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Indian Council of Agricultural Research
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Seahorse resources in India

Need for paradigm shift in approach for sustainable fisheries and conservation

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K. Vinod, R. Saravanan, B. Johnson, A. Murugan, K.K. Joshi and E. Vivekanandan

Seahorse resources in India: need for paradigm shift in approach for sustainable fisheries and conservation

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Foreword

The seahorses are one of the least studied marine natural resources in India. Considering their vulnerability to anthropogenic pressures because of their unique biological characteristics, the Government of India imposed a moratorium on the fishery and trade in 2001. This document brings to light that the fishery for seahorses, particularly the bycatch fishery and trade continue to thrive, making the conservation effort largely ineffective. It appears that there is a need to go beyond what the government considers to be the best way to manage this unique natural resource. This publication attempts to find some answers to this issue by suggesting a shift in approach to management – i.e., addressing the trade-off between conservation and sustainable development of the seahorse fishery. The publication emphasises the link between conservation and sustainable utilisation of natural resource on the one hand, and poverty reduction on the other. It also stresses the need to strengthen the capacities at different levels and learning from the experiences of other countries.

This publication is the result of consolidation of research carried out by ICAR-CMFRI and other research organisations in India as well as the result of partnership between ICAR-CMFRI and Bay of Bengal Large Marine Ecosystem project (BOBLME). From the perspective of ICAR-CMFRI, the publication fits into one of the mandates of the Institute to monitor and assess the marine fisheries resources of the Indian Exclusive Economic Zone (EEZ) and develop sustainable marine fishery management plans. By stressing the need for ecosystem approach to management as well as co-management, the publication has given an opportunity to the ICAR-CMFRI to assist in providing the concepts, guidelines, ideas, methods and tools to those interested not only in seahorse management, but in management of other natural resources as well.

I sincerely hope that this publication will be useful to the scientific community as well as planners to take appropriate measures for the conservation and sustainable use of seahorse resources in India and I assure that the ICAR-CMFRI will ever remain committed to this cause.

A. Gopalakrishnan
Director, ICAR-CMFRI

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Executive Summary

The seahorses have increasing demand in the international market as they are highly sought after for use in Traditional Chinese Medicines (TCM), marine aquarium trade and as curios. Reports across the world have indicated that the heavy demand has resulted in over-harvesting of these vulnerable syngnathids and consequent depletion of their population in the wild. In India, a total of seven species have been reported of which 5 species are in the Vulnerable category while the remaining 2 species are in the Data Deficient category of the IUCN Red List of Threatened Species. Information on the biology of only two species are available. The available information are insufficient to estimate the status of seahorse resources due to paucity of data on exploitation. The present document is an outcome of the research taken by the ICAR-CMFRI and the FAO-BOBLME supported project on conservation of seahorses. It is aimed at consolidation of available information on seahorses in the country, particularly in the Gulf of Mannar and Palk Bay. We propose a paradigm shift for effective conservation and long-term sustainability of seahorse resources.

In the 1980s, a well established seahorse fishery existed in the Gulf of Mannar and Palk Bay; in 1990s, the demand was also met by target fishing through diving and India emerged as one of the leaders in the export of seahorses. Concerned by the rapid expansion of the fishery, the Ministry of Environment, Forests and Climate Change, Government of India declared a moratorium to ban the collection and trade of seahorses, which came into force with effect from July 2001. Despite the moratorium, illegal fishing and trade of seahorses continue which obviously defeats the conservation efforts taken by the government. It is not clear whether the ban imposed by the government has helped reviving the wild population of seahorse in the last 15 years. However, the ban has seriously affected the livelihood of many artisanal and subsistence coastal fishers who were dependent on seahorse collection.

As the moratorium is not supported by the fishers and has led to illegal fishing, a regulated fishery with effective monitoring would be a preferred option to achieve the twin goals of sustainable utilization and conservation of seahorses. The regulatory measures for seahorse fishery management would include issue of license, fixing of catch quota, Minimum Legal Size, sex-selective fishing, rotation of harvest areas, seasonal closures, gear limitation, habitat protection, creating sanctuaries and captive breeding for replenishment of the wild stock. Although many management measures are suggested in this document, all the measures cannot be implemented in one place and the most suitable measures should be selected after careful

planning and discussion with stakeholders. Involvement of local communities needs to be ensured at every stage of planning and implementation, as community participation will hold the key for success of any conservation and management programmes. Periodic surveys need to be undertaken to assess the wild stock of different species of seahorses and the regulatory measures in fishery to be tuned accordingly. Globally too, only a few success stories are available with regard to conservation and management of seahorses. However, it is time that all the concerned stakeholders collectively think, plan and implement the necessary management measures for the sustainable utilization and conservation of seahorses in the country.

1
Chapter

Background

1.0 Background

The seahorses belong to the family Syngnathidae, which also encompasses pipefishes and seadragons. They are found distributed from 50°north to 50°south latitude, with most species occurring in the Western Atlantic Ocean and the Indo-Pacific region. All seahorses are marine, except for some, which are found in estuaries. They generally live among seagrasses, seaweeds, mangroves and coral reefs (Foster and Vincent, 2004) in shallow temperate and tropical waters.

The peculiar body features, appearance, and behaviour make seahorses a highly sought-after fish for marine aquarium industry and are traded worldwide. The seahorses have head at right angles to their body and prehensile tail by which they wrap around seagrass rhizomes, corals, sticks or any hard suitable substrata. These traits along with eyes that swivel independently of each other, tubular snout, lack of stomach and teeth, camouflaging behaviour and presence of a series of bony plates, make them unique. Unlike other teleosts, the lophobranchiate gills are small and compacted. They swim using the propulsive force of dorsal fin, and the pectoral fins are used for steering and stability.

The seahorses are characterized by sparse distribution, low mobility, narrow home range, monogamous breeding behaviour, low fecundity, slow growth, site specificity and high degree of lengthy parental care which makes them vulnerable to exploitation. In addition to their live trade in the marine aquarium industry, they are also highly sought-after for medicinal purposes, particularly in traditional Chinese medicines.

Due to increasing demand, the seahorses are heavily extracted in large numbers by poor subsistence fishers involved in artisanal fishing and fishing crews in the mechanized sector, particularly for preparation of dried products and sent to countries with large ethnic Chinese populations. They are also components in by-catch of many fishing gears, particularly the trawl (mechanized and non-mechanized). The behaviour and ecology of seahorses suggest that they are vulnerable to over-exploitation leading to decline in population. The degradation of habitats like the seagrass meadows and coral reefs, mainly due to anthropogenic activities, contributes to further depletion. These factors, along with decline in population of seahorses in the wild, are causes of serious concern all over the world (Vincent, 1996).

In India, the fishery of seahorse was not subjected to any regulations until the Ministry of Environment, Forests and Climate Change (MoEF & CC), Government of India banned the export permits for all syngnathids from July 2001 (as per Notification S.O. 665 (E) of MoEF dated 11th July, 2001) and classified them under Schedule I, Part II-A (Fishes) of the Indian Wildlife (Protection) Act, 1972. Following implementation of ban, there is considerable decrease in fishing of syngnathids in the last 15 years, but clandestine fishing, bycatch and trade take place.

It is not clear whether the enforcement of ban on collection and trade of seahorses has helped re-building the population of seahorses in India. However, the ban has seriously affected the livelihood of scores of poor coastal/artisanal fishermen who were fully dependent on collection of seahorses and without other options for livelihood.

The ICAR-Central Marine Fisheries Research Institute (CMFRI) conducted several studies on seahorses since 1993. Recently, under the FAO-BOBLME supported project "Participatory management for conservation of seahorses in the Gulf of Mannar, south-east coast of India", the CMFRI conducted a study on the status of seahorse resources in the Gulf of Mannar and Palk Bay. The study included interviews and consultation workshops with the fishermen and other key stakeholders to understand the impact of moratorium on seahorse fishery on their socio-economic and livelihood status, and also to understand their perception on conservation of seahorse resources. Two stakeholder consultation workshops were conducted under the project; the first in December 2014 at the Mandapam Regional Centre of ICAR-CMFRI and the second at Tuticorin in May 2015. The workshops enabled proposing management guidelines for conservation and sustainable management of seahorse resources in the Gulf of Mannar and Palk Bay.

The present document is an outcome of the initiatives taken by the ICAR-CMFRI and the FAO-BOBLME supported project. It is aimed at consolidation of available information on seahorses in the country, particularly in the Gulf of Mannar and Palk Bay and proposing new guidelines for effective conservation and long-term sustainability of seahorse resources.

This document has been prepared with the following objectives:

(i) To update the information on the present status of seahorse fishery;

(ii) To understand the socio-economic condition of fisherfolk who were once involved in the seahorse fishery in the Gulf of Mannar and Palk Bay;

(iii) To record the perception of fishers on the conservation and sustainable seahorse fishery management; and

(iv) To appraise effectiveness of the current management measures and propose management guidelines for conservation and sustainable use of seahorse resources.

Chapter 2

An overview of seahorse resources

2.1 Global diversity of seahorse species

A total of 41 valid species of seahorses (Table 1) have been reported worldwide (FishBase, 2017). Of these, one species is Endangered (EN), 10 are Vulnerable (VU), 2 are Least Concern (LC), 20 are Data Deficient (DD) and 8 are Not Evaluated (NE) in the IUCN Red List of Threatened Species (IUCN, 2017).

Table 1. Global list of valid species of seahorse

Sl. No.	Species	Common name	IUCN Red List Status
1.	*Hippocampus abdominalis* Lesson, 1827	Big-belly seahorse	DD
2.	*Hippocampus algiricus* Kaup, 1856	West African seahorse	VU
3.	*Hippocampus angustus* Gunther, 1870	Western spiny seahorse	DD
4.	*Hippocampus barbouri* Jordan & Richardson, 1908	Barbour's seahorse	VU
5.	*Hippocampus bargibanti* Whitley, 1970	Pygmy seahorse	DD
6.	*Hippocampus breviceps* Peters, 1869	Shorthead seahorse	DD
7.	*Hippocampus camelopardalis* Bianconi, 1854	Giraffe seahorse	DD
8.	*Hippocampus capensis* Boulenger, 1900	Knysna seahorse	EN
9.	*Hippocampus colemani* Kuiter, 2003	Coleman's pygmy seahorse	NE
10.	*Hippocampus comes* Cantor, 1849	Tiger tail seahorse	VU
11.	*Hippocampus coronatus* Temminck & Schlegel, 1850	Crowned seahorse	DD
12.	*Hippocampus debelius* Gomon & Kuiter, 2009	Softcoral seahorse	NE
13.	*Hippocampus denise* Lourie & Randall, 2003	Denise's pygmy seahorse	DD
14.	*Hippocampus erectus* Perry, 1810	Lined seahorse	VU
15.	*Hippocampus fisheri* Jordan & Evermann, 1903	Fisher's seahorse	DD
16.	*Acentronura gracilissima* Temminck & Schlegel, 1850	Bastard seahorse	LC
17.	*Hippocampus guttulatus* Cuvier, 1829	Long-snouted seahorse	DD
18.	*Hippocampus hippocampus* (Linnaeus, 1758)	Short-snouted seahorse	DD
19.	*Hippocampus histrix* Kaup, 1856	Thorny seahorse	VU

20.	*Hippocampus ingens* Girard, 1858	Pacific seahorse	VU
21.	*Hippocampus jayakari* Boulenger, 1900	Jayakar's seahorse	DD
22.	*Hippocampus jugumus* Kuiter, 2001	Collared seahorse	NE
23.	*Hippocampus kelloggi* Jordan & Snyder, 1901	Great seahorse	VU
24.	*Hippocampus kuda* Bleeker, 1852	Spotted seahorse	VU
25.	*Hippocampus lichtensteinii* Kaup, 1856	Lichtenstein's seahorse	NE
26.	*Hippocampus minotaur* Gomon, 1997	Bullneck seahorse	DD
27.	*Hippocampus mohnikei* Bleeker, 1853	Japanese seahorse	DD
28.	*Hippocampus paradoxus* Foster & Gomon, 2010	Paradoxical seahorse	NE
29.	*Hippocampus patagonicus* Piacentino & Luzzatto, 2004		NE
30.	*Hippocampus pontohi* Lourie & Kuiter, 2008	Pontoh's pygmy seahorse	DD
31.	*Hippocampus pusillus* Fricke, 2004	Pygmy thorny seahorse	NE
32.	*Hippocampus reidi* Ginsburg, 1933	Longsnout seahorse	DD
33.	*Hippocampus satomiae* Lourie & Kuiter, 2008	Satomi's pygmy seahorse	DD
34.	*Hippocampus sindonis* Jordan & Snyder, 1901	Shiho's seahorse	LC
35.	*Hippocampus spinosissimus* Weber, 1913	Hedgehog seahorse	VU
36.	*Hippocampus subelongatus* Castelnau, 1873	West Australian seahorse	DD
37.	*Hippocampus trimaculatus* Leach, 1814	Longnose seahorse	VU
38.	*Hippocampus tyro* Randall & Lourie, 2009		NE
39.	*Hippocampus whitei* Bleeker, 1855	White's seahorse	DD
40.	*Hippocampus zebra* Whitley, 1964	Zebra seahorse	DD
41.	*Hippocampus zosterae* Jordan & Gilbert, 1882	Dwarf seahorse	DD

EN : Endangered, VU : Vulnerable, LC : Least Concern, DD : Data Deficient
NE : Not Evaluated

Globally, nearly half of the reported species (48.8%) fall under the Data Deficient category, while 19.5% of the species have been Not Evaluated (Fig. 1). Any management measures rely mostly on the ecological and biological information of the concerned species. The paucity of data on many of the seahorse species is a cause for concern and could be a major impediment in evolving fishery management and conservation measures.

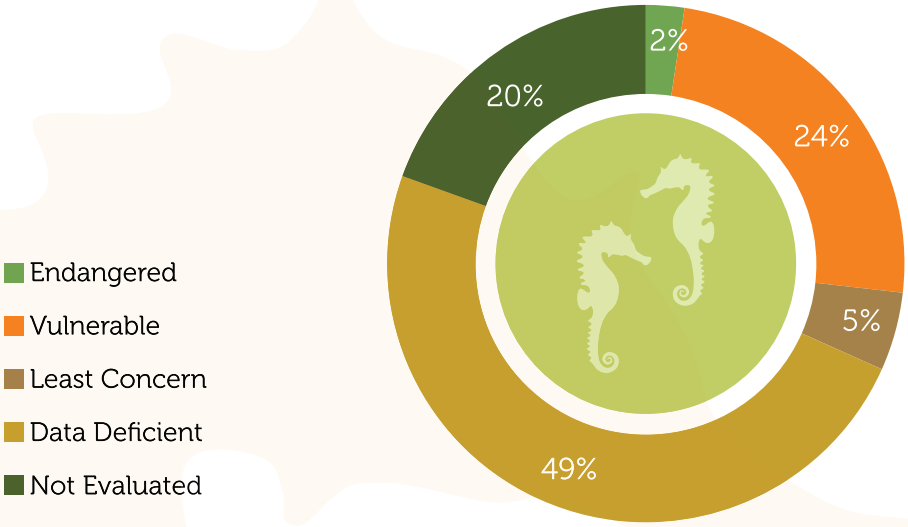


Fig. 1. Percentage of globally reported seahorses in different categories of IUCN Red List of Threatened Species

2.2 Seahorse diversity and distribution in the Indian waters

Seven species of seahorses *viz.*, *Hippocampus trimaculatus, H. kuda, H. spinosissimus, H. kelloggi, H. histrix, H. mohnikei* and *H. camelopardalis* have been reported in the Indian waters (Marichamy *et al.*, 1993; Lipton and Thangaraj, 2002; Murugan *et al.*, 2008; Murugan *et al.*, 2011; Thangaraj and Lipton, 2011; Rajagopal *et al.*, 2012; Lipton and Thangaraj, 2013; Subburaman *et al.*, 2014, BOBLME, 2015; Murugan *et al.*, 2017). Of these seven species, six (except *H. camelopardalis*) are found along the Tamil Nadu coast (southeast coast of India), one (*H. kuda*) along Puducherry, three (*H. trimaculatus, H. kuda* and *H. kelloggi*) in Kerala waters, one (*H. kelloggi*) along the Andhra Pradesh coast, one (*H. kuda*) in Karnataka (Karwar and Kumta), one (*H. kuda*) in Goa (Panjim estuary and Marmagao), one (*H. kuda*) in Maharashtra (Mirya Creek), one (*H. kuda*) in West Bengal, one (*H. kuda*) in Odisha (Chilka lake), two (*H. kuda* and *H. histrix*) in Andaman and Nicobar Islands, two (*H. kuda* and *H. histrix*) in Lakshadweep Islands and one (*H. camelopardalis*) in Gujarat (Mithapur reef) (Table 2 & Fig. 2).

