, today known as Kodingan. The island of Spermonde was still named as one of the richest trepang fishing grounds.

The commercial fishing reached a peak in the mid-eighteenth century. The annual export of dried trepang from the Kei Islands was estimated at 600,000 and 1,200,200 specimens [41]. Yearly shipping from Makassar was 400 and 550 tons [42].

It is difficult to determine how many species of trepang were fished. The list includes 112 different local names, several of them describing the same species. The list includes a range of commercially relevant trepang species mentioned in the literature between 1812 and 2004. The references cited in the supplementary material are listed in Supplementary Text S1.

While the species definitely played a role in determining the locally available trepang, the size of the animal and the skills used in processing were also important. In diverse colloquial names referred to the same species, whose value was high. In 1820, Crawford described: “In the market of Makassar, the greatest variety of trepang not less than thirty varieties are distinguished ... the trepang is one of the most valuable articles that can embark with any safety.” [44:442]. The most expensive was the *trepang pasir* from the Spermonde Archipelago near Makassar. Partly due to the skilful way in which the product was prepared by the Bajaks. According to VOC sources, in the second half of the 18th century one *pikul* of trepang cost 77.5 rixdollars, while the cheapest kind (black trepang) sold for 10 rixdollars. At the same time, a *pikul* of rice cost about 1.5 rixdollars [38].

Off to new territories—the voyage to Marege

The most fascinating and also comparatively well-known part of the trepang fishery is its extension towards the northern coasts of Australia. Due to the work of Charles Campbell Macknight, we have a relatively complete picture of the sophistication of what he has called “Australia's first modern industry.” Since there is not much to add to his work, we will be rather brief here, and refer to his magnificent and detailed descriptions [5], [45].

The two major trepang fishing areas were Marege, also known as Maree, a part of the Northern Territory, and Kayu Jawa, the so-called Kimberley Australia (see [Figure 1](#)). Lion [\[42\]](#) reported about activities at various points along the coast of Queensland, but this was apparently based on a misreading of a map [\[46\]](#).

The British hydrogeographer Alexander Dalrymple was the first who wrote about Bugis in Australia [\[47\]](#). Some 30 years later, in February 1803, Matthew Flinders surveyed the north-eastern part of Arnhem Land. His first detailed description of trepanging in Australian waters:

“After clearing the narrow passage between Cape Wilberforce and Cape Flinders, we followed the main coast to the S.W. having on the starboard hand several small islands, which closed in towards the coast a-head so as to make it difficult to find any passage between them. Under the nearest island was perceived a large number of men; and in a sort of roadstead, at the south of the same island, there were several boats covered over like hulks, as if laid up for the bad season.” [\[48:228–230\]](#)

As it turned out, the vessels came from Makassar. They were part of a seasonal trade year—using the north-west monsoon starting in December—travelled to the north of northern Australia in search for trepang. They were equipped with several small camps close to the shore, where they also erected smokehouses for the preparation of trepang. The majorities of supplies were brought from Makassar, including tobacco and other commodities for Aboriginal people who were to be employed. Only firewood for smoke-drying was gathered from mainland Australia.

Depending on the wind, about 10–15 days were needed for the 1,600-mile journey from Makassar to Marege. Each year, up to 2000 men made the journey and were 1000 in processing camps between the Cobourg Peninsula and the bottom of the Gulf of Carpentaria. They mainly gathered *grey trepang*, also described as *Carolin trepang*. While this variety was not the most valuable, it still fetched a high price. It was available in great quantities. According to contemporary sources, *trepang Kayu Jawa* became distinguished varieties in the market, and the success of the trepangers depended on their ability to transform their catch into *trepang Marege* or *trepang Kayu Jawa* [\[5\]](#). When the wind changed, the vessels returned to Makassar. Their average cargoes varied from 8 to 22 tons. Macknight [\[5\]](#) assumed a total production of some 350 tons in the second half of the nineteenth century, which seemed to have slightly decreased over time.

According to Macknight [\[5\]](#), [\[27\]](#), Sutherland [\[7\]](#) and Boomgaard [\[2\]](#), the trepanging activities in Australia did last from at least 1750 to 1906–1907, when the British government decided to stop trepanging in its waters. While among the reasons put forth for the ban was the need to protect the Aboriginal population from the influence of the Makassans, who imported spirits, it rather seems that British imperial sentiments played the main role: “The Makassans were prohibited from trading with foreigners...” [\[5:124\]](#). The political decision to curtail the Makassar trade in Australia did not only end the annual voyages between Makassar and Australia but also stopped a cultural exchange that was certainly older than the earliest contacts with the continent and that has been preserved in the form of rock art.

behind by 19th and early 20th century aboriginal Australians [49].

Early signs of overfishing

When considering the amounts of sea cucumbers that were collected, it is implausible that overfishing did not take place at least in some localities. In fact, a number of sources do contain descriptions which can be interpreted as less obvious signs of early overfishing.

