REVIEW

DIVERSITY, EXPLOITATION AND CONSERVATION STATUS OF COMMERCIALLY IMPORTANT SEA CUCUMBER (CLASS HOLOTHURIA) SPECIES IN SOUTHEAST ASIA

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ABSTRACT

Recent trends in sea cucumber fisheries show a marked increase in landings due to a strong increase in demand. The risk of overexploitation at present is high since the case of sea cucumber fisheries in Southeast Asia (SEA) shows a very complex system of interactions, where economic and social factors play important roles. Results showed that most of the countries in SEA Region, particularly Philippines and Indonesia, have the highest number of species harvested every year and placed in highest exporting countries of dried sea cucumber therefore placing them in over-exploited category. Lack of data on basic biological parameters of most species and cultural and sociological non-acceptance of aquaculture as an alternative fishing method for sea cucumber are also to blame for the decline in sea cucumber population in the wild. It is suggested that countries in SEA should implement two important steps to manage existing and future holothurian fisheries. First, the increasing rate of new fisheries had best be reduced to a level where management has time to react to early warning signs of resource depletion. Second, lacking changes in regulation, the catch trajectory and patterns of serial spatial, species and size expansion or depletion are largely predictable. Knowledge of the impending sequence of events can therefore be pre-emptively incorporated into the management of new and existing high-value marine fisheries. Overall, the study highlights the urgent need for better monitoring and reporting of catch, abundance data and proper scientific stock, and ecosystem impact assessment to ensure more sustainable harvesting of sea cucumbers.

KEYWORDS: biodiversity loss, trepang, marine invertebrates, conservation management, tropical fisheries

INTRODUCTION

In the past decades, exploitation of invertebrates for fisheries have increased in production and have generated great income worldwide. One

increasingly harvested group are the sea cucumbers (Class Holothuroidea), which are highly valued in Asia specifically in China. Sea cucumbers are marine invertebrates with a leathery skin and an elongated body containing a single, branched gonad. Sea cucumbers are commonly found on the sea floor worldwide (Bell, 1892; Mortensen, 1927; Lawrence *et al*., 2004). A global estimation of 14, 000 holothurian species were documented (Pawson, 2007) and occur in most benthic marine habitats, in temperate and tropical oceans, and from the intertidal zone to the deep sea (Hickman *et al*., 2006). These organisms are consumed, both reconstituted from a dried form (called trepang) and in a wet form, with muscles cut in strips and boiled (Sloan 1984).

Coastal communities in Southeast Asia (SEA) have a long history of fishing for sea cucumbers. In the recent years, rapid increase in catch and value of these organisms around the region were noted (Conand and Byrne, 1993; Conand, 2004; FAO, 2008). This increase in sea cucumber fisheries has been attributed to increasing demand (Clarke, 2004; Berkes *et al.*, 2006), the need for new resources to harvest (Pauly *et al.*, 2002; Anderson *et al*., 2011) and the increasing abundance because of their release from predation (Worm and Myers, 2003; Heath, 2005; Savenkoff *et al.*, 2007; Baum and Worm, 2009). However, despite an overall global increase in catches and target species, many individual fisheries have shown severe reduction or even collapse in production (Anderson, 2010). The vulnerability of sea cucumber populations to overfishing can be attributed for at least two primary reasons. First, local fishermen can easily and effectively capture shallow water holothurians (Uthicke and Benzie, 2000; Bruckner *et al.*, 2003). Second, their late age at maturity, slow growth and low rates of recruitment make for slow population replenishment (Uthicke *et al.*, 2004; Bruckner, 2005). Owing to these factors, overexploitation has severely decreased the number of many sea cucumber populations (Skewes *et al.*, 2000; Conand, 2004; Lawrence *et al.*, 2004). Up to this point, even with harvesting closures, sea cucumber stocks seem slow to recover (D'Silva, 2001; Uthicke *et al.*, 2004; Ahmed and Lawrence, 2007) and recovery can potentially be on the order of decades (Uthicke *et al.*, 2004).

This paper tackles the current status of sea cucumber fisheries in SEA and determines the actions made with regards to sea cucumber conservation. This review assessed the biodiversity of commercially important sea cucumbers within the region for possible application in formulation of policy, conservation and management of fishery and trade.