Table 2. Reported distribution of seahorses in India

Sl. No.	Species	Distribution	References
1.	*Hippocampus kuda*	Palk Bay, Tamil Nadu	Marichamy *et al.* (1993), Gokulakannan (2002), Lipton & Thangaraj (2002), Salin *et al.* (2005), Murugan *et al.* (2008), Lipton & Thangaraj (2013), BOBLME (2015)
		Gulf of Mannar, Tamil Nadu	Murugan *et al.* (2008), Murugan *et al.* (2011), Lipton & Thangaraj (2013), BOBLME (2015)
		Karaikal, Puducherry	Rajasegar & Sendhilkumar (2009)
		Coromandel coast, Tamil Nadu	Murugan *et al.* (2008)
		Malabar coast, Kerala	Lipton & Thangaraj (2013)
		Karwar & Kumta, Karnataka	Singh *et al.* (2011)
		Panjim estuary & Marmagao, Goa	Singh *et al.* (2011)
		Mirya creek, Ratnagiri	Murugan *et al.* (2017)
		West Bengal	Mahapatra *et al.* (2016)
		Chilka lake, Odisha	Kumar & Pattnaik (2012)
		Kavaratti & Minicoy, Lakshadweep	Jones & Kumaran (1980), Prabhakaran *et al.* (2013)
		Andaman & Nicobar Islands	Dorairaj (1994), Sriramachandra Murty (1996), Rao *et al.* (2000)
2.	*Hippocampus trimaculatus*	Palk Bay, Tamil Nadu	Marichamy *et al.* (1993), Lipton & Thangaraj (2002), Salin *et al.* (2005), Murugan *et al.* (2008), Lipton & Thangaraj (2013), BOBLME (2015)
		Gulf of Mannar, Tamil Nadu	Murugan *et al.* (2008), Murugan *et al.* (2011), Lipton & Thangaraj (2013), BOBLME (2015)
		Coromandel coast, Tamil Nadu	Murugan *et al.* (2008)
		Kerala coast	Salin *et al.* (2005), Lipton & Thangaraj (2013)

3.	*Hippocampus spinosissimus*	Palk Bay, Tamil Nadu	Salin *et al.* (2005), Murugan *et al.* (2008), BOBLME (2015)
		Gulf of Mannar, Tamil Nadu	Murugan *et al.* (2008), Murugan *et al.* (2011), BOBLME (2015)
		Coromandel coast, Tamil Nadu	Murugan *et al.* (2008)
4.	*Hippocampus kelloggi*	Gulf of Mannar, Tamil Nadu	Thangaraj & Lipton (2011), Lipton & Thangaraj (2013), BOBLME (2015)
		Coromandel coast, Tamil Nadu	Murugan *et al.* (2008)
		Kanyakumari, Tamil Nadu	Lourie *et al.* (1999)
		Malabar coast, Kerala	Lipton & Thangaraj (2013)
		Andhra Pradesh	Anonymous (2016)
5.	*Hippocampus histrix*	Gulf of Mannar, Tamil Nadu	Lipton & Thangaraj (2013)
		Andaman Islands	Rajan *et al.* (2011)
		Kadamat & Kavaratti, Lakshadweep	Jones & Kumaran (1980)
6.	*Hippocampus mohnikei*	Palk Bay, Tamil Nadu	Thangaraj & Lipton (2007), Gokulakannan (2002)
7.	*Hippocampus camelopardalis*	Mithapur reef, Gulf of Kachchh, Gujarat	Subburaman *et al.* (2014)

As evident from Table 2 and Figure 2, the distributional reports are more from the Tamil Nadu coast which was the main centre for fishery and trade of seahorses. However, it is possible that more species than that are listed in the table are distributed in other locations along the Indian coast. The limited reef research is one of the main reasons for the poor understanding of seahorse diversity and distribution in India, particularly its occurrence from the coral reef regions like the Gulf of Kachchh, Andaman and Nicobar Islands and Lakshadweep Islands. Of the seven species of seahorses recorded from Indian waters, five species (*H. trimaculatus*, *H. kuda*, *H. spinosissimus*, *H. kelloggi* and *H. histrix*) are listed as 'Vulnerable', while two (*H. mohnikei* and *H. camelopardalis*) are listed as 'Data Deficient' in the IUCN Red List of Threatened Species (IUCN, 2017) (Table 3). In India, all species of seahorses are listed in Schedule I of the Indian Wildlife (Protection) Act, 1972 since the year 2001, which bans collection and trade.

Fig. 2. Distribution of seahorses in the Indian waters

Table 3. Conservation status of seahorse species recorded from the Indian waters

Sl. No.	Species	Conservation status		
		IUCN Red List of Threatened Species	CITES	Indian Wildlife (Protection) Act, 1972
1.	*Hippocampus trimaculatus*	Vulnerable (VU)	Appendix II	Schedule I
2.	*Hippocampus kuda*	Vulnerable (VU)	Appendix II	Schedule I
3.	*Hippocampus spinosissimus*	Vulnerable (VU)	Appendix II	Schedule I
4.	*Hippocampus kelloggi*	Vulnerable (VU)	Appendix II	Schedule I
5.	*Hippocampus histrix*	Vulnerable (VU)	Appendix II	Schedule I
6.	*Hippocampus mohnikei*	Data Deficient (DD)	Appendix II	Schedule I
7.	*Hippocampus camelopardalis*	Data Deficient (DD)	Appendix II	Schedule I

2.3 Studies on seahorses by ICAR-CMFRI and other research institutions in India

The ICAR-CMFRI initiated studies on seahorses in the year 1993 with the first report by Marichamy *et al.* in 1993 on the large-scale exploitation of the seahorse *H. kuda* along the Palk Bay coast of Tamil Nadu. The subsequent publications on seahorse fishery are those of Lipton (1998), Lipton and Thangaraj (2002), Salin *et al.* (2005) and Salin and Nair (2006). The ICAR-CMFRI also conducted studies on taxonomy of seahorses (Thangaraj and Lipton, 2007, 2010, 2011; Thangaraj *et al.*, 2012 a, b), biochemical

Table 4. Research projects undertaken on seahorses in India during 1999–2015

Sl. No.	Title of the Project	Period	Funding agency	Implementing Institution
1.	Culture of seahorses	1999-01	ICAR	ICAR-CMFRI, Mandapam
2.	Biology of seahorses	2000-03	Department of Ocean Development, MoES	CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University
3.	Captive breeding, rearing and sea-ranching of seahorses	2002-05	MoEF & CC	ICAR-CMFRI, Vizhinjam
4.	Breeding and rearing of Indian seahorses	2005-08	Department of Ocean Development, MoES	CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University
5.	Standardization of captive breeding and rearing for Indian seahorses	2008-11	Department of Biotechnology	National Institute of Oceanography (CSIR), Goa
6.	Seahorse recovery	2009-10	Gulf of Mannar Marine National Park	SDMRI, Tuticorin
7.	Isolation of antimicrobial compounds from seahorses	2009-11	Department of Ocean Development, MoES	CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University
8.	Participatory management for conservation of seahorses in the Gulf of Mannar, southeast coast of India	2014-15	FAO-Bay of Bengal Large Marine Ecosystems (BOBLME) Project	ICAR-Central Marine Fisheries Research Institute
9.	Community-based approach for the conservation of seahorse in Palk Bay, India	2016	Wildlife Trust of India & CAF, India	S. Meenakshi, R. Saravanan & A. Murugan

composition (Thangaraj and Lipton, 2004), tagging (Lipton and Thangaraj, 2007), captive breeding and rearing (Anil *et al.*, 1999; Ignatius *et al.*, 2000; Ignatius and Jagadis, 2003; Lipton and Thangaraj, 2005; Lipton *et al.*, 2006), nutrition (Thangaraj and Lipton, 2008) and diseases of seahorses (Thampiraj *et al.*, 2010).

Nine research projects had been undertaken on seahorses by various Institutions of India from 1999 to 2015. The projects were funded by various agencies like the Indian Council of Agricultural Research (ICAR), Ministry of Environment, Forests & Climate Change (MoEF & CC), Ministry of Earth Sciences (MoES), Department of Biotechnology (DBT), the Gulf of Mannar Marine National Park (GOMNP) and the FAO-Bay of Bengal Large Marine Ecosystem (BOBLME) Project (Table 4). Studies also led to six doctoral dissertations on various aspects of seahorses, particularly on the species which are widely traded *viz. H. kuda*, *H. trimaculatus* and *H. kelloggi* (Table 5).

Table 5. Doctoral dissertations on seahorses in India

S. No.	Name	Title of the Dissertation work	University	Year
1.	R. Balasubramanian	Studies on seahorses with special references to *Hippocampus kelloggi* (Jordan and Snyder, 1902), southeast coast of India.	Annamalai University, Tamil Nadu	2002
2.	K. Gokulakannan	Systematics of seahorses and biology of yellow seahorse *Hippocampus kuda* (Bleeker, 1852) from Palk Bay region, southeast coast of India.	Annamalai University, Tamil Nadu	2002
3.	K.R. Salin	Reproductive biology and larval rearing of *Hippocampus kuda*, and the taxonomy of seahorses from southern India.	ICAR-Central Institute of Fisheries Education, Mumbai	2003
4.	A. Murugan	Biology and culture of the seahorse *Hippocampus trimaculatus* (Leach, 1814).	Annamalai University, Tamil Nadu	2004
5.	D. Chelliyan	Eco-biology of the yellow seahorse, *Hippocampus kuda* from Palk Bay region.	Bharathidasan University, Tamil Nadu	2012
6.	H. Pawar	Development and standardization of hatchery technique for conservation of Yellow Seahorse, *Hippocampus kuda*.	Goa University, Goa	2014

An analysis of the available literature indicates that research on seahorses in India focused mainly on taxonomy, distribution, catch rate, captive breeding and larval rearing (Table 6). Information is also available on biology and genetics of a few species. However, the available information are insufficient to estimate the status of abundance of seahorse resources and only meagre information is available for conservation and management of seahorses, mainly due to paucity of data on exploitation.

Table 6. Scientific publications on seahorses in India

Subject	No. of publications
Taxonomy and Distribution	30
Biology	7
Ecology and Abundance	5
Genetics	8
Breeding and Culture	12
Biotechnology	2
Microbiology	3
Disease	2
Conservation	3

2.4 Brief description of seahorse species recorded from the Indian waters

1 *Hippocampus trimaculatus* Leach, 1814

Synonyms: *Hippocampus mannulus* Cantor, 1849
Hippocampus kampylotrachelos Bleeker, 1854
Hippocampus manadensis Bleeker, 1856
Hippocampus planifrons Peters, 1877
Hippocampus lenis De Vis, 1908
Hippocampus dahlia Ogilby, 1908
Hippocampus takakurae Tanaka, 1916

Common name: Longnose seahorse

Description

H. trimaculatus (Fig. 3) inhabits gravel or sandy bottoms around shallow reefs, estuaries and near mangroves. It can tolerate lower salinities. The maximum recorded adult height is 22 cm (TL) (Kuiter and Tonozuka, 2001). The colouration is golden orange, sand coloured or totally black and may have large dark spots on the dorso-lateral surface of the first, fourth and seventh trunk rings. The dark spots are more common in males than in females and they are less visible in dark specimens. Some specimens have a zebra pattern striped in brown and white. It is also characterized by a narrow head, low coronet, hook-like cheek, eye spines which appear flat, and absence of nose spine.

Genetic diversity

Genetic stock structure studies through sequence variation analysis of a 350 bp cytochrome b gene fragment revealed occurrence of distinct genetic stocks of *H. trimaculatus* in the southeast (Mandapam, Tamil Nadu) and southwest coasts (Kollam, Kerala) of India (Goswami *et al.*, 2009). The study indicates that, of the nine haplotypes, five were unique to Kollam population and the remaining four were found in Mandapam population, and a highly significant pair-wise genetic divergence value (Φ_{ST}=0.6337; P<0.001) between two populations.

Genetic diversity studies between three populations (Mullimunai in Palk Bay, Tuticorin in Gulf of Mannar and Vizhinjam in the south Kerala coast) of *H. trimaculatus* using four

polymorphic microsatellite loci indicated a genetic distance value of 0.183 between Mullimunai and Tuticorin, 0.461 between Tuticorin and Vizhinjam and a greater distance of 0.837 between Mullimunai and Vizhinjam (Thangaraj *et al.*, 2012b). The study indicated that Mullimunai and Tuticorin populations were genetically identical, while, the stock of Vizhinjam was found to be genetically distinct from Mullimunai and Tuticorin populations.

Fig. 3. *Hippocampus trimaculatus*

Microsatellite analysis by Singh *et al.* (2012) using 12 polymorphic loci to determine the population structure of *H. trimaculatus* detected 4 private alleles exclusively in the Palk Bay and Gulf of Mannar population and 7 in Kerala population, indicating no mixing of gene pool between population of the southeast (Palk Bay and Gulf of Mannar) and southwest (Kerala) coasts of India. As seahorses have low mobility, the chances of genetic mixing of populations appear to be rare.

Distribution

Globally, this species is found in Australia, Cambodia, China (Hong Kong SAR and Province of Taiwan), France (Tahiti), India, Indonesia, Japan, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam (Lourie *et al.*, 2004). In India, this species was recorded from the coasts of Tamil Nadu (Marichamy *et al.*, 1993; Lipton and Thangaraj, 2002; Salin *et al.*, 2005; Murugan *et al.*, 2008; Lipton and Thangaraj, 2013; BOBLME, 2015) and Kerala (Salin *et al.*, 2005; Lipton and Thangaraj, 2013).

Uses

H. trimaculatus is the most sought-after fish in the trade for traditional Chinese medicines and are also marketed for curios.

2 *Hippocampus kuda* Bleeker, 1852

Synonyms:
Hippocampus moluccensis Bleeker, 1852
Hippocampus taeniopterus Bleeker, 1852
Hippocampus polytaenia Bleeker, 1854
Hippocampus melanospilos Bleeker, 1854
Hippocampus chinensis Basilewsky, 1855
Hippocampus rhynchomacer Dumeril, 1870
Hippocampus tristis Castelnau, 1872
Hippocampus aterrimus Jordan & Snyder, 1902
Hippocampus hilonis Jordan & Evermann, 1903
Hippocampus taeniops Fowler, 1904
Hippocampus horai Duncker, 1926
Hippocampus kuda multiannularis Raj, 1941
Hippocampus novaehebudorum Fowler, 1944
Hippocampus raji Whitley, 1955

Common name: Yellow seahorse, Spotted seahorse

Description

H. kuda (Fig. 4) inhabits coastal bays and lagoons rich in seagrass and floating weeds. It can tolerate lower salinities and is found in muddy bottom of mangrove regions. The maximum recorded adult height is 30 cm (TL) (Myers, 1991). The colouration is often totally black with a grainy texture, alternatively pale yellow or cream with fairly large dark spots. Sometimes it is sand-coloured blending with the surroundings. It is also characterized by a deep head, deep body and a thick snout. The coronet is of low to medium height, rounded and overhanging at the back, often with a cup-like depression on the top. The spines appear as low rounded bumps and are not sharp.

Genetic diversity

Genetic stock structure studies through sequence variation analysis of a 350 bp cytochrome b gene fragment revealed distinct genetic stocks of *H. kuda* in southeast (Mandapam, Tamil Nadu) and southwest coasts (Kollam, Kerala) of India (Goswami *et al.*, 2009). The study showed four haplotypes specific to Mandapam stock and four unique to Kollam and a highly significant pair-wise genetic divergence value (Φ_{ST}=0.6528; P<0.001) between two populations.

Further studies based on partial sequence information of mitochondrial genes – 16 S rRNA and Cytochrome C Oxidase Subunit I (COI) also confirmed significant levels of genetic differentiation of southeast coast and southwest coast populations, while no significant partitioning was observed between the Palk Bay and Gulf of Mannar populations (Singh *et al.*, 2011).

Twelve polymorphic microsatellite loci were used to detemine the population structure of *H. kuda* from Indian waters (Singh *et al.*, 2012). The results are consistent with the values obtained using mitochondrial DNA sequences (Singh *et al.*, 2011) and exhibited significant genetic differentiation in populations of *H. kuda* between east and west coasts of India. Within the southwest coast, Singh *et al.* (2012) found that *H. kuda* population from Kerala and Goa are not from the same gene pool and that physical barriers existed inhibiting breeding between populations. They detected private alleles exclusive to Kerala and Goa populations and occurrence of significant genetic heterogeneity between these two populations.

Fig. 4. *Hippocampus kuda*

Distribution

This species is found in Australia, Cambodia, China (Hong Kong SAR and Province of Taiwan), Fiji, France (New Caledonia and Tahiti), India, Indonesia, Japan, Malaysia, Pakistan, Papua New Guinea, Philippines, Federal States of Micronesia, Singapore, Solomon Islands, Thailand, Tonga, United States of America (Hawaii) and Vietnam (Lourie *et al.*, 2004). In India, this species was reported from Tamil Nadu (Marichamy *et al.*, 1993; Gokulakannan, 2002; Lipton and Thangaraj, 2002; Salin *et al.*, 2005; Murugan *et al.*, 2008; Murugan *et al.*, 2011; Lipton and Thangaraj, 2013; BOBLME, 2015), Puducherry (Rajasegar and Sendhilkumar, 2009), Kerala (Lipton and Thangaraj, 2013), Karnataka (Singh *et al.*, 2011), Goa (Singh *et al.*, 2011), Maharashtra (Murugan *et al.*, 2017), Odisha (Kumar and Pattnaik, 2012), West Bengal (Mahapatra *et al.*, 2016) Lakshadweep Islands (Jones and Kumaran, 1980; Prabhakaran *et al.*, 2013), and Andaman & Nicobar Islands (Dorairaj, 1994; Sriramachandra Murty, 1996; Rao *et al.*, 2000).

Uses

H. kuda is dried for use in traditional Chinese medicines and curios. It is also traded in live condition to meet the demand of aquarists and hobbyists.

3 *Hippocampus spinosissimus* Weber, 1913

Synonyms:
Hippocampus arnei Roule, 1916

Common name:
Hedgehog seahorse

Description

This species inhabits the sandy bottom near coral reefs. The maximum recorded adult height is 17.2 cm. It is pale with darker saddles across dorso-lateral surface and with darker cross bands on tail (Fig. 5). The coronet is of low to medium height with four or five sharp spines. The spines are generally well developed, either blunt or sharp; usually longer on first, fourth, seventh and eleventh trunk rings and with a regular series of longer spines on tail. The nose spine is small or absent and the cheek

Fig. 5. *Hippocampus spinosissimus*

spine is either single or double. The spine in front of coronet is undeveloped.