Knaap and Sutherland [38] depict that when trepang became the main commodity in Makassar at the end of the eighteenth century, a shift in fishing grounds took place. This is supported by Klaehn, who in 1833 noted that "the extent of trepang fishing at Australia's coasts might had been related to the fact that the seas between the Moluccas and the Sunda Islands is not sufficient to supply the ever growing market in luxurious China" [50:90]. This continuous demand also becomes obvious from the amounts exported from Makassar:

An explicit account of local overfishing was given by Bosscher [41], who noted that on the islands of Aru, people would gather trepang at the same sand banks, but these seemed to have been depleted. Polunin [33] reported about a general decline in the trade between 1840–1850, without mentioning the original sources. Similarly, Vosmaer [51:180–184] describes a significant decline in the trade in the 1830s, but relates this to the politico-economic situation in the Netherlands rather than ecological causes (see also [7]). Interestingly, the first signs of overexploitation of pearl-oysters were undertaken by the Dutch colonial government at the same time, indicating that depletion of marine resources actually occurred at that time.

Shortly afterwards, a new harvesting technique was adopted along with dredging. Searcy [52:28] provided the first description of this activity: "The twelve canoes, which were almost in line, had their immense triangular masts, and were gliding through the rippling water ... and the canoes were four proas [perahus, boats] at anchor, close to the beach. A Malay camp was formed."

Fishing for sea cucumbers became more effective. However, the amount of trepang exported from the region over a long time seems to confirm that the depletion it occurred, was probably a temporary problem of a limited area that was replenished before the next harvest the following year, but replenished before the next harvest [5]. On the other hand, Mackinnon reported that the large quantities produced in the Queensland Coast could not be maintained after the 1880s.

From the few sources available, it seems fair to assume that some depletion occurred, but was restricted to certain locations and limited periods of time. Sustainable harvesting was obviously still possible, and species which occurred in greater abundance were more likely to be overexploited. The scattered information does not allow more detailed answers to the question if the changing spatial exploitation patterns were driven by stock depletion or rather driven by competition. However, it should

historical overfishing could have gone largely unnoticed, especially had virtually no value outside the Asian markets.

Industrialisation and recent overfishing

As discussed above, although considerable amounts of sea cucumber harvested for centuries in some localities, ecological overfishing hi appear to pose a major threat since harvest was confined to comp. depths. Larger individuals occurring at greater depths possibly pro individuals that could replenish the population once it was depleted [43]. This situation changed towards the end of the 20th century, wh collapsed in many places because so many people took part in coll movement of certain groups of collectors from reef to reef accelera stocks of certain species were quickly depleted in one area after a technology enabled far more efficient harvesting.

In the 1980s and 1990s, increasing demand from China and other p revived the trepang fishing activities [12] (see Table S2 in the suppl Collectors in the Spermonde Archipelago began to make use of cor reach ever greater depths [53]. Consequently, a rapid decline in se observed. While large specimens were still common on sandy bottc in the 1980s, several species were rigorously depleted only a deca end of the century, Massin [55:130] reported that “some reefs off U [Makassar] have nearly been stripped from the largest and comme species such as *Holothuria nobilis*, *H. scabra*, *Stichopus* spp., *Thelen Bohadschia* spp.”. Nowadays, most of the fishermen in Spermonde r large distances, e.g. to the coasts of Kalimantan, to collect trepang from own interviews in June and November 2009).

A study recently published by FAO [25] shows a similar situation for areas worldwide, all of which are under intense harvesting pressur more valuable species fully exploited or overexploited, fisheries ha quantity-high value to high quantities-low value ventures, and also species to multispecies fisheries. The report also notes that “... sea not a traditional activity...” [25:6], and reasons that overfishing is re strong dependency of many coastal communities on trepang as an source. This is certainly not true for the Makassan trepanging activi to a long tradition of at least 300 years. The report does show, how increasing demand in the twentieth century led to an expansion of into virtually all suitable areas, and also enabled a far greater num participate than those traditionally being involved.

Potential effects on ecosystems

While the social systems linked to trepang fishing and trade have ir researched, the ecological effects of removing a large number of b from shallow tropical ecosystems for the most part are still unknow recovery of *H. nobilis*, a highly sought-after species, showed that ov

take decades to recover [57], and that ecosystem impacts therefore lasting. Model calculations have shown that the natural population species on a reef flat in the Great Barrier Reef potentially could renew the sediment in the area within one year, thereby recycling nutrients [58]. Thus, they play an important role in controlling the benthic microbes [59]–[60]. A healthy sediment community is important for the general reef ecosystems, as it has been shown that up to 50% of the net fixed corals in the form of mucus can be retrieved by benthic recycling, the characteristic high productivity of coral reefs [61].

