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Present Status of Holothurians (Echinodermata) in Palk Bay and Gulf of Mannar – A Case Study

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ABSTRACT

Holothurians are commercially important echinoderms, included under Schedule-I category of Wildlife Protection Act 1972. The present status of their density, biomass, diversity, distribution and standing stock has been studied from 18 stations along Palk Bay and Gulf of Mannar region. Apart from that the primary and secondary productivities of these regions were also estimated. It is revealed that the population of holothurians was drastically reduced especially *Holothuria scabra* and *Holothuria spinifera* as they give high-quality *Beche-de-mer*. *Holothuria atra* is the only species predominantly found at all the stations of study. This paper also discusses the overexploitation of these resources and possible measures to conserve them.

INTRODUCTION

Holothurians or sea cucumbers have been known from ancient times as they are conspicuous animals of the ocean littoral, and common in tropical and temperate regions. Holothurians are distributed in different ecological niches as they have adapted themselves to live in different habitats. The product *Beche-de-mer* derived from processed holothurians is commercially important and considered as a delicacy in China, Japan and Korea. Besides, the sea cucumber has aphrodisiac qualities and the pharmacological properties for treatment of high blood pressure, muscular disorder and cholesterol problems (James 1998). According to FAO's annual statistics for 1984 the world echinoderms harvest in 1983 amounted to approximately 80,000 tonnes. The Indian *Beche-de-mer* industry is more than 1000 years old (Hornell 1917). Past several years Palk Bay and Gulf of Mannar with their potential of sea cucumber resources supported this industry in India. The export trend of Indian *Beche-de-mer* was fluctuating and it earned very high foreign exchange of Rs.1.55 crores during 1979 (James & James 1993) but in 1999 it reduced to Rs. 6.2 lakhs due to overexploitation as indicated by Marine Products Export Development Authority.

Around 1400 species of holothurians are reported from various parts of the world oceans. In Indian waters nearly 200 species belonging to 6 Orders and 16 Families have been recorded of which 31 species alone have been reported from Gulf of Mannar and Palk Bay. Among them 12 species such as *Actinopyga miliaris, Actinopyga mauritiana, Actinopyga echinites, Bohadschia argus, Bohadschia marmorata, Stichopus chloronotus, Stichopus variegatus, Thelenota ananas, Holothuria nobilis, Holothuria atra, Holothuria scabra* and *Holothuria spinifera* are commercially important (James & James 1994).

In order to conserve the resources of sea cucumbers, Government of India imposed a ban on the export of *Beche-de-mer* of less than 3 inches in length in 1992. However, it became impractical to

regulate the catch of the undersized holothurians as the huge number of sea cucumber processing industry scattered along the Gulf of Mannar and Palk Bay region. Subsequently on 11th July 2001 Notification, the Ministry of Environment and Forests, Government of India included all species of holothurians under Schedule-I category of Wildlife Protection Act, 1972 and totally banned their collection. These animals have also been recommended for inclusion under Appendix-II listing of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to conserve their declining population (Nithyanandan 2003).

Considerable amount of literature is available on the holothurians of Indian Seas since the pioneer study made by Coiller (1830). Thurston (1887) and Thurston (1990) described 7 and 16 species of holothurians in Rameswaram and neighbouring islands respectively. Thurston (1894) also reported 10 species of holothurians from intertidal and shallow waters of Tuticorin and Pamban region of Gulf of Mannar. Subsequently several studies were made in Indian waters on ehinoderms, in general, or holothurians in particular, by various authors. Among them studies on holothurians from Andaman (Bell 1887, Rao 1973, 1975, Soota et al. 1983), Rameswaram (Bell 1889, Thurston 1887), Krusadai and neighbouring islands (Gravely 1927), Chennai (Gravely 1941), Gulf of Kachchh (Gideon et al. 1957, Gopalakrishnan 1969), Mumbai (Sane & Chhapgar 1962), Waltair (Rao 1968), Kanyakumari (Mary Bai & Ramanathan 1977), Malvan (Parulekar 1981) and Lakshadweep (Mukhopadhyay & Samanta 1983) were made significant contribution to holothurians diversity. Apart from these studies on holothurians, taxonomy (James 1967, 1968, 1986 a&b), resources and its industry (James 1973, 1983, 1986c, 1987, 1988, 1989, 1991, 2001, James & Baskar 1994), and zoogeography (James 1986a, James et al. 1993) are worth mentioning.

Nithyanandan (2003) reported the indiscriminate fishing and overexploitation of sea cucumbers in Gulf of Mannar. However, no study is available on the quantitative assessment of standing stock of holothurians except the report on *Holothuria scabra* James (1982) and status survey of sea cucumbers conducted by Venkataraman et al. (2003) in Palk Bay. It is imperative to assess the present status of holothurians in Gulf of Mannar and Palk Bay after imposing the total ban on its fishing as they are conserved under law and hence the present study.