Distribution

Globally, this species is found distributed in Australia, Cambodia, China (Province of Taiwan), Indonesia, Malaysia, Myanmar, Philippines, Singapore, Sri Lanka, Thailand, Vietnam (Lourie *et al.*, 2004). In India, this species is found in the Palk Bay, Gulf of Mannar and Coromandel Coast of Tamil Nadu (Salin *et al.*, 2005; Murugan *et al.*, 2008; Murugan *et al.*, 2011; BOBLME, 2015).

Uses

H. spinosissimus is dried for traditional medicines and curios. It is also traded in live condition for aquarium and hobbyists use.

4 *Hippocampus kelloggi*

Jordan & Snyder, 1901

Common name:
Great seahorse

Description

This species is found in the soft bottom and is generally found associated with gorgonids and sea whips. It grows to very large size and the maximum recorded adult height is 28 cm. It is pale, often with tiny white spots running in vertical lines. It is characterized by a deep head and a narrow body with a thick snout (Fig. 6). The coronet is high, with five short spines and there is a

Fig. 6. *Hippocampus kelloggi*

high plate in front of coronet. It has thick body rings and a prominent rounded eye spine. The spines are low and rounded. They have long, slightly backward pointing, rounded cheek spine.

Distribution

Globally, this species is found distributed in China, India, Indonesia, Japan, Malaysia, Pakistan, Philippines, Thailand, United Republic of Tanzania and Vietnam (Lourie *et al.*, 2004). In India, this species was observed in the Gulf of Mannar, Coromandel Coast and Kanyakumari in Tamil Nadu (Lourie *et al.*, 1999; Murugan *et al.*, 2008; Thangaraj and Lipton, 2011; Lipton and Thangaraj, 2013; BOBLME, 2015), Malabar coast of Kerala (Lipton and Thangaraj, 2013) and Andhra Pradesh (Anonymous, 2016).

Uses

H. kelloggi is dried for traditional medicines and curios. This species fetches more price in the Chinese market because of its large size.

5 *Hippocampus histrix* Kaup, 1856

Synonyms:
Hippocamphus hystrix Kaup, 1856
Hippocampus hystrix Kaup, 1856

Common name:
Thorny seahorse

Description

H. histrix (Fig. 7) inhabits seagrass beds, weedy rocky reefs, and amidst sponges (Kuiter and Debelius, 1994). It is also found in soft bottom with soft corals and sponges (Kuiter, 2000), and is generally found in pairs. The maximum reported depth at which they were found is 20 m (Kuiter and

Fig. 7. *Hippocampus histrix*

Debelius, 1994). The base colour is variable, including pale pink and yellow or green (Lourie *et al.*, 2004). The spines are often with dark tips and are extremely long and sharp. They may have pale saddles, with small dark spots across dorso-lateral surfaces (Lourie *et al.*, 2004). This species is characterized by a long snout, single cheek spine, short dorsal fin base and a prominent spine in front of coronet (Lourie *et al.*, 2004). The maximum recorded adult height is 17 cm (Masuda *et al.*, 1984).

Distribution

Globally, *H. histrix* is found distributed in China, Federated States of Micronesia, France (New Caledonia, Reunion and Tahiti), India, Indonesia, Japan, Malaysia, Mauritius, Papua New Guinea, Philippines, Samoa, South Africa, Tonga, United Republic of Tanzania, United States of America (Hawaii) and Vietnam (Lourie *et al.*, 2004). In India, it is reported from the Gulf of Mannar, Tamil Nadu (Lipton and Thangaraj, 2013), Andaman Islands (Rajan *et al.*, 2011), and Kadamat and Kavaratti in Lakshadweep Islands (Jones and Kumaran, 1980).

Uses

H. histrix is dried for use in traditional Chinese medicines and for curios. It is seldom used live for marine aquarium trade (Lourie *et al.*, 2004).

6 *Hippocampus mohnikei* Bleeker, 1853

Synonyms: *Hippocampus monckei* Bleeker, 1853
Hippocampus monickei Bleeker, 1853
Hippocampus monikei Bleeker, 1853
Hippocampus japonicas Kaup, 1856

Common name: Japanese seahorse

Description

H. mohnikei generally inhabits seagrass beds. The maximum recorded adult height is 8 cm (Lourie *et al.*, 1999). It is characterized by low coronet and low spines. The tail length is in proportion to body. It has double rounded cheek spines and double rounded spines below the eye (Lourie *et al.*, 2004). The colouration is often dark brown.

Distribution

H. mohnikei was earlier reported only from Japan (Lourie *et al.*, 2004) and was reported for the first time from India (Palk Bay, southeast coast) in the year 2007 (Thangaraj and Lipton, 2007).

Uses

The international trade of this species is not known (Lourie *et al.*, 2004).

7 *Hippocampus camelopardalis* Bianconi, 1854

Synonyms: *Hippocampus cameleopardalis* Bianconi, 1854
Hippocampus cameleopardalus Bianconi, 1854
Hippocampus subcoronatus Gunther, 1866

Common name: Giraffe seahorse

Description

H. camelopardalis inhabits shallow reefs, seagrass and algal beds (Kuiter, 2000). The maximum recorded adult height is 10 cm (Lourie *et al.*, 1999). It is characterized by dark spot on top of the coronet and dark spots on the dorso-lateral surface of the first, fourth and seventh trunk rings which are not always visible (Lourie *et al.*, 2004).The single specimen obtained from the Gulf of Kachchh, India had no spots on the trunk ring as well as on the coronet, but had small black rounded spots all along the trunk region (Subburaman *et al.*, 2014). This species is also characterized by high coronet, inclined backwards with a rounded top.

Distribution

H. camelopardalis is found distributed in Mozambique, South Africa and the United Republic of Tanzania (Lourie *et al.*, 2004). In India, this species was first reported by Subburaman *et al.* (2014) from Mithapur reef in the Gulf of Kachchh, Gujarat.

Uses

This species is dried for use in traditional Chinese medicines and curios. It is also traded in live condition to meet the demand of aquarists and hobbyists.

2.5 Habitat of seahorses

The seahorses are exclusively marine, except for some which are found in estuaries. They are primarily found in the seagrass meadows and coral reefs (Fig. 8), while some species are also found in the mangroves. They are also known to be associated with soft bottom communities such as sponges, sea squirts and gorgonids. They are slow moving and generally hold on to the hold-fast using their prehensile tail (Fig. 9a, b, c) and feed on tiny organisms that come along. They have the ability to camouflage and can change their colour in minutes to match their surroundings. They can also grow extra skin filaments (Ginsburg, 1937) to imitate algal fronds attached to seagrass stems or the seaweed present in their habitats.

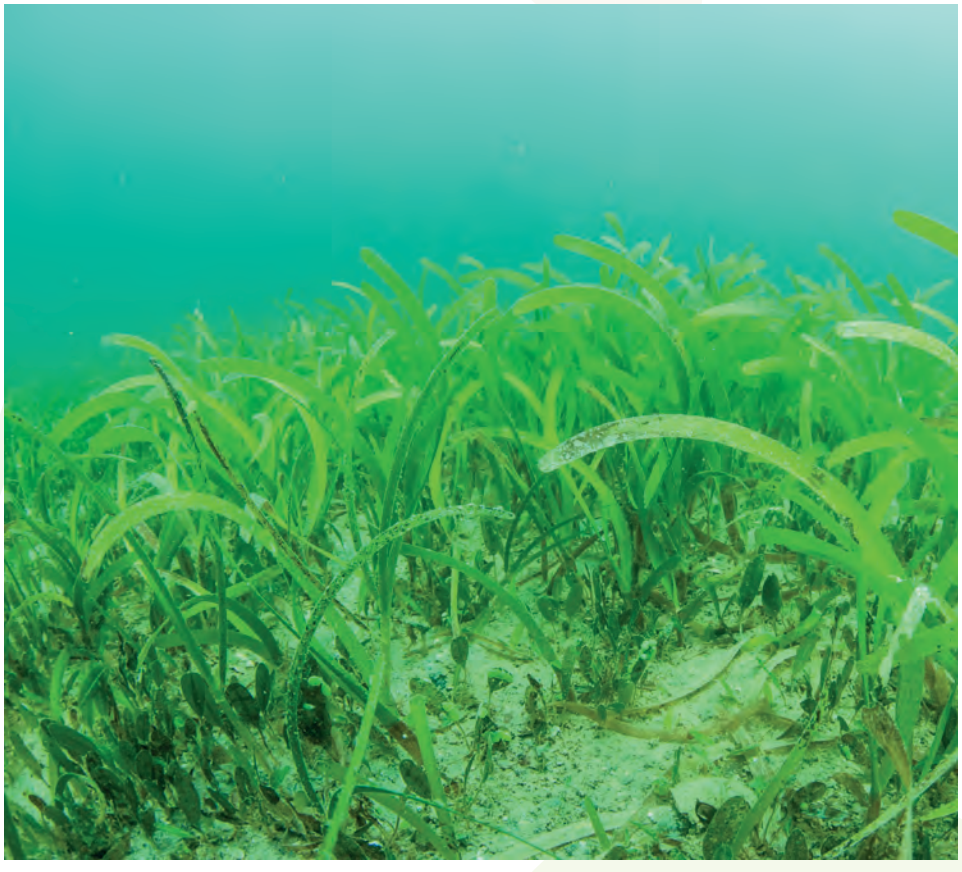


Fig. 8. A view of seagrass meadow in the Palk Bay

Fig. 9a. Seahorses holding on to the seagrass using their prehensile tail in the Palk Bay

Fig. 9b. A close view of the prehensile tail of seahorse

Fig. 9c. *H. kuda* holding on seapen

2.6 Biological characteristics

Studies on the biological characteristics of different species of seahorses are essential for their conservation and management. However globally, such studies are scanty and the available information have been synthesized by Foster and Vincent (2004). In India, although some information are available on *H. kuda* and *H. trimaculatus*, hardly any information has been generated for other species, as evident from Table 7.

Feeding

The seahorses are unique creatures with peculiar morphological features for feeding. They have no teeth and stomach (Rauther, 1925); the prey that are swallowed pass rapidly through the digestive system. Most seahorse species are active during day and generally feed on mobile prey organisms (James and Heck, 1994; Bergert and Wamwright, 1997). They wait until the prey comes close to their mouth and then through rapid intake of water, the prey is drawn up through the snout. They generally feed on small crustaceans and also on fish fry and invertebrates (Boisseau, 1967; Tipton and Bell, 1988; Vincent,

1996; Do *et al.*, 1998; Teixeira and Musick, 2001). Herald and Rakowicz (1951) reported that 2-week old seahorses are able to feed at least 3600 brine shrimp larvae in a 10-hour period. In Palk Bay, the gut of *H. kuda* was dominated by crustaceans like copepods, mysids, cumaceans, amphipods, isopods, decapod larvae and tiny caridean shrimps (Salin, 2003). The sub-adults and adult seahorses have few natural predators due to their unpalatable ring-like bony plates and spines (Lourie *et al.*, 1999).

Reproduction

The seahorses show very peculiar breeding behaviour in that the males become pregnant and give birth to young ones. They have highly structured social behaviour and form faithful pair bonds. All the species are ovoviviparous (Table 7).

Reproductive season

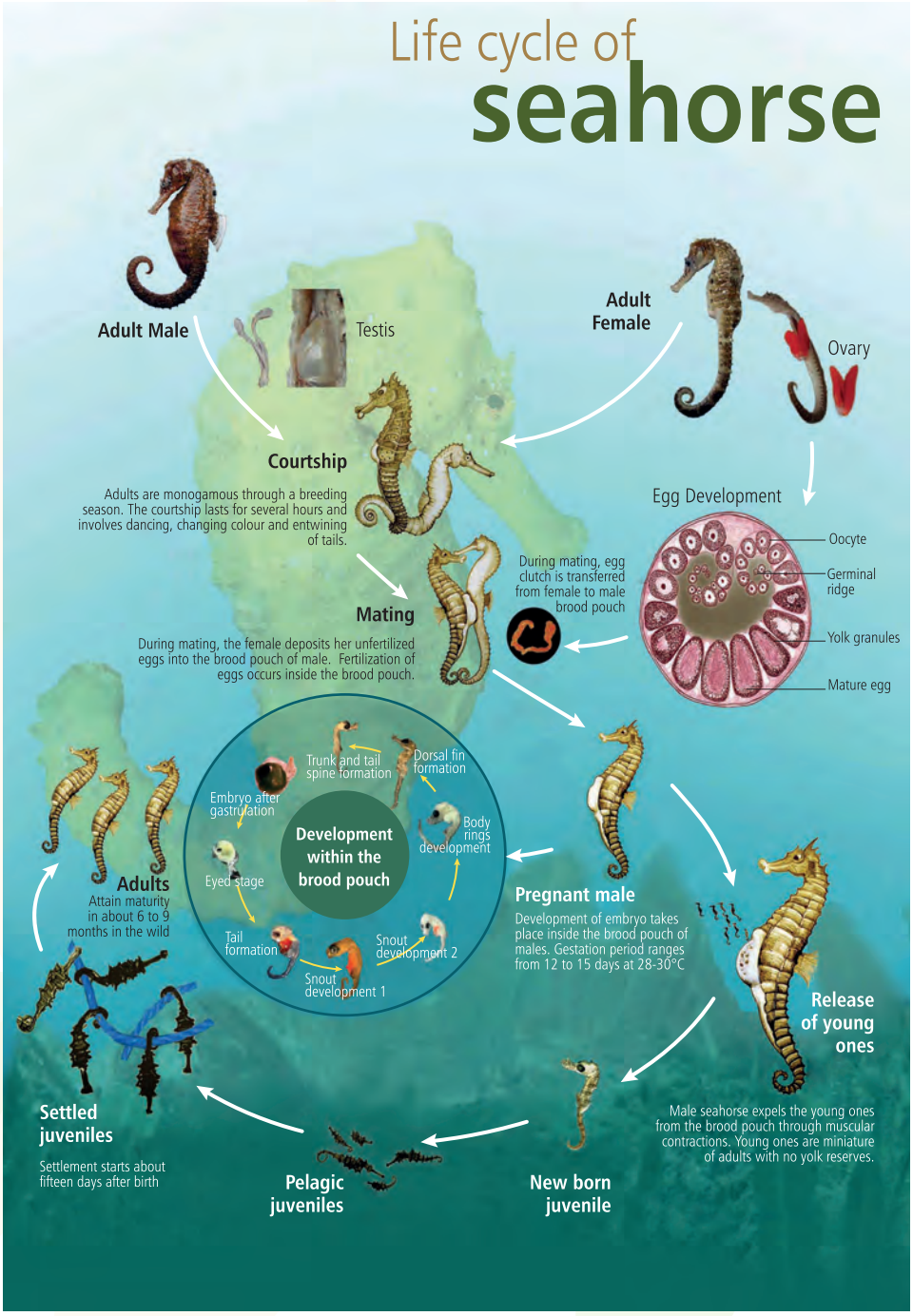
The reproductive season varies among the different seahorse species and is generally influenced by light, temperature, turbulence from monsoon rains and winds (Vincent, 1996). *H. fuscus* breeds during different times of the year along the Sri Lankan coast and the breeding season coincides with monsoon (Lourie *et al.*, 1999). However, *H. comes* breeds throughout the year in the Philippines, irrespective of the rains (Perante *et al.*, 2002). Although *H. kuda* was found to breed throughout the year in the Palk Bay, the major breeding season extended from June to September with a peak during July to August (Salin, 2003).

Monogamous breeding behaviour

The male and female seahorses form faithful bonds. Most seahorse species are monogamous (Vincent, 1994; Vincent and Sadler, 1995; Masonjones and Lewis, 2000); the adult male and female remain as partners and continue to mate successive times during the entire breeding season and sometimes even during successive breeding seasons. The pair bond is reinforced by exchange of daily greetings soon after dawn every day. During this time, the male and female seahorses change colour and dance together which lasts for about ten minutes. The pair then separates for the rest of the day. The greeting rituals facilitate reproductive synchrony of male and female, so that the female has ripe eggs ready as soon as the male gives birth. Both sexes refuse to respond to the displays of non-partners. If one of the pair is removed or dies, the remaining partner will take many weeks to find a replacement (Vincent and Sadler, 1995).