In 1825, Kolff gave the following description from the Tanimbar Islands through a number of small islands ... and trepang lay on the banks in abundance.” [13:268]. In 1999, a survey in the Indo-Pacific revealed that most common species were totally absent from 39% of the surveyed reefs. If more information is urgently needed, it seems highly unlikely that the effects of these species that used to be a basic component of coral reef ecosystem effects on the structure and functioning of these systems.

Comparison with other marine resources and management

Certain regions in maritime Southeast Asia still largely depend on resources from the sea. Besides traditionally harvested commodities such as pearls and shark fins, a number of new products have entered the market over the years, such as live food fish or ornamentals. While the exploitation of sea resources is unique in its magnitude and in the role which certain ethnicities use, it also shares a number of similarities with more recent exploitation patterns of marine resources.

A common feature is their exclusive destination for markets outside the region. Thus, utilization changes according to international demands, and there is a shifting hierarchy of middlemen and other traders.

In regions such as South Sulawesi, the role of patrons or *punggawa* is central in the market chain. Patrons react to market signals by providing their clients with the necessary equipment for fishing activities. Primary resource collectors hardly choose what to fish. They are bound to their *punggawa* by their exploitation strategies accordingly. While *punggawas* specialize in certain commodities, their clients do so as well. This has led to spatially different patterns between locations: In the Spermonde Archipelago, some islands focus on their live food fishing activities, while others utilize ornamental fish (own observations).

A pattern common to marine resource exploitation is the spatially exclusive harvesting of species known as the “roving bandit syndrome”. Roving collectors, due to the *de facto* open access nature of marine resources in many areas, which are not defined or secured. Such roving collectors are thought to hinder the local conservation of resources. The proposed remedy is the so-called “stationary bandit”, which simply means that fishermen stay in one place. As the future existence of their local resources, stationary users are highly

vested interest in the maintenance of these resources [63]. However, there are examples where mobility is used as a strategy to conserve travels by Bajau to areas off their all-day fishing grounds were also to avoid local overexploitation [64]. Ending such practises would th overexploitation in some areas. This strengthens the demand for s flexibility in the management of marine resources. More flexible reg include local communities in conservation measures, which in turn effectiveness [65].

Discussion

For centuries, trepang has played an important role in the economic maritime Southeast Asia. It laid the foundations for a complex web c integrating scattered seafaring populations into long distance trad commercial possibilities of outlying regions.

While trepang fishing shares a number of similarities with the explo resources, such as (1) a strong influence of international markets, (client-relationships and (3) the roving bandit syndrome, there is als its longevity. For 300 years, trepang remained a major export comm Southeast Asia. Fishing for live food fish such as grouper has a hist years. After half of that time, some waters including Riau and the Sp were already fished out. In order to obtain reasonable catches, div islands must now roam further away, e.g., to Take Bone Rate Atoll a Moluccas and Raja Ampat in West Papua. Additionally, fashion is ex plays a major role in determining a fish's desirability. Like any fashi preferred species of live reef fish tend to change with time [21]. Th fished out, or simply drops in demand, new sorts will be targeted. In form of trepang fishery, utilizing compressor diving and reaching to depths, is a novel activity more similar to other emerging marine fis distinguished from the century-old practise of collection in shallow

Another major difference is the existence of certain management s fishing in some areas led to the development of property rights whi right to capture sea cucumbers. Harvest restrictions were impleme closures of collection areas, the so-called *sasi teripang*, and local ov avoided by travelling to other areas. Such institutions are complete recently exploited resources, and also for trepanging in its modern management forms have to be created, such as pro-active manage the periphery of presently exploited areas [66].

Thus, understanding the similarities and differences between histo exploitation of marine resources, as is currently being attempted by frame of the History of Marine Animal Populations (HMAP) project, c step towards finding sustainable solutions for the emerging proble

Materials and Methods

This article draws on an extensive analysis of historical documents and secondary sources. Research for this article was initiated by a systematic search of digitalized documents available in the online repository of the Royal Netherlands Institute of Southeast Asian and Caribbean Studies (KITLV) in Leiden, The Netherlands, and Google Books. Data was then augmented by original documents deposited in archives: the KITLV in Leiden, and the National Archives of the Republic of Indonesia in Jakarta, Indonesia. The historical information was complemented by field visits to Makassar and the Spermonde Archipelago between January and February 2010.

Supporting Information

Table S1.

Commercially relevant trepang varieties with their local and scientific names. <https://doi.org/10.1371/journal.pone.0011346.s001>
(0.13 MB DOC)

Table S2.

Makassarese trepang export and production from 1975–2009. <https://doi.org/10.1371/journal.pone.0011346.s002>
(0.07 MB DOC)

Text S1.

References for Tables S1–S2. <https://doi.org/10.1371/journal.pone.0011346.s003>
(0.03 MB DOC)

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Author Contributions

Analyzed the data: KSM SCAF. Wrote the paper: KSM SCAF.

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