Diversity of Commercially Important Sea Cucumber Species in Southeast Asia

Southeast Asia has been the leading producer of tropical sea cucumbers for the global markets. As the historical global center of tropical sea cucumber harvest (Gamboa *et al.*, 2004; Schwerdtner *et al.*, 2010),

countries throughout the region contribute large percentage on the world's overall yield of trepang. As per Perez and Brown (2012), the leading producers of trepang are Indonesia, Malaysia and Philippines with respective share of 12.76, 9.61 and 7.87%. Trepang first appeared in Southeast Asian trade statistics in 1970 and continually contributes significant share up to this date.

Based on listing by Choo (2008a,b), an overall of 52 species of sea cucumbers are commercially exploited as food with most of them comprising tropical and sub-tropical species from the families Holothuriidae and Stichopodidae, including the genus *Holothuria, Actinopyga, Bohadschia* and *Stichopus.* Holothuriidae and Stichopodidae from the order Aspidochirota comprise almost 100% of the world's catch. The wide diversity of sea cucumber species fished in SEA were listed in Table 1. The high number of commercially important species present in SEA shows rich sea cucumber resources in the region. Sea cucumbers listed are easily harvested mainly by gleaning on reef flats and sand flats at low tide. In terms of distribution, Figure 1 shows plot of the number of species harvested in different areas around SEA. Philippines and Indonesia caters the highest number of target sea cucumber species for food exploitation in the region (Choo, 1998; Purcell *et al.*, 2013). High production and large number of utilized species are attributed to trade chains in small-scale fisheries.

Small-scale fisheries are important in about 90% of countries in SEA. This scale mostly concern a large number of species and tends to be longer and more complex than those of industrialized fisheries leading to unregulated fishing and overexploitation of some sea cucumber species. Fishers tend to exhaust marine resources due to absence of a law that governs management and conservation of marine resources (Bell *et al.*, 2008). Population growth and socio-economic development are also fuelling an increasing demand for fishery and aquaculture products all over the world. This rise in demand has led to increasing pressures on marine ecosystems, and has also contributed to accelerating degradation and exploitation of ecosystem within this region (Worm *et al.*, 2009; Von Essen, 2013).

Overexploitation of Sea cucumber in Southeast Asia

Worldwide, most sea cucumber fisheries are ineffectively managed, leading to declining stocks and potentially eroding the resilience of fisheries and most of the tropical fisheries are small-scale (Purcell *et al.*, 2013). Overfishing is the main problem contributing to the depletion of sea cucumber resources and generally lacking in management measures to conserve and sustain their sea cucumber fisheries. Most important producing countries such as Indonesia and Philippines do not have management plans specific to sea cucumber conservation. Other threats to sustain the sea cucumber resources include habitat loss, lack of accurate statistics, global warming and new

Table 1: List of sea cucumber species fished in Southeast Asia (Conand, 2006; Choo, 2008a,b and Purcell, 2012, Purcell *et al.*, 2013).

Family	Genus	Scientific name	Exploitation
Holothuriidae	*Actinopyga*	*Actinopyga echinites* (Jaeger, 1833)	Vietnam
		Actinopyga lecanora (Jaeger, 1835)	Philippines and Vietnam
		Actinopyga mauritiana (Quoy and Gaimard, 1833)	Malaysia, Indonesia and Philippines
	Bohadschia	*Bohadschia atra* (Massin, *et al.*, 1999)	Indonesia
		Bohadschia marmorata (Jaeger, 1833)	Indonesia, Malaysia, Thailand, Vietnam, and Philippines
		Bohadschia vitiensis (Semper, 1868)	Vietnam
		Bohadschia subrubra (Quoy & Gaimard, 1833)	Thailand
	Holothuria	*Holothuria atra* (Jaeger, 1833)	All throughout Southeast Asia
		Holothuria coluber (Semper, 1868)	Indonesia and Philippines
		Holothuria cinerascens (Brandt, 1835)	Indonesia and Philippines
		Holothuria edulis (Lesson, 1830)	Indonesia, Malaysia, Thailand, Vietnam, and Philippines
		Holothuria impatiens (Forsskål, 1775)	Vietnam and Indonesia
		Holothuria leucospilota (Brandt, 1835)	All throughout Southeast Asia
		Holothuria notabilis (Ludwig, 1875)	Indonesia
		Holothuria pervicax (Selenka, 1867)	Indonesia
		Holothuria scabra (Jaeger, 1833)	All throughout Southeast Asia

Table 1 (*cont'd.*).