Table 7. Biological characteristics of seahorse species reported from Indian waters

Biological characteristics	*H. kuda*	*H. trimaculatus*	*H. spinosissimus*	*H. histrix*	*H. kelloggi*	*H. mohnikei*	*H. camelopardalis*	References
Max. length (cm)	30.0 [6]	22.0 [5]	17.2 [4]	17.0 [7]	28.0 [9]	8.0 [12]	10.0 [10]	[4] Nguyen & Do (1996); [5]Kuiter & Tonozuka, (2001); [6]Fishbase (2017); [7]Randall (1995); [9]Kuiter, (2000); [10]Dawson (1986); [12]Lourie *et al.* (1999)
Feeding habits	Mainly crustaceans[1], Zooplankton[2]	-	-	Zooplankton and small crustaceans[8]	-	-	-	[1]Salin (2003); [2] Lim *et al.* (2008); [8]Bacchet *et al.* (2006)
Type of reproduction	Ovoviviparous[3]	Ovovivi-parous[3]	Ovovivi-parous[3]	Ovovivi-parous[3]	Ovovivi-parous[3]	Ovovivi-parous[3]	Ovovivi-parous[3]	[3]Breder & Rosen (1966)
Size at first maturity (cm)	Males 6.6 [1]		10.4 [6]	-	-	-	-	[1]Salin (2003); [6]Fishbase (2017)
	Females 7.8 [1]							
Breeding season	June to September (Palk Bay)[1]	-	-	-	-	-	-	[1]Salin (2003)
Clutch size (nos.)	-	15-75 [19]	-	-	-	-	-	[19]Murugan *et al.* (2009)
Ova diameter	0.5-0.8 mm[1]	-	-	-	-	-	-	[1]Salin (2003)
Gestation period in males (day)	18-20 [1], 20-28 [3]	12-14 [13]	-	-	-	-	-	[1]Salin (2003); [3]Breder & Rosen (1966); [13]Murugan *et al.* (2013)
Brood size (nos.)	20-1000 [3]; 1465 [15]; 1405 [16]; 1025 [17]. 328-495 [1], 247-566 [14]; 56-192 [18]	318-635 [13]	-	-	-	-	-	[1]Salin (2003), [13]Murugan *et al.* (2013); [14]Murugan *et al.* (2017); [18]Anil *et al.* (1999); [3]Breder & Rosen (1966); [15]Ignatius *et al.* (2000); [16]Job *et al.* (2002); [17]Gokulakannan (2002)
Size of juvenile (mm)	7-8 [1]	6-7 [19]	-	-	-	-	-	[1]Salin (2003) [19]Murugan *et al.* (2009)


Life cycle of
seahorse
Adult Male
Testis
Adult Female
Ovary
Courtship
Adults are monogamous through a breeding season. The courtship lasts for several hours and involves dancing, changing colour and entwining of tails.
Egg Development
Oocyte
Germinal ridge
Yolk granules
Mature egg
During mating, egg clutch is transferred from female to male brood pouch
Mating
During mating, the female deposits her unfertilized eggs into the brood pouch of male. Fertilization of eggs occurs inside the brood pouch.
Development within the brood pouch
Trunk and tail spine formation
Dorsal fin formation
Embryo after gastrulation
Body rings development
Eyed stage
Tail formation
Snout development 2
Snout development 1
Pregnant male
Development of embryo takes place inside the brood pouch of males. Gestation period ranges from 12 to 15 days at 28-30°C
Release of young ones
Male seahorse expels the young ones from the brood pouch through muscular contractions. Young ones are miniature of adults with no yolk reserves.
New born juvenile
Pelagic juveniles
Settled juveniles
Settlement starts about fifteen days after birth
Adults
Attain maturity in about 6 to 9 months in the wild

Maturity, courtship and mating

The seahorse attains first maturity and starts breeding at an age of 6 months to one year (Jiaxin, 1990; Truong and Nga, 1995; Whitfield, 1995; Lourie *et al.*, 1999). Sexual maturity in male can be recognized by the appearance of brood pouch and the size of the brood pouch depends on the reproductive state. The fecundity is generally low (for example, 56.8 nos. per gram body weight in *H. kuda*; Salin, 2003). The eggs are large, pear-shaped, semi-transparent and orange; when sliced transversely, they appear as spirals, with developing oocytes moving to the outer edge of the ovary as they mature (Boisseau, 1967; Selman *et al.*, 1991). During the reproductive season, all stages of eggs are present in the ovary; the earlier stages in the centre of the ovary and the later stages towards the outside of the spiral (Boisseau, 1967).

The courtships in seahorse are colourful and lengthy. During the last few hours of courtship, the female rises to the surface and during the same period, the male begins to pump, forcing water in and out of the pouch (Vincent, 1994; Vincent and Sadler, 1995; Masonjones and Lewis, 1996). After an elaborate courtship, mating occurs and the female deposits her entire egg clutch into the male's brood pouch where it is fertilized. The development of embryo takes place inside the brood pouch. Each embryo embeds in the epithelial tissue lining the pouch wall, and the surrounding capillaries supply oxygen to the developing embryos (Boisseau, 1967). The gestation period ranges from 12 to 15 days at a temperature of 28 to 30°C.

Release of young

At the end of pregnancy, the male seahorse expels the young ones from the brood pouch through muscular contractions. The labour usually takes place during late night or early morning hours, pumping and thrusting for hours before releasing the young ones. The young ones resemble miniature adult seahorses with no yolk reserves and are 6 to 12 mm long, depending on species. They are independent from the time of birth and receive no parental care. Most of the seahorse species produce about 100 to 300 young ones per pregnancy, although smaller species (*H. zosterae*) produce only about five young ones per cycle (Masonjones and Lewis, 1996). The young ones generally drift in the water column for the first few days, while in some species they settle at the bottom within few hours of hatching (Graham, 1953; Lourie *et al.*, 1999).

2.7 Commercial uses of seahorse

As medicine

Since long, seahorses are believed to have many curative properties for various ailments. The Roman Natural Historian, Pliny the Elder (23-79 A.D.) cited seahorses as agents against leprosy, seahare venom, bites from mad dogs and baldness (Vincent, 1996). The seahorses are eaten as tonic foods, even without prescription; however about 30% of seahorses sold in China are used in patent medicines (Lourie *et al.*, 1999). The seahorses are the major constituents in the Traditional Chinese Medicines (TCM); their derived forms are '*Kanpo*' in Japan, '*Hanyak*' in Korea and '*Jamu*' in Indonesia (Murugan *et al.*, 2008). TCM is practised in China, Hong Kong, Taiwan, Singapore and ethnic Chinese communities worldwide. In the Central Philippines, seahorses are used to treat asthma, gas pains and hyperactivity (Alino *et al.*, 1990). In India, elderly people believed that dried seahorse powder with honey would help to relieve asthma (Vincent, 1996). Many fishermen in Kerala believe that seahorses could prevent epilepsy and other similar disorders, if kept attached to the body as a talisman.

In aquarium

The seahorses are one of the most popular fishes in marine aquarium trade. Their peculiar body features like horse-like head, prehensile tail, tubular snout and camouflaging behaviour make them a favourable choice of many marine aquarium hobbyists. Majority of seahorses that enter the aquarium trade are wild-caught, mainly from Indonesia and the Philippines and exported to North America, Europe and Japan.

As curios

The seahorses are used in curios like jewellery, paper weights, key chains etc. The seahorses, when dried, retain their shape and structure and hence the dried seahorses are popular as curios. They are generally kept for sale as souvenirs in beach side shops and resorts in many countries.

2.8 Seahorse resources in Palk Bay and Gulf of Mannar

The coasts of Tamil Nadu, particularly the Gulf of Mannar and Palk Bay, are known for rich diversity of seahorses, and this region was the main contributor to the export trade of seahorses from India until 2001. Until late 1980s, seahorses were landed as by-catch by trawlers. Target fishing (through skin diving) for export was initiated in 1992 in the Palk Bay, concomitant with the heavy demand for the dried seahorses and also due to the decline of sea cucumber fishing (Marichamy *et al.*, 1993). The major centres for seahorse collection by diving were Thiruppalaikudi, Mullimunai, Morpanai and Thondi along the Palk Bay coast of Tamil Nadu. Since then, the fishery continued and expanded rapidly during 1996-1997 (Lipton and Thangaraj, 2002) and until implementation of moratorium on seahorse fishery and trade in 2001.

In the Gulf of Mannar, 5 species of seahorses *viz.*, *H. trimaculatus*, *H. kuda*, *H. spinosissimus*, *H. kelloggi*, and *H. histrix* have been recorded, while in the adjacent

Sponge beds in the seagrass meadows of Palk Bay

Palk Bay, 4 species *viz.*, *H. trimaculatus*, *H. kuda*, *H. spinosissimus* and *H. mohnikei* are found to occur. Along the Coromandel Coast, 4 species of seahorses have been recorded (*H. trimaculatus*, *H. kuda*, *H. spinosissimus* and *H. kelloggi*).

The seahorse survey undertaken by Murugan *et al.* (2008) during 2000 and 2001 reported that *H. kelloggi* was abundant in the Coromandel Coast, *H. kuda* in the Palk Bay, and *H. trimaculatus* in the Gulf of Mannar. The Colachel and Chinnamuttom region of Kanyakumari district and Coromandel Coast appear to be the major centres for large-sized species of seahorse *H. kelloggi* which fetches around Rs.200 to Rs.350 (US$ 3.5 to 6.0) per individual.

The ICAR-CMFRI under the FAO-BOBLME project recorded five species of seahorses *viz.*, *H. trimaculatus*, *H. kuda*, *H. borboniensis* (now treated as synonym to *H. kuda* – Lourie *et al.*, 2016), *H. spinosissimus* and *H. fuscus* (now treated as synonym to *H. kuda* – Lourie *et al.*, 2016) from both Gulf of Mannar and Palk Bay in 2015 (Table 8). In addition to the five species, *H. kelloggi* was recorded, but rarely from the Gulf of Mannar and not from the Palk Bay. *H. kelloggi* was recorded for the first time from the Gulf of Mannar by Murugan *et al.* (2008). *H. histrix* (Lipton and Thangaraj, 2013) and *H. mohnikei* (Gokulakannan, 2002; Lipton and Thangaraj, 2013) reported by earlier workers from the Gulf of Mannar and Palk Bay respectively, were not observed during the 2015 survey. In the Gulf of Mannar region, the dominant species was *H. trimaculatus* while in the Palk Bay, the dominant species was *H. kuda* and the findings were in corroboration with that of Murugan *et al.* (2008). However, Lipton and Thangaraj (2013) stated that *H. kuda* was the dominant species in both Gulf of Mannar and Palk Bay.

Table 8. Seahorse species recorded from the Gulf of Mannar and Palk Bay during the 2015 survey

S. No.	Gulf of Mannar	Palk Bay
1.	*Hippocampus trimaculatus* Leach, 1814	*Hippocampus trimaculatus* Leach, 1814
2.	*Hippocampus kuda* Bleeker, 1852	*Hippocampus kuda* Bleeker, 1852
3.	*Hippocampus spinosissimus* Weber, 1913	*Hippocampus spinosissimus* Weber, 1913
4.	*Hippocampus borboniensis* Dumeril, 1870*	*Hippocampus borboniensis* Dumeril, 1870*
5.	*Hippocampus fuscus* Ruppell, 1838*	*Hippocampus fuscus* Ruppell, 1838*
6.	*Hippocampus kelloggi* Jordan and Snyder, 1901	

* Treated as synonym to *Hippocampus kuda* (Lourie *et al.*, 2016)

Chapter 3

Fishery and trade

3.1 Global scenario

The seahorse fishery is a low volume, high value fishery and contributes to the income of the local fisher communities (Pajaro *et al.*, 1997; Sadovy and Vincent, 2002). Although there exists an international trade that consumes millions of these syngnathids, it is rarely a subject of fisheries management (Vincent, 1996). The demand-driven over-exploitation resulted in the depletion of wild stock in many seahorse harvesting countries. In recognition of threats to their conservation status, all species of seahorses were included in Appendix II of CITES and the signatories to the Convention are now compelled to monitor the international trade and limit exports to levels that do not damage the wild populations.

The Asian countries are the main exporters as well as importers of seahorses. Thailand is the primary source for seahorses in dried trade, while Hong Kong SAR, Taiwan and mainland China are the major consumers (Evanson *et al.*, 2011). As per the data of CITES, vast majority of dry seahorse trade was dependent on one of the three Asian species (*H. trimaculatus*, *H. spinosissimus* and *H. kelloggi*) or one West African species (*H. algiricus*). The southeast Asian countries were the leaders in the trade of live seahorses, and the USA remained the primary destination for the live trade. *H. kuda* and *H. reidi* were the two species that make up more than three quarters of live trade volumes according to the CITES data.

With the inclusion of seahorses in Appendix II of CITES, some countries have imposed regulations for the protection of wild population of seahorses. However, the trade goes unregulated in many countries, especially in the dried seahorse trade. In most of the countries which are involved in the export of dried seahorses, the collection of seahorse comes mainly from the incidental catches in trawl nets and to a smaller extent through target fishing by artisanal fishers. In China, the import and export of seahorses have been monitored in the mainland since 1998 as all species of seahorses were on the HS Commodity List of Import and Export of Wild Fauna and Flora in China. In Brazil, the dried seahorse trade is unregulated and is mainly sustained by the incidental catch in trawl nets. The dried seahorse is primarily a domestic market while the live trade is for export which is regulated through national quotas (Rosa *et al.*, 2011). When seahorses were added to the Appendix II of CITES, the Philippines had a Fisheries Code that forbade fishing of any aquatic species listed by CITES. However, in 2016, the country adjusted its legislation to facilitate sustainable exports of seahorses listed under Appendix II.

In Vietnam, about 6.5t of dried seahorses were taken annually as by-catch by trawlers (Giles *et al.*, 2005). The domestic consumption is small and most seahorses were exported through unofficial and unregulated channels to China. The by-catch rates were low, but the commercial export was supported through enhanced fishing efforts. Foster and Vincent (2004) also observed low by-catch rates in trawl and low density of wild seahorse population in Vietnam, indicating a serious threat to the fishery.

The data on exports and imports recorded by the nations signatory to the CITES need to be accurate and these are extremely crucial to implement strict regulations. While evaluating the CITES Trade Database, Evanson *et al.* (2011) indicated that the Parties need to improve their entries by identifying the exported species of seahorses, providing proper units like kilogram, number etc. and recording all trade shipments.

3.2 History of seahorse collection in India

The Gulf of Mannar was known for pearl oyster and sacred chank fishing for several centuries. For exploiting these resources, a well-managed fishing was organized through the Tamil Nadu State Fisheries Department until the 1970s. Due to huge demand for pearl oysters and sacred chanks, fishermen developed the skill for breath-hold fishing up to a depth of 60 m. The fishermen (skin divers) involved in these fisheries were distributed from Kanyakumari to Thondi region. As the above resources were depleted, the fishermen targeted sea cucumber for their livelihood which are also found in large numbers in these ecosystems and could be collected through skin diving. In most of the areas, seahorses and sea cucumbers are found together and are easy to collect. Hence, the fishermen started collecting both the resources, but the sea cucumber was the primary target.

Subsequently, the seahorse fishery became well established in the Gulf of Mannar and Palk Bay in the 1980s (Marichamy *et al.*, 1993). Also, as the demand from China increased for seahorses in the 1980s, incidental catches from various gears like trawl nets as well as target fishing provided the much needed numbers for the TCM trade. The seahorses were dried and exported by entrepreneurs through the Marine Products Export Development Authority (MPEDA). While seahorses were traded from 1977 onwards, the collection centres and trade expanded from 1985. Enquiries made with fishermen who were involved in the collection of seahorse revealed that the density of seahorse was around 15 per square meter during 1980s, which suggest that seahorses were abundant in the Gulf of Mannar and Palk Bay. Vincent (1996) also reported a density of 15 per square meter in the seagrass meadows of Palk Bay.

3.3 Seahorse fishing in India prior to the ban

Before implementation of ban, target fishing (skin diving) for seahorse, sea cucumber and sacred chank at Palk Bay was carried out by groups of six to eight divers from each boat, locally called *vallam*. Fishing season was determined by the prevailing weather conditions. Normally, the fishery was from May to October with a peak in August in Palk Bay. In the Gulf of Mannar, fishing was from November to March, with peak in December. About 700 boats were in operation in the entire stretch of approximately 250 km along Palk Bay and Gulf of Mannar. Fishing was managed by small co-operatives established by the fishermen community, whereas the expense for the fishing boat was shared between the skin diving crew. The landing of seahorses was more along the Palk Bay compared to the Gulf of Mannar, mainly due to the vast extent of seagrass beds in the Palk Bay, which is one of the most preferred habitat of most of the seahorse species.

The incidental catches of seahorse in small country trawls as well as shrimp trawls added substantially to the landings. The country trawls are wind-driven and are generally operated in shallow coastal waters at depths ranging from 2 to 6 m, while the shrimp trawl nets are operated at depths from 3 to 12 m along the Gulf of Mannar and Palk Bay (Murugan *et al.*, 2008; 2011). All species of seahorses found in the Gulf of Mannar and Palk Bay generally occur at depths less than 10 m.

3.4 Seahorse trade from India prior to the ban

India and the Philippines were the top source countries involved in collection and export of dried seahorses in the 1990s (Foster *et al.*, 2016). The seahorses collected from the Gulf of Mannar and Palk Bay were dried and exported to Singapore, Hong Kong and Malaysia (Marichamy *et al.*, 1993). Vincent (1996) reported that Palk Bay contributed 3.04 t (84.4%) to the annual seahorse trade of 3.6 t from India during 1995. According to official estimates, about 2.53 t of seahorses worth 1.5 million rupees (US $ 40,000) was exported from India during 2000-2001 and 4.34 t worth 2.67 million rupees (US$ 70,000) during 2001-2002 (Anonymous, 2003). The export from India was mainly to Singapore, Hong Kong and the United Arab Emirates.

However, Salin *et al.* (2005) estimated the landing of seahorses from the Gulf of Mannar and Palk Bay as 18.2 t and the total quantity of exported dried seahorses as 9.8 t during 2001. This estimate is 2.2 times higher than the official statistics. An estimated 9.4 t was landed in Thondi (Palk Bay) alone in 2001, a major fishing centre for seahorse (Salin *et al.*, 2005). This shows that much of the exports from the country took place through illegal and unreported channels even before the moratorium. There were also reports of courier deals in which traders received free trips to Singapore and Malaysia in exchange for filling their checked air luggage with 20 to 30 kg of dried seahorses (Vincent, 1996).

The estimate of Vincent (1996) was somewhat close to the official export estimates from India. Her estimates indicated harvest of 3040 kg (approximately 1.2 million individuals) of seahorses annually from the Palk Bay and about 350 kg (about 350,000 nos.) annually from the Kerala coast, thereby indicating at least 3600 kg (approximately 1.5 million individuals) of seahorses in trade annually from the southern coast of India.

The TCM traders believe that the trade ban in India was a consequence of CITES limiting its exports to countries like Hong Kong, Taiwan and China (Lam *et al.*, 2016). The collection and trade of seahorses from Tamil Nadu continues in a clandestine manner even after the implementation of ban, which is evident from periodic reports in newspapers on seizures of dried seahorses by the officials of the Forest Department, Indian Coast Guard, Coastal Marine Police and the Wildlife Crime Control Bureau (Table 9). Since the trade is not documented by any agency, the volume of export after 2002 is not known. It is understood that the target collection of seahorse through breath-hold fishing has considerably reduced and illegal trade is mainly based on incidental catches in various fishing gears.

Table 9. Seahorse seized during 2007 to 2017 from Tamil Nadu

Sl. No.	Date of offence	Place	Wildlife Range	Wildlife Division	Quantity of seahorse seized
1.	16th July, 2007	Ramanathapuram, Tamil Nadu	Ramanathapuram	Ramanathapuram	7 nos.
2.	18th July, 2007	Tuticorin, Tamil Nadu	Tuticorin	Ramanathapuram	44 kg
3.	13th June, 2011	Rameswaram, Tamil Nadu	Mandapam	Ramanathapuram	3 kg
4.	14th December, 2011	Mandapam, Tamil Nadu	Mandapam	Ramanathapuram	22 kg
5.	22nd January, 2012	Alagankulam, Tamil Nadu	Ramanathapuram	Ramanathapuram	120 nos.
6.	5th November, 2012	Rameswaram, Tamil Nadu	Mandapam	Ramanathapuram	12 kg
7.	7th October, 2014	Thondi, Tamil Nadu	Ramanathapuram	Ramanathapuram	1020 nos.
8.	15th March, 2016	Nagapattinam, Tamil Nadu	Sirkali	Nagapattinam	20 kg
9.	3rd July, 2016	Uppoor, Ramanathapuram District, Tamil Nadu	Ramanathapuram	Ramanathapuram	9 kg
10.	17th August, 2016	Chennai Airport	Chennai	Chennai	6.3 kg
11.	1st November, 2017	Kodupangu, Thondi, Tamil Nadu	Ramanathapuram	Ramanathapuram	5 kg

Source: Data of the Wildlife Crime Control Bureau (WCCB)

3.5 Incidental catch of seahorse in different fishing gears: A recent study by ICAR-CMFRI

In order to estimate the quantity of seahorses in incidental catches in trawl, country trawl and shore seines, field surveys were conducted in selected landing centres under the BOBLME-CMFRI project (BOBLME, 2015). The results of the study is briefly given here.

From January to May 2015, surveys were conducted in fish landing centres along the Gulf of Mannar and Palk Bay where regular landings of seahorses occurred. The observation at different landing centres ranged from 8 to 12 days and the number of fishing boats observed at different centres ranged from 64 to 252. For observations on trawl landings, seven landing centres were selected along the Palk Bay (Rameswaram, Mandapam North, Soliyakudi, Jegathapattinam, Kottaipattinam, Sethubhavachathiram, Mallipattinam) and four centres along the Gulf of Mannar (Pamban, Mandapam South, Keelakarai, Ervadi) (Fig. 10). The observations of incidental catches of country trawl were made at Devipattinam, Karankadu, Mullimunai, Thondi, Mimmisal, Kattumavadi, Karanguda and Adhiramapattinam along the Palk Bay and at Akkalmadam, Chinnapalam,

Fig. 10. Landing centres along the Gulf of Mannar and Palk Bay observed for incidental catch of seahorse in trawl landings

Vethalai, Periyapattinam and Thalamuthunagar along the Gulf of Mannar (Fig. 11). The landings of shore seines were observed at Mukuntharayar Chathiram North, Cherankottai, Ariyaman, Irumeni, and Othathalai along the Palk Bay and at Mukuntharayar Chathiram South, Paradi, Kundhukal, Vethalai, Puthumadam, Ervadi, Sadaimuniyan Valasai, Mariyur and Valinokkam along the Gulf of Mannar (Fig. 12).

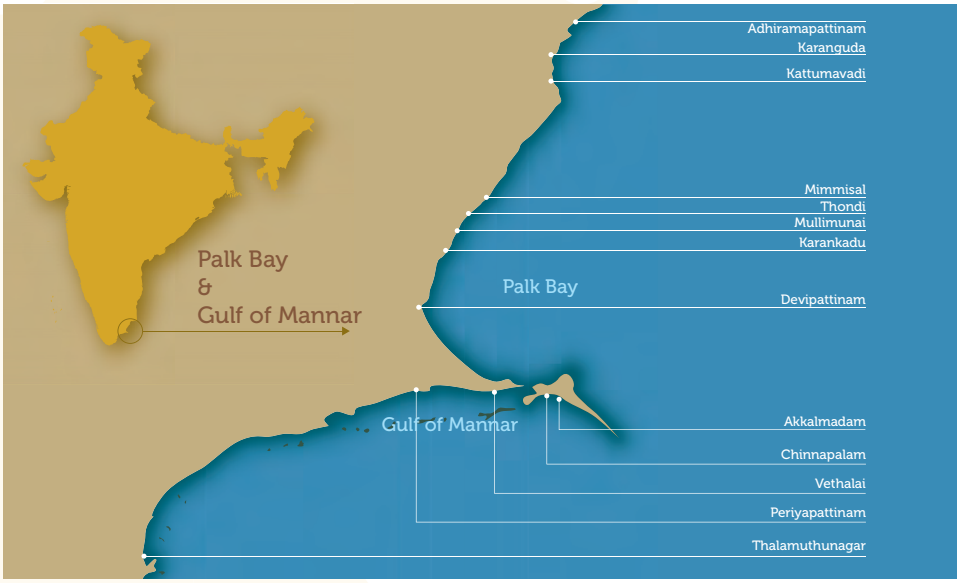


Fig. 11. Landing centres along the Gulf of Mannar and Palk Bay observed for incidental seahorse catch in country trawl

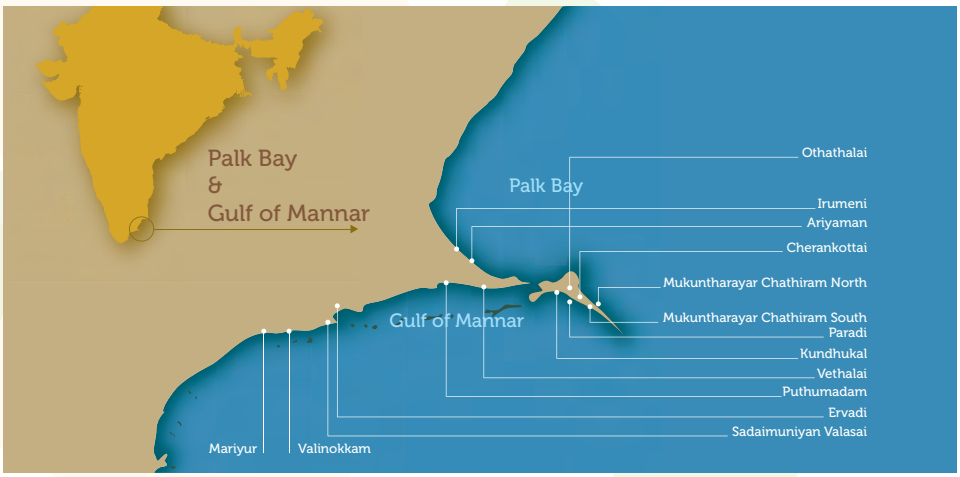


Fig. 12. Landing centres along the Gulf of Mannar and Palk Bay observed for seahorse catch in shore seines

In the Gulf of Mannar region, the dominant species was *H. trimaculatus* followed by *H. kuda*, while in the Palk Bay, the dominant species was *H. kuda* followed by *H. trimaculatus*. The standard length of *H. kuda* and *H. trimaculatus* caught in trawl from both the Gulf of Mannar and Palk Bay are given in Table 10.

Table 10. Size range of *Hippocampus kuda* and *Hippocampus trimaculatus* caught in trawl net from the Gulf of Mannar and Palk Bay

Region	Species	Sex	Standard Length (mm)
Gulf of Mannar	*Hippocampus kuda*	Male	98 to 162
		Female	96 to 166
	Hippocampus trimaculatus	Male	100 to 160
		Female	104 to 161
Palk Bay	*Hippocampus kuda*	Male	92 to 160
		Female	90 to 161
	Hippocampus trimaculatus	Male	95 to 154
		Female	92 to 153

Sex ratio in the incidental catches

The sex ratio of *H. kuda* and *H. trimaculatus* in the incidental catches at major trawl landing centres is shown in Table 11. In the case of *H. kuda*, the female specimens showed a higher percentage in all the landing centres. At Mandapam North, Mandapam South and Keelakarai, the males were around 42% while the females were around 57%. At Ervadi, the females were considerably higher (66.7%) when compared to males of *H. kuda* (33.3%).

Table 11. Sex ratio (%) of male and female *Hippocampus kuda* and *Hippocampus trimaculatus* in the incidental catch of trawl

Landing centres	*H. kuda*		*H. trimaculatus*	
	Male	Female	Male	Female
Mandapam North	42.7	57.3	46.4	53.6
Mandapam South	42.8	57.2	43.9	56.0
Keelakarai	42.1	57.9	45.7	54.3
Ervadi	33.3	66.7	42.7	57.3
Overall sex ratio	40.2	59.8	44.7	55.3

The sex ratio of *H. trimaculatus* was similar to that of *H. kuda*. The observation along the major landing centres revealed that male specimens of *H. trimaculatus* were less in number when compared to their female counterparts. Harvesting of large number of males, particularly the pregnant ones will have a serious impact on the recruitment. However, as the ratio of males in the population is not known, we do not have information on the proportion of males removed in relation to their number in the population.

Incidental catch of seahorse in trawl

The trawl nets operated in the Gulf of Mannar and Palk Bay are 100 m long and 25 m wide and are operated using a winch (Fig. 13). The mesh size at the mouth of the net is 80 mm which gradually decreases to 60, 50, 40, 35, 30, 25 and 20 mm towards the cod end of the net. The trawlers (shrimp trawls) spend 8.2 ±0.48 h of trawling per night and operate up to 44 km from the shore at depths ranging from 3 m to 40 m off Mandapam (South) and Pamban (South) with 4 to 6 tows per fishing trip (Murugan *et al.*, 2011). In Rameswaram, the trawlers operate up to 35 km offshore, at depths ranging from 5 to 35 m and spend 16.8 ± 1.25 h of trawling during day and night with 16 to 20 sweeps per fishing trip (Murugan *et al.*, 2011). In the Gulf of Mannar, the trawlers operate thrice a week with fishing days commencing on Mondays, Wednesdays and Saturdays.

Fig. 13. A trawler operated from Rameswaram fish landing centre

The number of seahorses caught in trawl was more from the Palk Bay than from the Gulf of Mannar (Table 12). This could be because the extent of seagrass bed is more in the Palk Bay than in the Gulf of Mannar. The number of seahorses per boat ranged from 3.4 (Ervadi) to 5.0 (Mandapam South) in the Gulf of Mannar. In the Gulf of Mannar, the highest number of boats is operated from Mandapam South landing centre and

Segregating the catch

Fig. 14. *Hippocampus trimaculatus* caught in trawl at Mandapam

an estimated 8,964 number of seahorses were caught from this centre during the survey period of 5 months, followed by Pamban with an estimated 1,709 numbers.

In the Palk Bay region, the maximum number of trawlers (6180) was operated from Rameswaram landing centre, followed by Mandapam North & Koilvadi (3066) and Jegathapattinam (1032). The number of seahorses per boat was the highest at Jegathapattinam (8.9 numbers), followed by Kottaipattinam (7.3), Mandapam North & Koilvadi (6.2) and Rameswaram (5.0). The estimated catch of seahorse during the survey period was highest in Rameswaram (30,900 numbers) followed by Mandapam North & Koilvadi (19,070). The images of incidental catch of seahorses landed by trawl at different landing centres are depicted in Figures 14 to 16.

Fig. 15. *Hippocampus kuda* caught in trawl at Mallipattinam

Fig. 16. Incidental catch of seahorse in trawl at Keelakarai

Table 12. Incidental catch of seahorse in trawl

Landing centres	Total boats operated in five months	No. of boats observed	Observed fishing days	No. of seahorses recorded	Estimated no. during survey period	Average no. of seahorses per boat
Gulf of Mannar						
Pamban	344	180	8	894	1,709	4.97
Mandapam South	1822	204	8	1003	8,964	4.92
Keelakarai	160	64	8	243	609	3.81
Ervadi	279	102	9	348	954	3.42
Palk Bay						
Rameswaram	6180	276	12	1380	30,900	5.00
Mandapam North+ Koilvadi	3066	158	12	982	19,070	6.22
Soliyakudi	344	96	8	264	949	2.76
Jegathapattinam	1032	204	12	1,815	9,184	8.90
Kottaipattinam	912	252	12	1,840	6,685	7.33
Sethubavachatiram	480	240	8	504	1,008	2.10
Mallipattinam	584	200	8	568	1,658	2.84

The country trawl, locally called *thallumadi* (Fig. 17 to 20), is operated in shallow depths ranging from 4 to 7 m, exclusively in the seagrass beds. Trawling is conducted

Fig. 17. A view of country trawls berthed at Thiruppalaikudi (Palk Bay)

Fig. 18. Country trawl operated in Thiruppalaikudi

Fig. 19. A view of the country trawl net

for about 6 hours with the help of wind and 5 to 7 tows are performed per fishing trip, with each tow lasting for 1 hour. The trawl net has a length of 10 m and width of 5 m. The mesh size at the mouth of the net is 30 mm which gradually decreases to 25 and 20 mm towards the cod end. It targets shrimps and other food fishes, but removes a large number of non-edible biota including sea urchins, gastropods, non-edible crabs, sponges, starfishes etc. The seahorses, which are one of the residents of seagrass beds, are also caught in the country trawl.

In the Gulf of Mannar, the number of seahorses caught per boat ranged from 2.0 (Periyapattinam) to 4.4 (Akkalmadam) (Table 13). The number of country trawls operated during the study period was more at Thalamuthunagar (264 nos.) with an average of 3.0 numbers of seahorses caught per boat and an estimated catch of 792 during the study period. The estimated number of seahorses caught was 432 and 422 from Chinnapalam and Akkalmadam, respectively.

Fig. 20. Hauling of the country trawl net

Table 13. Incidental catch of seahorse in country trawl

Landing centres	Total boats operated in five months	No. of boats observed	Observed fishing days	No. of seahorses recorded	Estimated no. during survey period	Average no. of seahorses per boat
Gulf of Mannar						
Chinnapalam	144	36	12	108	432	3.0
Akkalmadam	96	24	12	105	422	4.4
Vethalai	48	24	12	72	144	3.0
Periyapattinam	32	16	8	32	64	2.0
Thalamuthunagar	264	120	8	360	792	3.0
Palk Bay						
Devipattinam	2,076	420	12	5,170	25,555	12.31
Karankadu	504	336	12	2,143	3,215	6.38
Mullimunai	456	432	12	4,713	4,974	10.91
Thondi	3,120	312	12	2,586	25,864	8.29
Mimmisal	312	120	12	745	1,937	6.21
Kattumavadi	504	180	12	1,679	4,702	9.33
Karanguda	420	216	12	1,242	2,415	5.75
Adhiramapattinam	396	192	12	812	1,675	4.23

The number of seahorses caught in the country trawl (Fig. 21 to 23) from the Palk Bay was higher than in the Gulf of Mannar. In the Palk Bay, the number of seahorses caught ranged from 4.23 (Adhiramapattinam) to 12.31 (Devipattinam) per boat (Table 13). Like the pre-ban period, Thondi continues to be a prominent site for the landing

Fig. 21. Seahorses caught by country trawl at Chinnapalam

Fig. 22. Seahorses caught as incidental catches in country trawl at Devipattinam

Fig. 23. Seahorses caught as incidental catches at Mimmisal

of seahorses now also. The number of country trawls operated from Thondi was 3,120 with an estimated total catch of 25,864 numbers of seahorses during the study period. The total estimated catch of seahorse was 25,555 from 2,076 boats in Devipattinam landing centre.

Composition of brooding and non-brooding males in the incidental catches

The brooding males constituted a sizeable percentage of the catch. In the case of *H. kuda*, the brooding males ranged from 17.0 to 37.5% while in the case of *H. trimaculatus*, it ranged from 11.5 to 34.3% (Table 14). The number of developing embryos in a pregnant male ranged from 45 to 700 in the case of *H. trimaculatus* and 91 to 982 in the case of *H. kuda*. Removal of brooding males in large numbers will affect recruitment to the population. If the pregnant males are caught, the female partner would find it difficult for successive mating.

Fig. 24. Shore seine operation at Mandapam

The occurrence of seahorse in shore seines (Fig. 24) was negligible and only 1 number per net per day was caught.