Family	Genus	Scientific name	Exploitation
		Holothuria scabra var. versicolor (Conand, 1989)	All throughout Southeast Asia
	Pearsonothuria	*Pearsonothuria graeffei* (Semper, 1868)	Malaysia, Indonesia and Philippines
Stichopodidae	*Stichopus*	*Stichopus chloronotus* (Brandt, 1835)	Vietnam
		Stichopus herrmanni (Semper, 1868)	Indonesia, Malaysia, Thailand, Vietnam, and Philippines
		Stichopus horrens (Selenka, 1868)	Malaysia, Indonesia and Philippines
		Stichopus quadrifasciatus (Selenka, 1868)	Malaysia, Indonesia and Philippines
	Thelenata	*Thelenota ananas* (Jaeger, 1833)	Indonesia, Malaysia, Thailand, Vietnam and Philippines

uncontrolled uses for sea cucumber resources (Choo, 1998; Choo, 2008 a,b, Junio-Menez, 2012).

It should be noted that the Philippines and Indonesia had the highest number of sea cucumber exportation in Southeast Asia that are exported to Hong Kong and other parts of China (Brown *et al.*, 2010; Duy, 2012). The over-harvesting of sea cucumber in Malaysia for economic purposes is suspected to lead to the degradation and gradual loss of sea cucumber stock in the wild and lack of up to date species documentation inhibits the efforts taken by related agencies and other departments to protect sea cucumber resources (Kamarudin *et al.*, 2010, Akamine, 2010).

Current global analysis of Mills *et al.* in 2012 revealed an alarmingly high incidence of over-exploitation and depletion of sea cucumber stocks, particularly in the Indo-Pacific (Figure 2). A number of species are threatened and there is evidence of local extinctions in some tropical regions (Purcell *et al.*, 2013). Overall, 20% of total world's fisheries were depleted, 38% were over-exploited, 14% were fully exploited and 27% were underexploited

(Purcell *et al.*, 2013). According to this study of Mills and colleagues (2012), Southeast Asia's sea cucumber resources are overexploited. Due to the current situation, governments and scientific communities in the SEA region are uniting in creating laws and innovation in conservation sea cucumber population in the wild. Different radical management paradigms and new instruments to safeguard the reproductive capacity of stocks are currently being established (Purcell *et al.*, 2013, Bell *et al.*, 2008).

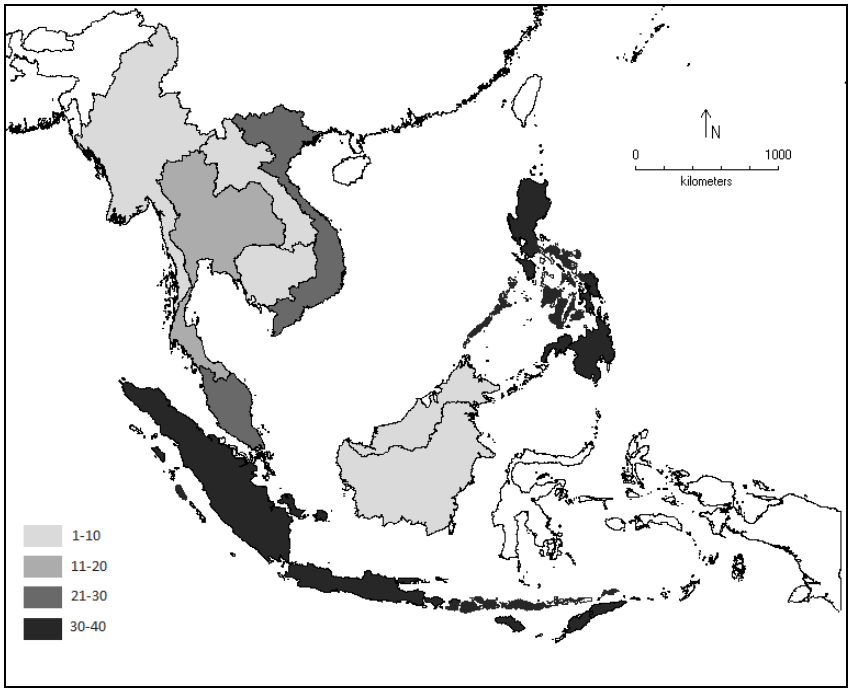

Figure 1: Number of species harvested in different countries in Southeast Asia (n=10). The shade of each country corresponds to the number species exploited (Conand, 2006; Choo, 2008a,b and Purcell, 2012, Purcell *et al.*, 2013).