Table 14. Composition (%) of brooding and non-brooding males of *H. kuda* and *H. trimaculatus* to the respective male catch in the incidental catch

Centres	*Hippocampus kuda*		*Hippocampus trimaculatus*	
	Brooding	Non-brooding	Brooding	Non-brooding
Mandapam North	24.6	75.4	11.5	88.5
Mandapam South	16.9	83.1	33.0	67.0
Keelakarai	37.5	62.5	25.0	75.0
Ervadi	25.0	75.0	34.3	65.7

Our study has shown that large quantities of seahorses are landed by both trawl and country trawl along the Gulf of Mannar and Palk Bay which are known for rich coral reefs and seagrass meadows. These ecosystems are the preferred habitats of the seahorses. Some of the trawls which operate very close to the shore sweep over the seagrass beds resulting in the removal of seahorses. The country trawl operates exclusively in the seagrass beds resulting in degradation and removal of seagrasses while catching the targeted shrimps and other resources.

The seahorses which are caught in various gears, even if alive, are not released back into the sea as they fetch income to the fishers. In the case of trawl, the persons who engage in sorting of fishes on the deck and fisherwomen who are engaged in drying of by-catch remove the seahorses and in the case of country trawl, the fishers themselves remove the seahorses. These seahorses are then collected by middlemen who in turn sell the seahorse to small traders. Although the number of seahorses collected from incidental catch in each boat is less, collectively it becomes a large number for trade (Fig 25).

Fig. 25. Seahorses collected by traders

Seagrass removed by trawl in Palk Bay

4
Chapter

Socio-economic condition and perception of fishers

4.1 Socio-economic survey

In the absence of proper assessment, it is not clear whether the enforcement of ban on the capture and trade of seahorses has helped revival of the seahorse population. However, the ban would possibly have social and economic impacts on those who were dependent on the seahorse fishery. Such information is not available from the Gulf of Mannar and Palk Bay where fishing and trade of seahorses existed. In this backdrop, the ICAR-CMFRI conducted a study under the FAO-BOBLME project during 2014-15, to understand the implications of the moratorium on the livelihood of the fishers. The study was also intended to get fishers' perception on the conservation and sustainable use of seahorse resources.

The interview survey with an ex post-facto research design was undertaken in Gulf of Mannar and Palk Bay. In the Gulf of Mannar, Ramanathapuram and Tuticorin districts; and in the Palk Bay, Ramanathapuram, Pudukottai and Thanjavur districts were selected for the survey. Based on available documents on seahorse occurrence, and discussions with fishermen and officials of fisheries and forest departments, 21 villages in Gulf of Mannar and 20 villages in Palk Bay (Fig. 27) were selected for the survey. A total of 450 fishermen who were engaged in seahorse fishery (like skin diving, trawl fishery and other modes of small-scale fishing), 40 middlemen and 10 traders were selected and interviewed using proportionate random sampling technique from the selected villages (Table 15, Fig. 26). Garrett's Ranking Technique was used to identify and rank the attributes on how the seahorse ban has affected their livelihood. The percent position of each rank was converted into scores referring to the table given by Garret and Woodworth (1969).

Fig. 26. Interaction with local communities

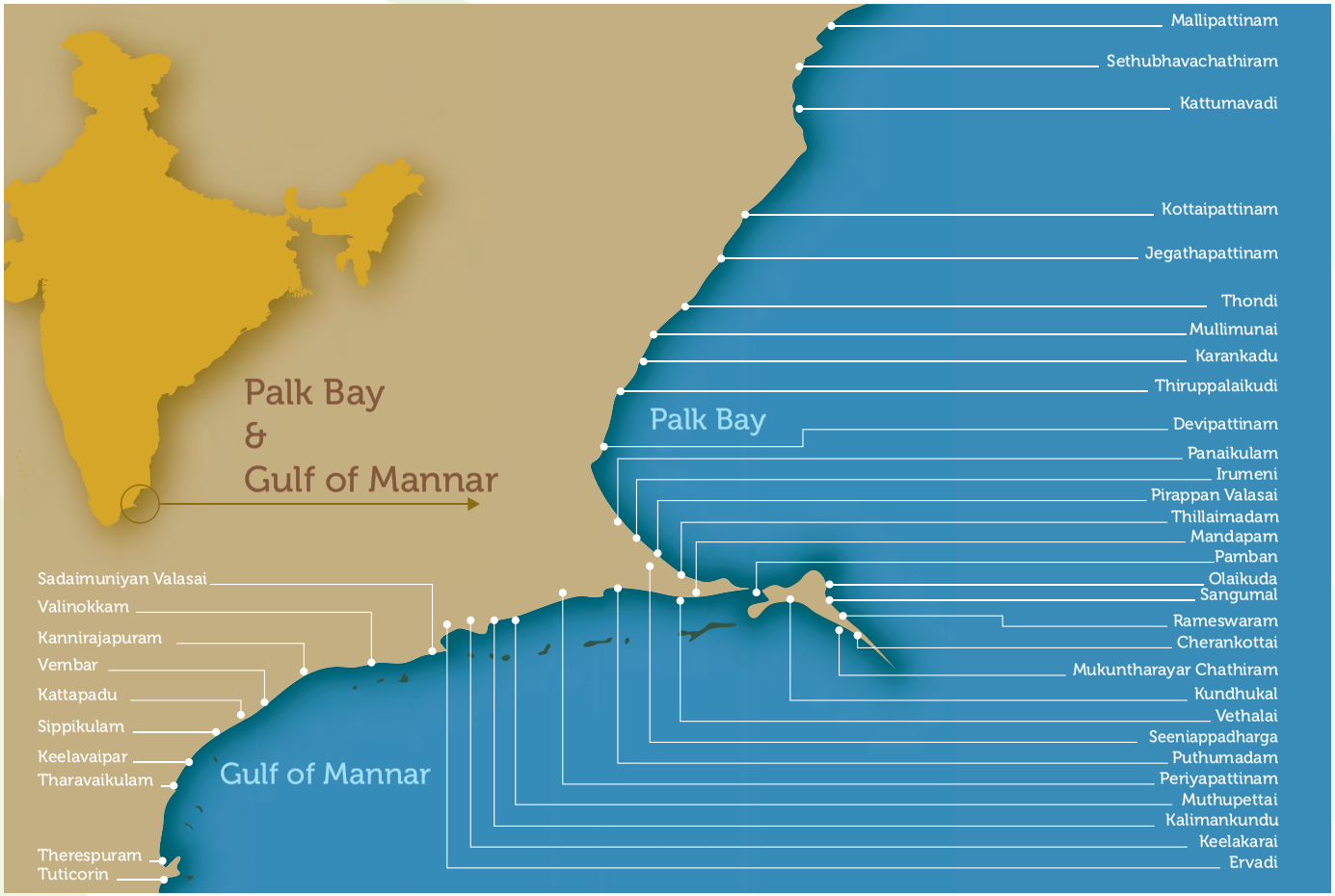


Fig. 27. Map showing the surveyed villages in the Gulf of Mannar and Palk Bay

Table 15. Proforma of the interview schedule used for survey in the Gulf of Mannar and Palk Bay

1 Name:

2 Age:

3 Address :

4 Level of education :

5 Experience in fishing (In years):

6 Perception on seahorse biology and ecology

Statement	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Seahorse breed throughout the year					
Seahorses are used for medicinal purposes					
Seahorse are highly vulnerable to intense fishing					
Seagrasses, seaweeds and coral reefs are suitable habitat for seahorses					
Seahorses are widely used in marine aquaria					
Others (specify if any)					

Before seahorse ban

7. Experience in seahorse fishing (In years):
8. Were you exclusively fishing / dependent on sea horse fishery for income? Yes/No
9. Mode of fishing of seahorse: Skin diving/ By-catch in Trawling/ By-catch in Shore seine/ By-catch in Thallumadi/ Others (specify if any)
10. Economics of seahorse fishing

Mode of fishing for seahorse	Expenditure incurred	Income
Skin diving		
Other (specify if any)		

11. Depth of collection of seahorses:
12. How many species of seahorse do you used to get?
13. Which species of seahorse was preferred for fishing?
14. In which habitat and location do you used to get seahorse:
15. Season of maximum abundance:
16. Whether it is abundant at fishing grounds and reserves: Yes/No
17. To whom do you used to sell the seahorse?

18. In what form do you used to sell the seahorse: Fresh/Dry
19. What price do you get per piece?

S. No.	Seahorse variety	Fresh	Dry
1.			
2.			
3.			

20. What price do middlemen get per piece

S. No.	Seahorse variety	Fresh	Dry
1.			
2.			
3.			

21. Whether there was any community initiative for sustainable seahorse fishing
22. Opinion about blanket ban on seahorse:

After the seahorse ban

23. Status of seahorse population (Increase/Decrease/Do not know)

	Before ban	After ban
Change in seahorse population		

24. If the seahorse population is reduced, what are the major reasons for reduction:
25. After seahorse ban, what type of activity in which you are involved:
26. What is your monthly income in that activity?
27. Whether seahorse fishing is continued after ban? (Yes/No/Do not know)
28. If yes,

Type of gear	Quantity	Rs. per piece

29. During regular fishing, whether do you get seahorse incidentally: Yes / No
    If yes how much quantity:
    What you do with that catch:

Give to the forest officials	Release back in the sea	Destroy it	Sell it

30. Whether seahorse ban has affected your livelihood: Yes / No
    If yes, what way it has affected your livelihood:

31. If a decision to lift the blanket ban is made in future, what effective management measures do you suggest for sustaining the stocks?

Management measures	Whether it can be implemented (Yes/No)	If yes, give your suggestion
Improved techniques of aquaculture		
Awareness programme on conservation		
Gear limitation		
No-take zone		
Stock enhancement through sea ranching		
Licensing		
Reporting the catches		
Others (specify if any)		

32. Scope for participatory management and how it can be done:

4.2 Perception on seahorse biology, ecology and population

Fishermen knowledge about seahorse biology is less in comparison to their knowledge about its ecology, since 11 to 36% of respondents did not know about seahorse biology (Table 16). About three-fourth of the respondents reported that the seagrasses, dead corals, and seaweeds are important habitats of seahorses, which is similar to the report by Murugan *et al.* in their survey in 2008. Tipton and Bell (1988) also stated that the seagrass meadows provide rich epi-faunal assemblage, on which the seahorses prey. The respondents had a better perception and knowledge on availability and status of seahorse population.

Table 16. Respondents' perception (%) on seahorse biology and ecology in Palk Bay and Gulf of Mannar (N=500)

Particulars	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Spawn throughout the year	42	45	11	1	1
Used for medicinal purposes	66	29	3	1	1
Highly vulnerable to intense fishing	11	25	36	16	12
Seagrasses, sea weeds, coral reefs are suitable habitats	70	27	3	0	0
Widely used in marine aquaria	74	19	6	1	0

The fishermen involved in seahorse fishing opined that the availability of seahorses is more during August to October in Gulf of Mannar and February to April in Palk Bay. The depth of collection of seahorses ranged from 3 to 15 m in the Gulf of Mannar and 3 to 8 m in the Palk Bay. Among the seahorse species, *H. trimaculatus* and *H. kuda* are mostly preferred by the fishermen for fishing. About 64% of the fishermen did not acknowledge that seahorses are vulnerable to intense fishing.

About two-third of the respondents stated that the seahorse population has decreased in the last 16 years during the prevalence of ban. The major cause is due to continuous removal of seahorses as incidental catch in trawl and country trawl operations. The degradation of essential, but restricted habitats like the seagrass beds due to anthropogenic causes is also a serious concern.

4.3 Mode of seahorse fishing prior to the implementation of ban

Before the moratorium, seahorses were mostly exploited by skin divers (34%) along with sea cucumbers and gastropods (Fig. 28). The skin divers involved in seahorse collection used country craft with inboard/outboard engine to reach the area where seahorse availability was good (8-10 m depth). The other source of collection of seahorses was from by-catch in *thallumadi* (country trawl) (33%), shore seine (26%) and trawling (7%).

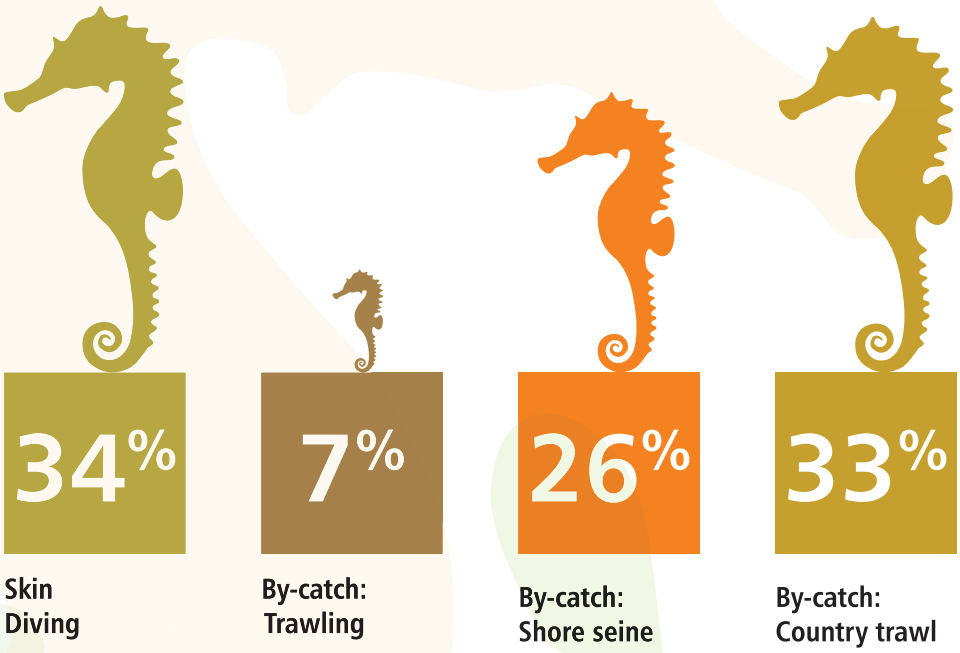


Fig 28. Distribution of respondents based on mode of fishing of seahorse before ban (N=450)

4.4 Effect of ban on livelihood

Those who complied with the ban and discontinued seahorse fishing expressed the opinion that the ban has affected their livelihood (Table 17). There was loss in their regular income and as a consequence, their debts increased. At present, most of these fishermen work as labourers in large fishing boats.

Table 17. In what ways seahorse ban affected the livelihood

S.No.	Particulars	Score	Garrett Rank
1	Affected the standard of living	73.0	I
2	Loss in regular income	56.0	II
3	Increase in debts	43.0	III
4	Loss in savings	27.0	IV

4.5 Seahorse supply/value chain

Majority of seahorse fishers stated that they do not consume seahorses, whereas some are using them as medicine and curios. Marichamy *et al.* (1993) also reported that the dried seahorses are used as medicine to arrest whooping cough in children.

Before ban, majority of the fishers sold the seahorses in dry form (sun dried) to first level middlemen. In every location there were many first level middlemen, who collected the dried seahorses in small quantities from individual fishers, and sold to second level middlemen. The second level middlemen sold the dried seahorses to the traders, who covered a larger area. The traders, after suitable packing, sold the products to exporters.

During the moratorium, majority of the fishers sell the seahorses in fresh form to first level middlemen. In every location, there are many first level middlemen, who collect fresh seahorses in small quantities and after drying, sell to second level middlemen. The second level middlemen sell the dried seahorses to the traders, who cover a larger area. It takes some time for the traders to accumulate the dried seahorses. Once sufficient quantity is gathered, traders sell the products to illegal exporters after suitable packing, who send the packed seahorses to international markets.

Average market price for dried seahorses

All those in the supply chain received a better price for dried seahorses in comparison to fresh ones, since the fresh seahorses cannot be stored for long duration. Moreover, the dried seahorses can be readily used for preparation of medicine. Both fresh and dried seahorses are sold either as 400-600 or 900 counts per kg. Larger dried seahorses of 400-600 counts fetch better price (Table 18) as it yields better quality and quantity for further processing than 900 counts. However,

availability of large-sized seahorses has reduced now and hence, the sale consists mostly of 900 counts.

In the last 15 years during ban, the price of 400-600 counts of dried seahorses has increased three to five times at every level in the market chain and that of 900 counts has doubled or tripled (Table 18). Before the ban, the fishermen got approximately 30% of the price offered for the exporters. During the ban, they are getting higher proportion i.e. approximately 30 to 50% of the price. Among those in the supply chain, the maximum profit during the ban was for the exporters, who sold the products for Rs. 40,000 (for 400-600 counts) by investing only Rs. 25,000, i.e., a profit of about 60% over investment. Before ban, the profit margin (% over investment) for exporters (400-600 counts and 900 counts) was still higher, at almost 100 per cent. This may be because the exporters are not revealing the actual export price to the fishers/ middlemen/traders during the ban.

Table 18. Average price for dried seahorses across the supply chain (1US$ = Rs. 65 approximately at 2015 exchange rate)

Actors in supply chain	Before ban (before 2001) (Rs. per kg)		During ban (2015) (Rs. per kg)	
	400-600 counts	900 counts	400-600 counts	900 counts
Fishermen	3,500	2,000	12,000	6,000
1st level Middlemen	3,900	2,100	13,500	6,500
2nd level Middlemen	4,200	2,250	15,000	7,000
Traders	5,000	3,000	25,000	9,500
Exporters	10,500	6,000	40,000	12,000

4.6 Management measures suggested by the fishers

- Ninety per cent of fishers suggested to enhance the wild population of seahorses through land-based hatchery production and sea ranching of juveniles in selected areas (Table 19).
- Majority of the fishers suggested that measures should be taken to reduce the number of bottom trawlers.