Biodiversity Conservation Management of Sea cucumbers in Southeast Asia

There are approximately of 52 species of sea cucumbers that are commercially exploited as food (Choo, 2008a,b, Toh, 2012). Despite the significant share of sea cucumber fisheries in economic growth, SEA countries are generally lacking in management measures to conserve and sustain their sea cucumber fisheries. As seen in Figure 3, there are still countries in the SEA region with little or no regulatory measures when it comes to sea cucumber fishing. The number of regulatory measures varies greatly among sea

cucumber fisheries in different countries in SEA. Enforcement and compliance capacity varied greatly among fisheries and tended to be weak in tropical fisheries in low-income countries (Choo, 1998; Purcell *et al.*, 2013), such as the Philippines and Indonesia.

The two most important producing countries, Indonesia and the Philippines do not have management plans specific to sea cucumber conservation (Bruckner *et al.*, 2003, Akamine, 2010, Junio-Menez, 2012). Vietnam also lacks a management plan for the sea cucumbers in their most important fishing area (Otero-Villanueva and Ut, 2007, Duy, 2012). Malaysia, on the other hand, has established Marine Parks Malaysia Order 1994 that acts as a protection against the illegal collection of marine organisms in marine parks. Although there is no quota system and minimum legal size to protect sea cucumbers from overfishing in non-marine park areas, some specific water areas have been reserved for the establishment of sanctuary in view of the indiscriminate harvesting of sea cucumbers (Choo, 2008a,b, Baine and Poh Sze, 1999).

A fundamental barrier to improved management of sea cucumber fisheries is the lack of data on basic biological parameters of most species. Management plans rarely addressed the risks to ecosystems or weighted regulatory measures on the ecological services of certain species to ecosystem function (Purcell *et al.*, 2013, Battaglene, 1999). The most tagging methods for long-term mark-recapture studies to assess growth, mortality rates and

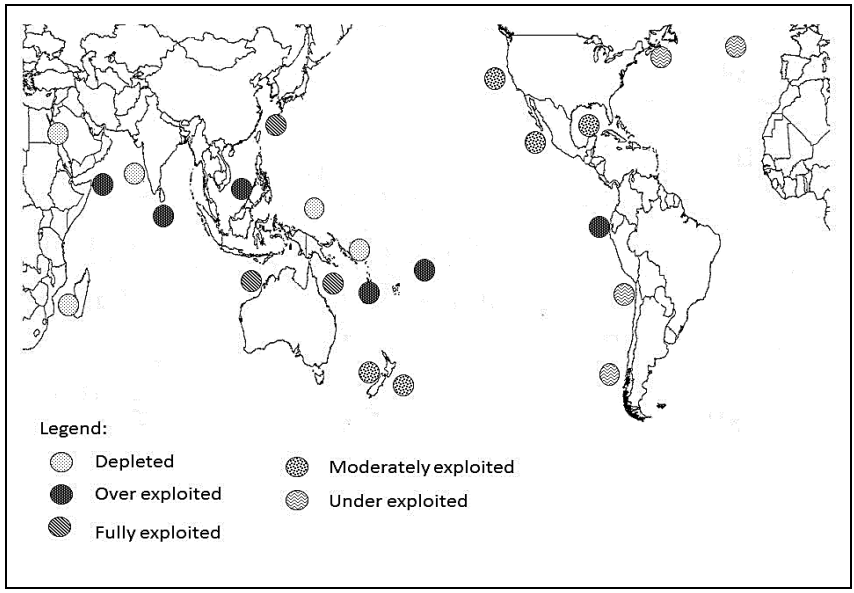

Figure 2: Global exploitation status of sea cucumber fisheries (n=69). The shaded-bubble plot corresponds to the exploitation status of different areas in the world (Purcell *et al.*, 2013).

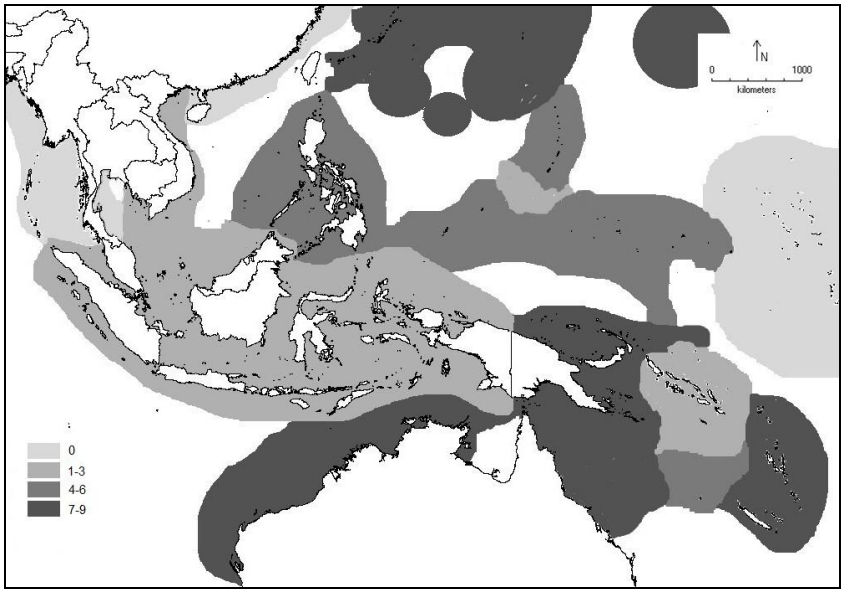

Figure 3: Number of regulatory measures employed in Southeast Asian sea cucumber fisheries (n=76). (Purcell *et al.*, 2013).

longevity are not reliable enough due to a number of limitations (Purcell *et al.*, 2013). Similarly, more contemporary management strategies, like rotational harvest strategy, also struggle with the lack of biological data on most exploited sea cucumbers. In addition, another major issues in the conservation of sea cucumbers is the proper taxonomic identification of the species entering the international market, especially after they have been processed. The lack of adequate tools to help enforcement officials and researchers has been one of the crucial points in any implementation of management actions on sea cucumber species (Worm *et al.*, 2009).

ACKNOWLEDGEMENT

The authors would like to thank Dr. Rey Donne Papa for his guidance and technical assistance. This review was written as a requirement for the authors' Advanced Ecology class in the UST Graduate School.

LITERATURE CITED

Ahmed, M.I. and Lawrence, A.J. 2007. The status of commercial sea cucumbers from Egypt's northern Red Sea Coast. SPC Beche de Mer Information Bulletin. 26: 14– 18.

Akamine, J. 2010. Problems on Sea Cucumber Conservation. In Globalization, Food and Social Identities in the Asia Pacific Region, J. Farrer, (ed.), Tokyo: Sophia University Institute of Comparative Culture. 11pp.

Anderson, S.C. 2010. Trends, drivers, and ecosystem effects of expanding global invertebrate fisheries. MSc thesis, Dalhousie University, 134 pages.

Anderson, S.C., Flemming, J.M., Watson, R., Lotze, H.K. 2011. Rapid global expansion of invertebrate fisheries: trends, drivers, and ecosystem effects. PLoS ONE, 6: 14735-14745.

Baine, M., and Poh Sze, C. 1999. Sea Cucumber Fisheries in Malaysia, towards a Conservation Strategy. SPC Beche de Mer Information Bulletin. 12: 6-10.

Battaglene, S.C. 1999. Culture of Tropical Sea Cucumbers for Stock Restoration and Enhancement. The ICLARM Quarterly, 22: 4-11.

Baum, J.K., and Worm, B. 2009. Cascading top-down effects of changing oceanic predator abundances. Journal of Animal Ecology, 78: 699–714.

Bell, F.J. 1892. Catalogue of the British Echinoderms in the British Museum (Natural History). British Museum, London. 202pp.

Bell, J., Purcell, S.W., and Nash, W. 2008. Restoring small-scale fisheries for tropical sea cucumbers. Ocean & Coastal Management, 51: 589–593.

Berkes, F., Hughes, T.P., and Steneck, R.S. 2006. Globalization, roving bandits, and marine resources. Science, 311: 1557–1558.

Brown E.O., Perez, M.L., Garces, L.R., Ragaza, R.J., Bassig, R.A., and Zaragoza, E.C. 2010. Value chain analysis for sea cucumber in the Philippines, Studies & Reviews2120. The WorldFish Center, Penang, Malaysia. 44pp.