- Majority of respondents suggested that areas where seahorse population is more, may be demarcated and all forms of fishing may be banned in that area for a specified period.
- Three-fourth of the respondents suggested that use of banned gears (pair trawling, *roller madi, thallumadi*) and dynamite fishing should be stopped completely.
- Conducting periodical awareness programmes on conservation of seahorses at village level was suggested by three-fourth of the respondents.
- Restriction of collection of seahorse brooders and juveniles was suggested by nearly two-third of the respondents.
- It was suggested to improve and standardise the technologies for aquaculture of selected species of seahorses.
- Only five per cent of the respondents suggested that fishermen cooperatives can be given license for seahorse trade.
- Majority of the respondents suggested that participatory co-management of seahorse conservation may be done through community monitoring at village level, for which they suggested establishment of Councils at the village level. Local institutions such as fishermen associations and fisherwomen cooperatives may be involved in effective management of seahorse fishery. Apart from these community organizations, non-government organizations, and self-help groups may be considered as stakeholders for effective management of the resources.

Table 19. Management measures as suggested by the respondents for sustaining the seahorse stocks if the ban is lifted/relaxed (N=500)

Management measures	(%)
Improved techniques of aquaculture	20
Awareness programme on conservation	75
Gear limitation	80
Strict enforcement of banned gears and fishing methods	75
No-take zone	80
Stock enhancement through sea ranching	90
Restriction on collection of seahorse brooders and juveniles	60
Licensing	5
Reporting the catches	5

The results of the interview surveys based on the perception of fishermen indicate that the seahorse population might have decreased in the Gulf of Mannar and Palk Bay region after the implementation of ban; or, the ban has not helped increase in the population. This indicates the prevalence of illegal trade, making the Wildlife (Protection) Act ineffective. The fishermen want the ban on seahorse fishing to be lifted, and are agreeable to follow regulatory measures for conservation of the resource through participatory co-management.

Chapter 5

Management and Conservation of Seahorses

5.1 Recommendations for sustainable seahorse fisheries management and conservation

The recommendations suggested in this Chapter are the outcome from the following sources:

i) Results of surveys on incidental catches carried out by the ICAR-CMFRI during 2014-2015;
ii) Existing management measures and their functioning;
iii) Interview surveys with stakeholders;
iv) Published scientific papers and reports;
v) Formal and informal expert consultations.

The above sources have provided multiple indicators to understand the status of the seahorse resources and arrive at potential management options for conservation and sustainable use of the resources. While the conclusions from the studies refer to seahorse resources in the Gulf of Mannar and Palk Bay, the recommendations, to a large extent, are applicable to seahorse resource management along the Indian coast.

The Government of India banned the export permits for all syngnathids from July 2001 and classified them under Schedule I, Part II-A of the Indian Wildlife (Protection) Act, 1972. Following implementation of the ban, there is considerable decrease in fishing of syngnathids in the last 15 years. However, the demand in the overseas market for dried seahorses has resulted in clandestine fishing and trade which may continue and may increase in future, if unchecked. Almost every fisherman and trader who was earlier engaged in seahorse fishery, expectedly, opposes the ban. The livelihood of fishers who were engaged in the collection and trade of seahorses has been severely affected and they have few alternate options of livelihood. The dependency on livelihood has also led to illegal collection and trade of seahorses during the ban. The moratorium imposed by the government may be effective in saving the stocks from extirpation, if illegal removals are effectively stopped and monitored. While it has not been proved that enforcement of ban has helped reviving the population of seahorses in Palk Bay and Gulf of Mannar, it is clear that the ban has social and economic negative impacts on scores of people, particularly the fishers, who were dependent on the fishery. The five

sources mentioned above indicate that a controlled or a regulated capture of seahorses from the wild with proper monitoring appears to be the preferred policy solution. The best management practices followed by some countries and their experiences in regulated fishery management and conservation can be adopted by modifying to Indian situations. The government can think of removal of the existing blanket ban imposed on all species of syngnathids, and allow regulated fishery, after ascertaining their population status in the wild through scientific assessments. Concurrently, arrangements need to be made to take up breeding and culture of important species of seahorses whose captive breeding techniques have been already standardised by research institutions. The fisher communities need to be trained and encouraged with required incentives to take up breeding and farming of seahorses for commerce as well as for conservation.

5.2 Principles of seahorse management

Any renewable natural resource can be utilized continuously, if it is done in a sustainable manner. In the case of seahorses, the demand in the international market has led to excess exploitation of resources. The objective of seahorse fishery management should be that the resources should be conserved and sustainably utilized. Any long-term management plan must ensure that people and wildlife can co-exist. The communities should have access to the resources and at the same time take the responsibility to conserve and sustainably use them. Conservation and sustainable use will provide a practical and integrated approach. There are several opportunities to achieve this and there are also global evidences that this twin objective could be achieved by active and genuine participation of communities and government institutions. To achieve this, it is suggested that the moratorium may be relaxed in India, but with restrictions on the fishery that would emerge.

Many seahorse species continue to remain either 'Data Deficient' or 'Not Evaluated' as evident from the IUCN Red List of Threatened Species, which calls for an urgent need to undertake research on various aspects of seahorses. For developing management strategies, it is always essential to have a good understanding and knowledge of seahorse resources in the wild, their behaviour and biology, habitat status, and various threats they face. At present, information available in the country on various biological parameters such as growth, mortality and recovery rates, spawning season, etc. are not sufficient to arrive at robust management decisions. While attempting to gather more information on biological and ecological aspects which are vital to management, the managers can go ahead and implement the best precautionary management practices, in order to initiate conservation measures.

5.3 Potential measures for management

The fishermen who are targeting sea cucumbers, were collecting seahorses too as both the resources are found in the same habitat and that the seahorses are fetching additional income to the sea cucumber collectors. Hence, it would be appropriate to consider many of the suggestions made by the ICAR-Central Marine Fisheries Research Institute on conservation and sustainable use of sea cucumber resources in India (Asha *et al.*, 2017) for seahorse resources as well.

The potential management measures for seahorse fishery may be grouped under three major categories: (i) Regulatory, (ii) Restocking, and (iii) Implementation. While the first is a bundle of measures that could be imposed on fishers and traders, the second is a stock recovery measure and the third is a road map for establishing the mechanism for institutionalising and implementing the first two set of measures.

The potential management measures suggested in this Chapter are a toolkit that could be used in specific situations and locations. All the tools in the kit may not be required, and selection depends on the management objectives, fishery types, species to be managed, acceptance by stakeholders and technical capacity of the managers.

Regulatory measures

i) Seasonal closure

Restriction on fishing or collection for a certain period of year would help in replenishment of stock. If the seasonal closure coincides with the breeding season of seahorse species, it would help substantially in recruitment. Seasonal closures could protect reproductive stocks of seahorses and successive recruitment can be ensured. However, this measure would be difficult to implement because a total of seven species of seahorses have been reported from the Indian waters and the breeding seasons may vary with species. Therefore this measure of seasonal closures may not be effective where seahorse fishery is multi-species. At present, the breeding season of *H. kuda* alone is known (Salin, 2003) and hence studies need to be undertaken to understand the breeding season of all the other species in order to plan the seasonal closures. It is suggested that seasonal closure may be

considered for the peak spawning periods and frequency of spawning months of seahorse population.

In India, seasonal fishery closure is followed for mechanised boats every year. This applies to Gulf of Mannar and Palk Bay as well, where a closure of 45 days was followed for the last 15 years during summer months from April 15 to May 30, and for 60 days from April 15 to June 15 from 2017 based on the peak spawning season of commercially important finfish and shellfish species. As the mechanised trawlers are included in the closure, there is considerable reduction of seahorse bycatch, even though the seahorses are not the focus of this closure. However, for seahorses, the presently existing 60-day closure may not be enough and if it has to be effective, it should be a component of a larger management framework consisting of several other measures, as mentioned in the succeeding sections.

To increase the effectiveness of seasonal closures with reference to seahorses, it is important to close the country trawl (*thallumadi*) fishery as well during the 60-day closure as the country trawl removes large number of seahorses. Also, the country trawls operate mainly in the seagrass beds which is one of the most preferred habitats of seahorses.

ii) Minimum Legal Size (MLS)

For any sustainable fishery, the 'Minimum Legal Size' (MLS) at capture is one of the important measures which would ensure restriction on removal of juveniles. The MLS is fixed based on the length at first maturity and this would vary from one species to the other. The MLS needs to be fixed for each of the traded species so that each individual fish gets an opportunity to spawn at least once during its life time, before it is caught. This would ensure a steady recruitment in the wild. All the seahorse species found in India are also listed in the Appendix II of CITES, wherein a minimum legal size of capture of 10 cm applies. Worldwide, most of the dried seahorses that enter the trade are collected from the incidental catch from the trawlers and seahorse collected by targeted fishing forms only a small portion. Application of MLS may be realistic to the target fisheries; but in bycatch fisheries, this measure will not be practical as there is no control on the size of organisms that are caught. It also depends on the survival of seahorses at the time of hauling, so that the smaller ones can be released back into the sea. Also, in India, there is a need to have two minimum legal sizes i.e. one for the moderate size seahorses like *H. kuda* and *H. trimaculatus* and the other for the large-sized seahorse species *H. kelloggi*.

iii) Sex-selective fishing

This is a measure that restricts collection of pregnant males. The collected live pregnant males can be released back into the sea, so that the animal gets an opportunity to release the young ones, before being sold. This measure will be valuable for target fisheries, but will be valuable, if only there is a high survival rate of animals in the by-catch.

iv) Rotation of harvest areas

Rotational harvest is a combination of both temporal and spatial closures and provides an opportunity for the habitat to recover. During every fishing season for seahorses, rotation of harvest areas may help in revival of population. Therefore, during every fishing season, certain areas may be restricted from fishing and fishing can be done in the subsequent year in these areas. This regular rotation of harvest areas might also help in maximising the catch.

v) No-take zones

It is imperative to identify certain areas as 'protected habitats' or 'no-take zones' as a measure of conservation. Since most of the seahorse collection and trade is from the Gulf of Mannar and Palk Bay, it is imperative to identify certain pockets as 'no-take zones' where collection/fishing of seahorses is completely restricted. The Gulf of Mannar Biosphere Reserve (GOMBR), being a Marine Protected Area (MPA), might have already helped revival of depleted stocks of seahorses, as human interventions are very much restricted. Also, being MPA, it is easy to identify certain locations as 'no-take zones', through community participation.

The Palk Bay on the other hand is characterised by vast stretches of seagrass meadows which is an ideal habitat for many marine invertebrates and seahorses. Therefore creation of 'no-take zones' in Palk Bay would not only help conservation of seahorses, but also helps preservation of seagrass habitats which are the preferred habitats of syngnathids, and several other biota like the sea cucumbers, juvenile shrimps and fishes. Increasing abundance of juveniles and adults within the identified no-take zones and marine reserves can have spill-over effect through dispersal of animals to surrounding areas and these supplemented stocks can be fished out.

The 'no-take zones' need to be identified involving local fishing communities who have a rich knowledge on the habitats and areas of abundance of the biota.

A community level self-imposed regulation would be far-reaching and successful in sustaining the resources in the designated no-take areas.

vi) Gear limitation

In addition to targeted removal, seahorses are also caught in trawl as incidental catches. The operation of trawl very close to the shore needs to be restricted in order to minimize the by-catch of seahorses. Under Marine Fishing Regulation Act (1981), trawlers are not permitted to operate in inshore areas (within 5 km from the shore), but this restriction is often violated by the fishermen. This stipulation should be strictly implemented, as the inshore areas in the Gulf of Mannar and Palk Bay are known for rich seagrass meadows. In addition to the trawlers, the country trawl or the mini trawl which are operated exclusively in the seagrass beds target shrimps and fishes and also catch seahorses; in the process of operation, seagrass beds are damaged. Such destructive gears need to be limited or restricted.

vii) Catch quota

The fishermen who were involved in the collection of seahorses should be registered and license need to be issued to each one of them. Quotas should be fixed for individual fishers or a fishing group, so that resources are not over-exploited and this also ensures equity in sharing of resource. The registered fishers should maintain log books on catch and sales, which should be made available to the concerned authorities for verification. Deciding upon 'Quota of Harvest' for each fishing unit should be based on the outcome of periodic stock assessment studies conducted by research institutions. Also, there should be strict inspection and monitoring of the harvested catch by the concerned authorities and the renewal of license should be denied for non-compliance of catch quota.

viii) Habitat protection

The seagrasses and coral reefs are the preferred habitats of seahorses. In India, the corals are protected under the Indian Wildlife (Protection) Act, 1972, but not the seagrass beds. The seagrass beds are used as trawling ground by the country trawl, which remove a large number of seahorses and other fauna that live amongst the seagrasses. The country trawls also remove large quantities of seagrasses during operation. The seagrass meadows are home to many organisms including sea cucumber, sea urchins,

sea anemones, starfish, shrimps, crabs and finfishes. Juveniles of many animals also take shelter in the seagrasses. Thus any step taken to protect the seagrass meadows would also help protecting large number of associated faunal communities, including the seahorse. Therefore it is important to protect and restore the critical habitats such as seagrass beds and coral reefs for conservation of seahorses.

ix) Trade management

The seahorses do not have any market within the country and the collection and trade is totally export-oriented. Although regular fishing and trade existed for several years prior to the ban imposed by the government in 2001, there is no much information or data available on the quantity of seahorses that were removed and traded. Even after the moratorium, illegal fishing and trade continues as mentioned in this publication, which defeats the purpose of conservation.

If the government lifts the moratorium and permits regulated fishing, the concerned government agencies should ensure that the poor fishers who toil hard get a fair share of the export price. The concerned agencies should monitor the market chain within the country and also the export, so that the trade is well regulated. Monitoring the whole market chain from fisher to exporter allows the government agencies to verify or set appropriate taxes and duties. It is necessary to have a process by which price data from the international market can be obtained regularly. Managers should also seek to involve the Marine Products Export Development Authority (MPEDA), Ministry of Commerce and the Customs Department in the country to support or conduct monitoring of export prices of seahorses.

Restocking programme

Aquaculture

One of the favourable options for recovery of seahorse stocks is through hatchery seed production and sea ranching. Hatchery seed production and farming will also help augmenting the export trade. In China, captive breeding programmes for seahorses were initiated as early as 1950s with facilities at Guangdong, Guangxi, Hainan, Fujian, Zhejiang, Shandong and Liaoning Provinces (Zhiyong, 2005). Seahorses were bred in captivity in 1987 in Rizhao, Shandong Province (Zhang, 2000). *H. kuda* and *H. trimaculatus* were successfully bred in captivity in 1998 by a private company in Guangdong Province (Zhiyong, 2005). At the Wilhelma Aquarium in Stuttgart, Germany,

two species of seahorse (*H. kuda* and one species from the Philippines) have been bred for generations since the early 1970s (Prein, 1995). One of the major constraints facing successful seahorse culture is the low juvenile survival rate in the first few months of rearing (Forteath, 2000). However, some researchers including Correa *et al.* (1989) obtained high juvenile survival rate of up to 97% in *H.erectus*.

In India, standardised technologies are available for seed production of two species of seahorse *viz.*, the three-spotted seahorse *H. trimaculatus* (Murugan *et al.*, 2013) and the yellow seahorse *H. kuda* (Anil *et al.*, 1999; Ignatius *et al.*, 2000; Gokulakannan, 2002; Lipton *et al.*, 2006; Murugan *et al.*, 2017). The stocking density, larval feed, growth, maturation time, reproductive efficiency, gestation period, time taken for juvenile settlement for these species have been studied. However, these initiatives have remained at experimental scale and large-scale culture operations have not been put into place. The solution for seahorse conservation lies in mass production to meet the demand as well as sea ranching.

It is possible to establish small hatchery units at different locations along the Gulf of Mannar and Palk Bay, involving the local communities. The seeds thus produced can be used for re-stocking and replenishment of stock. The seahorse aquaculture that does not involve seahorse fishers is unlikely to have any conservation benefits (Lourie *et al.*, 1999a). Hence community-based hatchery seed production programmes should be taken up on priority.

Implementation

Ideally, sustaining seahorse fisheries is possible by reducing the number of fishers per unit of fishing ground, improving the livelihood of local fisher communities and strengthening the enforcement capacity. An overarching goal in the management of seahorse fisheries should be to safeguard the pregnant males which ensure recruitment to the fishery. While we recognise that all these measures are not easy to implement, it is possible to move towards meeting these goals by a careful planning process. The most appropriate regulatory measures should be chosen and implemented depending on the level of exploitation, number of active fishers, etc.

Ecosystem approach

It is suggested that effective management of seahorse fishery could be achieved by following the ecosystem approach, in which multiple regulatory measures and management actions

could be applied in full consideration of the seahorse stocks, the ecosystems in which they live and the socio-economic systems that drive exploitation. In ecosystem approach, it is crucial to get the commitment of governments, fishery managers and scientists to develop, apply and strictly enforce the management measures, the plan for which has to be developed in a participatory and inclusive manner, together with resource users and other stakeholders. Ecosystem approach attempts to achieve ecological well-being and human well-being through good governance.

Co-management

Participation of all stakeholders holds the key for success in any fishery management plan. For sustainable management of seahorse fishery and conservation, a large number of stakeholders like the fishers, traders, exporters, officials of the Department of Fisheries, Department of Forests, Indian Navy, Indian Coast Guard, Coastal Marine Police, Wildlife Crime Control Bureau (WCCB), Gulf of Mannar Biosphere Reserve Trust (GOMBRT), Non-Government Organisations, scientists and students have defined roles to play and they should be involved at each stage of dialogue and implementation of plans.