Bruckner, A.W., Johnson, K.A., Field, J.D. 2003. Conservation Strategies for Sea cucumber: Can a CITES Appendix II listing promote sustainable international trade? SPC Beche de mer Information Bulletin, 18: 24-33.

Bruckner, A.W. 2005. The recent status of sea cucumber fisheries in the continental United States of America. SPC Beche de mer Information Bulletin, 22: 39–46.

Choo, P.S. 1998. Marine Biodiversity in Malaysia: Understanding the diversity, threats, and conservation strategies. Proceedings of the Third

National Congress on Genetics: Genetics Towards Better Quality Life. Bangi, Malaysia. 31-45

Choo, P.S. 2008a. Population status, fisheries and trade of sea cucumbers in Asia. A global review of fisheries and trade. FAO Fisheries and Aquaculture Technical Paper. 516: 81-188.

Choo, P.S. 2008b. The Philippines: a hotspot of sea cucumber fisheries in Asia. A global review of fisheries and trade. FAO Fisheries and Aquaculture Technical Paper. 516: 119-140.

Clarke, S. 2004. Understanding pressures on fishery resources through trade statistics: a pilot study of four products in the Chinese dried seafood market. Fish and Fisheries. 5:53–74.

Conand, C. 2004. Present status of world sea cucumber resources and utilisation: an international overview. In: Advances in Sea Cucumber Aquaculture and Management, FAO Fisheries Technical Paper, A. Lovatelli, C. Conand, S.W. Purcell, S. Uthicke, J.F. Hamel and A. Mercier, (ed.). Food and Agriculture Organization of the United Nations, Rome, Italy. 463: 13–23.

Conand, C. and Byrne, M. 1993. A review of recent developments in the world sea cucumber fisheries. US National Marine Fisheries Service Marine Fisheries Review. 55: 1–13.

D'Silva, D. 2001. The Torres Strait beˆche-de-mer (sea cucumber) fishery. SPC Beche de mer Information Bulletin. 15: 2–4.

Duy, N.D.Q. 2012. Large-scale sandfish production from pond culture in Vietnam. Australian Centre for International Agricultural Research Proceedings. 163: 34-39.

FAO. 2008. Sea Cucumbers: A Global Review of Fisheries and Trade. Technical Report 516, Food and Agriculture Organization of the United Nations, Rome, Italy. 7-293.

Gamboa, R., Gomez, A.L., and Nievales, M.F. 2004. The status of sea cucumber fishery and mariculture in the Philippines. Advances in Sea Cucumber Aquaculture and Management. FAO Fisheries Technical Paper 463. Food and Agriculture Organization of the United Nations, Rome, Italy. 463: 69–78.

Heath, M. 2005. Changes in the structure and function of the North Sea fish food web, 1973-2000, and the impacts of fishing and climate. ICES Journal of Marine Science. 62: 847–868.

Hickman, C.P., Roberts, L.S., Larson, A., I'Anson, H., and Eisenhour, D.J. 2006. Integrated Principles of Zoology, 13th ed. McGraw-Hill, New York, NY, USA. 180-641.

Junio-Menez, M.A., Pana, M.A., de Peralta, G.M., Catbagan, T.O., Olavides, R.D.D., Edullantes, C.M.A., Rodriguez, B.D.D. 2012. Establishment and management of communal sandfish (*Holothuria scabra*) sea ranching in the Philippines. Australian Centre for International Agricultural Research Proceedings.163: 121-127.

Kamarudin, K.R., Rehan, A.M., Hashim, R., Usup, G. 2010. An Update on Diversity of Sea Cucumbers (Echinodermata: Holothuroidea) in Malaysia. Malayan Nature Journal. 62(3): 315-334.

Lawrence, A., Ahmed, M., Hanafy, M., Gabr, H., Ibrahim, A., and Gab-Alla, A.F. 2004. Status of the sea cucumber fishery in the Red Sea – the Egyptian experience. Advances in Sea Cucumber Aquaculture and Management. FAO Fisheries Technical Paper. Food and Agriculture Organization of the United Nations, Rome, Italy.463: 79– 90.

Mills, D.J., Duy, N.D.Q., Juinio-Menez, M.A., Raison, C.M., Zarate, J.M. 2012. Overview of sea cucumber aquaculture and sea-ranching research in the Southeast Asian region. Australian Centre for International Agricultural Research Proceedings, 163: 22-33.