Any long-term management strategy should ensure involvement of local communities who are the custodians of resources in their locality. They are well aware of the importance of the resources and thereby the need for sustainable utilization. While aiming at conservation, the communities should have access to the resources; the local communities should be assured that they have a stake on the resources, provided they do not violate the regulatory measures imposed by the government.

In co-management of seahorse resources, both the communities or the local resource users and the government (Governments of India and Tamil Nadu) share the responsibility and authority for managing and determining the goals of the fishery, with various degrees of power sharing. Stakeholders will be the central part of the management process. In the Indian context, the Ministry of Environment, Forests & Climate Change is mandated to protect the species, while the responsibility of fisheries management and aquaculture is vested with the Ministry of Agriculture. Unless there is a close coordination between these two Ministries, it will not be possible to achieve sustainable management and conservation of seahorses.

Institutional requirements

For effective implementation of management measures, a governing council consisting of important players from fishing to export may be constituted. Establishment of institutions for resource management by fisher groups is a part of co-management and community-based management and encouraged within an ecosystem approach to fisheries. The management decisions and outcomes have to be vested with fishers or fishing communities who value the long-term benefits of a sustainable resource. Self-regulation by fishing groups and co-management can help to reduce the burden of conflict management. The government and non-government agencies in the governing council will play important roles in conflict resolution and ensure that the governing process is proceeding in the right direction.

To establish institutional mechanism, different types of fisher organizations or stakeholders need to be listed and a plan drawn to show how they are structured or linked within the current management institution. Other management activities like monitoring, surveillance and enforcement should be devolved with the governing council. Government agencies may monitor the fisheries, and regularly arrange meetings and operationalize management decisions.

Capacity development

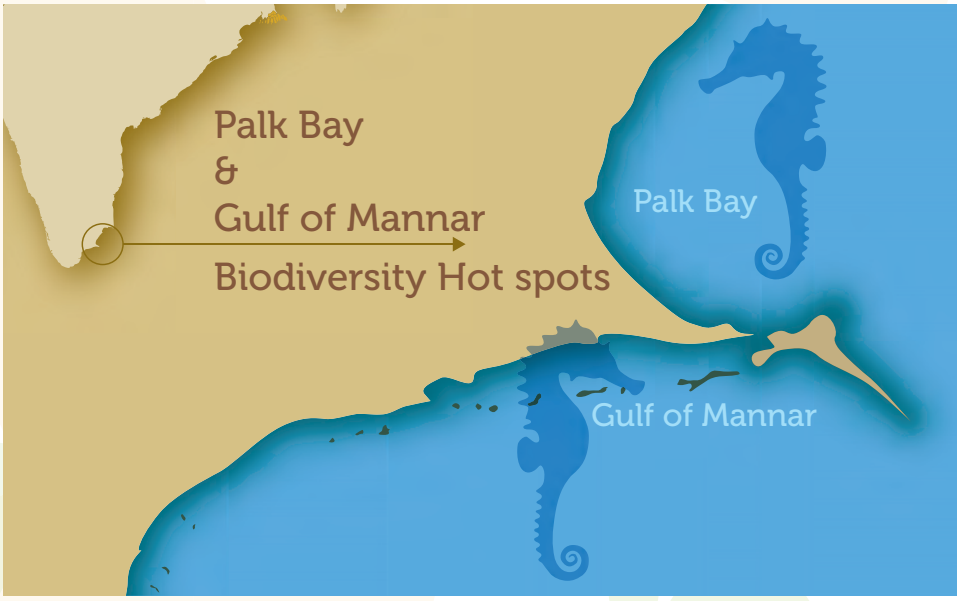
Capacity development at all levels, from fishermen to government officials is necessary to promote development and implementation of sustainable management approaches. It is necessary to improve the capacity for management at all levels like fishing, aquaculture, inspection of trade, data collection and monitoring. Capacity building programmes within the fishery creates an enabling environment for better management decisions, through consensus building. Informed stakeholders are in a better position to manage their resources in co-management and community-based management systems.

Regional cooperation

The Gulf of Mannar and Palk Bay is the predominant region for the harvest and trade of seahorses in India. The resources in this region are shared between India and Sri Lanka. While there is a complete ban on collection and trade of seahorses in India, the protection is somewhat weak on the Sri Lankan side. The seahorses that are illegally

caught in India are believed to be sent to Sri Lanka from where it is re-exported. Therefore, bilateral co-operation between the two nations is essential for strengthening the conservation efforts. It is important that binding or non-binding arrangements are established between governments that promote cooperation towards common interests and objectives of conservation and sustainable use of seahorse resources.

As the Gulf of Mannar and Palk Bay are biodiversity hotspots, it is worth considering managing the entire area through ecosystem approach by the two countries. It is recommended that a holistic approach for the management of Palk Bay and Gulf of Mannar may be followed by (i) Setting up of a cooperative mechanism within the existing bi-lateral framework of the Governments of India and Sri Lanka, (ii) Enhancing knowledge on ecological characters and conducting impact assessments, (iii) Ensuring conservation of resources and restoring fisheries habitats, (iv) Ensuring effective stakeholder participation, (v) Promoting livelihood options, and (vi) Strengthening institutions and capacities.



The above recommendations are generic, but if appropriately implemented, they should assist in conservation and sustainable use of the habitats and biodiversity in Palk Bay and Gulf of Mannar. The solutions need to be tailored to the specific context within which the challenges occur. A plan for conservation and sustainable management of seahorses in India is given in Figure 29.

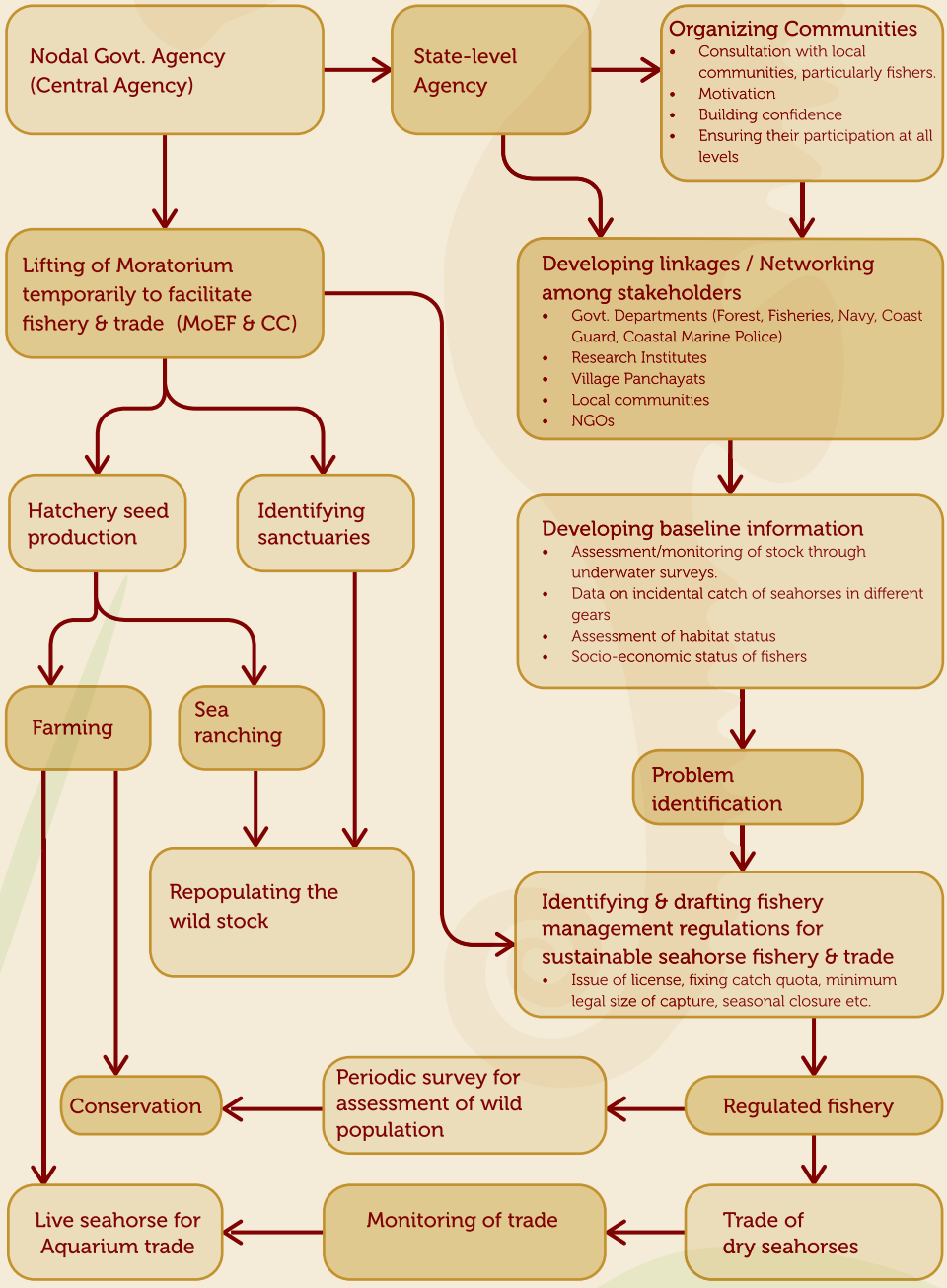


Fig. 29. Conservation and sustainable management of seahorses in India – Suggested way forward

5.4 Conservation efforts – lessons from other countries

Globally, not many examples are available to demonstrate successful management of seahorse fisheries. Paucity of scientific information on the population status, behaviour, biology etc. is a major bottleneck to evolve strategies for sustainable seahorse fisheries and trade. While there are not many success stories of conservation of seahorses in other countries, some of the case studies where management interventions have helped revival of seahorse population and fishery are given below.

1.Role of seahorse fishers in conservation and management: an example from Handumon village in Central Philippines (Pajaro *et al.*, 1997)

Issues

- About 40% of fishers in Handumon village were dependent on seahorses for their livelihood.
- The growing demand for both dried seahorses for traditional Chinese medicines and live seahorses for marine aquarium trade led to over-exploitation. An estimated reduction of 70% of catch from 1985 to 1994 was alarming. The fishers who reported catching 51 to 100 seahorses in a single night during 1970s informed that they got only 10 to 50 numbers in 1985, which further reduced to 0 to 25 seahorses by 1994.
- There was a targeted fishery by free-diving and using hookah compressors. Seahorses were also collected as by-catch of trawl and drive-net fishing which often employ the prohibited fine-meshed nets.
- Non-selective extraction like the removal of juveniles (SL < 7.5 cm) and pregnant males reduced the seahorse population.
- Dynamite blasting, cyanide poisoning and trawl fishing resulted in habitat destruction.

Initiatives

- Establishment of village-based seahorse conservation project using Community-based Resource Management (CBRM) approach by the Haribon Foundation, an environmental non-governmental organisation.
- The Foundation focused on involving local communities, particularly the seahorse fishers in the management process.
- The project provided formal and informal education, and conducted environmental sessions, group discussions, film shows, exposure visits and lecture discussions.
- Baseline information on seahorse fishery at Handumon like the socio-economic profile, documentation of indigenous knowledge, seahorse yields and behaviour of seahorse in the wild was prepared.

Outcome

- Fishers refrained from catching small seahorses (less than 7.5 cm).
- Harvest areas rotated regularly.
- The fishers maintained monthly diary of catch and income. They were always willing to share information like the catch, size, effort, area of fishing, etc. with the project staff.
- Fishers participated in monitoring surveys for seahorses to determine recovery of depleted populations.
- Established a 33 ha marine sanctuary (a complete no-take zone), with strict village patrols.
- Fishers donated young seahorses to the sanctuary in an effort to repopulate.
- Cages were established and the pregnant males were stocked in cages where they give birth. The young escape while the adults are sold.
- Efforts were also made by cooperatives to hold young seahorses in cages for a few months, allow them to grow and reproduce at least once, before being sold.
- The seahorse fishers of Handumon village shared their ideas and experiences with seahorse fishers of other villages influencing them to adopt similar conservation and management measures.

2. Management options for an artisanal fishery for seahorses in the Central Philippines (Martin-Smith *et al.*, 2004)

Issues

- Seahorse populations in the Central Philippines were found to be overfished.

Initiatives

- Developed management options at a Workshop of fisheries experts from different backgrounds.
- This was followed by an iterative process of consultation involving fishers, traders, consumers, aquarists, conservationists, and policy groups.

Outcome

- The stakeholders strongly supported implementation of no-take Marine Protected Areas and for imposing minimum size limits (10 cm height) in the fishery.
- Sex-selective fishing, avoiding pregnant males had moderate support across the stakeholder groups.

3. Local knowledge as an information base for local management: An example from Brazil (Rosa *et al.*, 2005)

Issues

- Many fishing communities in Brazil are involved in seahorse collection for their livelihood. Brazil has been involved in dried seahorse trade; however, the trade is unregulated and exports have not been officially recorded.
- Brazil is also one of the world's leading exporters of ornamental fishes and has been a major exporter of seahorses since 1999. Permits were required for aquarium trade of live seahorses, but quotas were not strictly enforced.

- Blast fishing and use of ichthyotoxins occurred in northeast Brazil.
- Although prohibited by law, beach seines with mesh size below 30 mm were operated.
- Most fishermen reported decline in seahorse catch since 1990. Heavy fishing pressure, pollution, trawling, disorganised tourism, harvest of large number of pregnant males were some of the reasons that the fishers perceived for the dwindling catch (Rosa *et al.*, 2005).

Initiatives

- The value of local knowledge was long realised as a potential information base for the management of the marine environment and its resources, particularly in the tropics, where there is little or no data (Ruddle, 1996). Rosa *et al.* (2005) attempted to capture perception and knowledge of Brazilian fishers on the biology and ecology of the long-snout seahorse *H. reidi*. The study was aimed at evaluating potential management options based on the knowledge of fishers on seahorse habitat, feeding ecology, captive care, predation, reproduction, sexual behaviour, sex differentiation, social structure and population declines.

Outcome

- The fishers were willing to have dialogue with researchers.
- Many fishers started recognizing the significance of pregnant males for sustenance of wild population of seahorses.
- The fishers also recognized the importance of microhabitats for the survival of wild seahorse populations.
- The study indicated that local knowledge and the involvement of fishers is the key for successful management.

4.Other countries

A few more countries have management initiatives for sustainable fishery of seahorses.

Australia: Seahorses and their relative species are protected under the Wildlife Protection Act from 1st January 1998, and then placed under the Environment Protections and Biodiversity Act in 2001. Export permits are granted only for fisheries practiced under

approved management plans or captive-bred animals. The states of Tasmania and Victoria have banned seahorse removal without a special permit, under fisheries regulations.

China: *H. kelloggi* is listed under Category II of the Law of Wild Animal Protection of the People's Republic of China, and as Priority Fish Species (Grade B) in National Biodiversity Action Plan. Several hatcheries are functioning, producing up to one million seahorses per year.

Mexico: Intentional capture and trade of wild seahorses is prohibited. However, trade of cultured and incidentally caught seahorses is permitted.

South Africa: Harvest of *H. capensis* and other syngnathids is illegal without permit from Cape Nature Conservation (CNC) under CNC Ordinance 19, 1974 (Draft Regulations of the Marine Living Resources Bill, and Sea Fisheries Act, 1988).

Thailand: According to CITES, more than 75% of the seahorses in international trade each year come from Thailand. More than five million dried seahorses are reported to be taken from the wild and exported annually since 2004. Recently, Thailand has announced its decision to end seahorse exports until it can trade in a sustainable manner, without damaging the wild populations.

In India, after the implementation of total ban on removal and trade of seahorses in 2001, adequate efforts were not made to undertake scientific studies to assess the population status of different species of syngnathids. As illegal removal and trade of seahorse continues, relaxing the moratorium temporarily for a few years and replacing with controlled fishery coupled with periodic scientific monitoring would be the way forward to achieve the goal of sustainable seahorse fishery and trade in future. Also, concerted efforts need to be taken up for stock replenishment of seahorse in the wild through captive breeding and sea ranching programmes. Participation of all concerned stakeholders, particularly the local fisher communities is imperative at each stage for successful planning and implementation of management and conservation programmes.

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Acronyms

BOBLME	Bay of Bengal Large Marine Ecosystem
CAF	Charities Aid Foundation
CBRM	Community-based Resource Management
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMFRI	Central Marine Fisheries Research Institute
DBT	Department of Biotechnology
DD	Data Deficient
EEZ	Exclusive Economic Zone
EN	Endangered
FAO	Food and Agriculture Organisation of the United Nations
GOMBR	Gulf of Mannar Biosphere Reserve
GOMBRT	Gulf of Mannar Biosphere Reserve Trust
GOMNP	Gulf of Mannar Marine National Park
ICAR	Indian Council of Agricultural Research
IUCN	International Union for Conservation of Nature
LC	Least Concern
MLS	Minimum Legal Size
MoEF & CC	Ministry of Environment, Forests and Climate Change
MoES	Ministry of Earth Sciences
MPA	Marine Protected Area
MPEDA	Marine Products Export Development Authority
NE	Not Evaluated
SL	Standard Length
TCM	Traditional Chinese Medicines
TL	Total Length
VU	Vulnerable
WCCB	Wildlife Crime Control Bureau

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The increasing demand in the international market has resulted in over-harvesting of seahorse resources in many parts of the world. In India, all species of seahorses are listed under the Schedule I, Part II-A (Fishes) of the Indian Wildlife (Protection) Act, 1972. The moratorium which bans collection and trade of seahorses came into force with effect from July 2001. This book is aimed at proposing a paradigm shift in approach for effective conservation and long-term sustainability of seahorse resources in India.

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Seahorse resources in India: need for paradigm shift in approach for sustainable fisheries and conservation