Mortensen, T.H.. 1927. Handbook of the Echinoderms of the British Isles. Humphrey Milford Oxford University Press, Oxford, London. 350-439.

Otero-Villanueva, M.D.M., and Ut, V.N. 2007. Sea cucumber fisheries around Phu Quoc archipelago: a cross-border issue between South Vietnam and Cambodia. SPC Beche de mer Information Bulletin #5. 32-36.

Pauly, D., Christensen, V., Guenette, S., Pitcher, T.J., Rashid Sumaila, U., Walters, C.J., Watson, R., and Zeller, D. 2002. Towards sustainability in world fisheries. Nature. 418: 689–695.

Pawson, D.L. 2007. Phylum echinodermata. Linnaeus Tercentenary: Progress in Invertebrate Taxonomy, Zootaxa, Z.Q. Zhang and W. Shear, (ed.). Magnolia Press, Auckland, New Zealand. 1668: 749–764.

Perez, M.L., and E.O. Brown, 2012. Market potential and challenges for expanding the production of sea cucumber in Southeast Asia. Australian Centre for International Agricultural Research Proceedings.. 163: 177-188.

Purcell, S.W. 2012. Principles and science of stocking marine areas with sea cucumbers. Australian Centre for International Agricultutral Research Proceeding. 163: 92-103.

Purcell, S.W., Mercier, A., Conand, C., Hamel, J.H., Toral-Granda, M.V., Lovatelli, A., Uthicke, S. 2013. Sea cucumber fisheries: global analysis of stocks, management measures and drivers of overfishing. Fish and Fisheries. 14: 34-59.

Savenkoff, C., Swain, D., Hanson, J., Castonguay, M., Hammill, M.O., Bourdages, H., Morissette, L., et Chabot, D. 2007. Effects of fishing and predation in a heavily exploited ecosystem: comparing periods before and after the collapse of groundfish in the southern Gulf of St. Lawrence (Canada*).* Ecological Modelling. 204: 115–128.

Skewes, T., Dennis, D., and Burridge, C. 2000. Survey of *Holothuria scabra* (sandfish) on Warrior Reef, Torres Strait. CSIRO Divison of Marine Research, Cleveland, Queensland. 4-28.

Sloan, N.A. 1984. Echinoderm fisheries of the world: a review. Proceedings of the Fifth International Echinoderm Conference, B.F. Keegan and B.D.S. O'Connor, A.A. Balkema, Rotterdam, Netherlands, 109–124.

Schwerdtner Máñez K. and Ferse, S.C.A. 2010. The history of Makassan trepang fishing and trade. PLoS ONE. 5(6): e11346. DOI: 10.1371/journal.pone.0011346 .

Toh, K.B., Chou, L.M., Tay, Y.C., and Phang, V.X.H. 2012. The Impacts of Climatic Extremes on Coastal and Marine Biodiversityin Singapore and Management Challenges. Proceedings of the Asian Conference on Sustainability, Energy & the Environment, International Academic Forum, Osaka, Japan. 423-430.

Uthicke, S., Welch, D., and Benzie, J. 2004. Slow growth and lack of recovery in overfished holothurians on the Great Barrier Reef: evidence from DNA fingerprints and repeated large-scale surveys. Conservation Biology. 18: 1395–1404.

Uthicke, S. and Benzie, J. 2000. Effect of beˆche-de-mer fishing on densities and size structure of Holothuria nobilis (Echinodermata: Holothuroidea) populations on the Great Barrier Reef. Coral Reefs. 19: 271–276.

Von Essen, L.M., Ferse, S.C.S., Glaser, M., Kunzmann, A. 2013. Attitudes and perceptions of villagers toward community-based mariculture in Minahasa, North Sulawesi, Indonesia. Ocean and Coastal Management. 73: 101-112.

Worm, B. and Myers, R.A. 2003. Meta-analysis of codshrimp interactions reveals top-down control in oceanic food webs. Ecology. 84: 162–173.

Worm, B., Hilborn, R., Baum, J.K., Branch, T.A., Collie, J.S., Costello, C., Fogarty, M.J., Fulton, E.A., Hutchings, J.A., Jennings, S., Jensen, O.P., Lotze, H.K., Mace, P.M., McClanahan, T.R., Minto, C., Palumbi, S.R., Parma, A.M., Ricard, D., Rosenberg, A.A., Watson, R., Zeller, D. 2009. Rebuilding global fisheries. Science**.** 325: 578–585.