The status of holothurians was assessed in 18 stations along Palk Bay and Gulf of Mannar situated between lat. 10°16.494 to 08°05.773'N and long. 79°49.400 to 77°33.770'E (Fig. 1). This area is highly productive seas of the world and their biodiversity is globally significant. In Gulf of Mannar, 21 islands located between Rameswaram and Tuticorin covering an area of 623 ha have been declared as Marine Park by Ministry of Environment

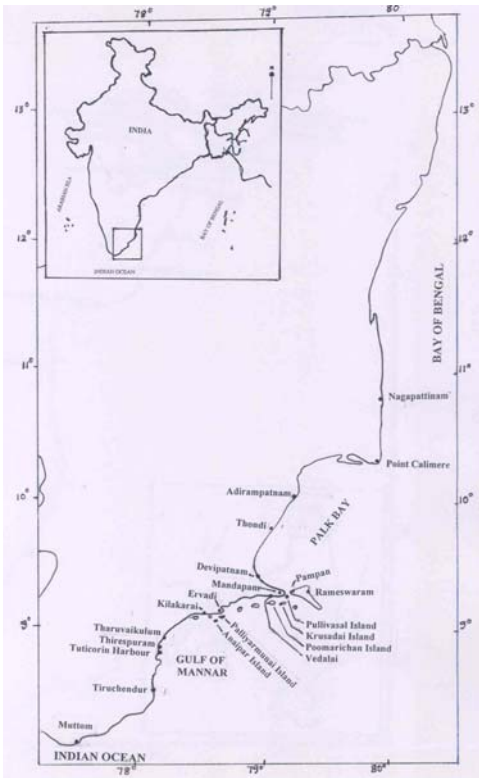

Fig. 1: Map showing the study area.

and Forests, Government of India and Tamil Nadu Forest Department. About 3600 species of flora and fauna have been recorded in this area. This area also harbours rare and endangered species of sea turtles, dolphins, sea cows and whales. More than 600 species of fishes have been recorded from Gulf of Mannar, out of which 72 species are commercially important and its fishery production gradually increased from 55,300 tonnes in the year 2001 (NEERI 2004). The average primary productivity of Palk Bay and Gulf of Mannar is 205 and 223 mg C/m^3/day respectively (NEERI 2004).

MATERIALS AND METHODS

The density and diversity of holothurians were estimated during December 2006 by conducting field studies where the distribution of these animals has been frequently reported and collecting by-catch data from fishermen. The Line Intercept Transect (LIT) method (English et al. 1994) was adapted for estimating density and distribution of holothurians. In this method quadrnat was employed at every 50m interval at a depth of 1-3.5 meters in the subtidal region of the fringe area of Krusadai Island, Pullivasal Island, Poomarichan Island, Ervadi coast, Palliyarmunai Island and Annaipar Island in Gulf of Mannar by engaging divers and by snorkeling during low tides. The holothurians found under quadrant were quantified and identified following the monograph of echinoderms (Clark & Rowe 1971).

Standing stock of the holothurians was estimated in selected transect along the Palk Bay and Gulf of Mannar. The data were collected along the coast of Nagapattinam, Adirampatnam, Thondi, Tharuvaikulum and Tiruchendur by horizontal hauling of trawl net using fishing trawler for 0.5 to 1.0 hours at 5.0 knot. Holothurian catches at the end of trawling operation were quantified species-wise in terms of wet weight. The standing stock of holothurians in the given area was calculated by Swept-Area method (Pauly 1984) using the following formula. The results were expressed per km^2 area of the sea floor.

$$B = \frac{C/f \times A}{a \times X_1}$$

Where, B - standing stock, C/f - mean catch in kg, A - distance covered in km, X_1 - escapement factor (0.5)

$$A = t \times V \times h \times X_2$$

Where, t - time spent for trawling, V - speed of the trawler, h - length of the trawl's head rope, X_2 - effective width of the net divided by length of the head rope.

Data on the incidental catch of holothurians by fishing gears such as trawl net, gill net and sail based artisional mini trawl (*Thallumadi*) were collected from 16 stations along the study area. This information was collected from 10 fishing boats for each gear and the mean values are calculated to obtain the present status of holothurians in the fishing grounds.

The physico-chemical and biological productivities of seawater from the study area were also estimated. The temperature was measured by mercury thermometer while salinity was analyzed by handheld refractrometer (Model ERMA, Japan). The pH was obtained using portable water quality analyzer, Model ELICO PE 136. The transparency of seawater column was determined by Secchi disc. The coordinates of all the sampling stations were collected using Global Positioning System

model GARMIN, 12 Channel GPS.

Phytoplankton samples were collected by filtering 50-L of surface seawater through 20µ mesh sized boltic silk net. The phytoplankton samples were concentrated to 250 mL and preserved by adding 5 mL of 40% formalin and 2 mL of Lugol's iodine. All the samples were qualitatively and quantitatively estimated using Sedgewick Rafter Counting Cell. The phytoplankton species were identified following standard monographs (Husted 1930, Pergallo 1965).

Zooplankton samples were collected by surface haul using Heron-Tranter plankton net with a mesh size of 300µ for 10 minutes at 2 knot. The zooplankton in terms of wet weight, dry weight and volume were calculated. The numerical density of zooplankton was estimated using Sedgewick Rafter Counting Cell and species were identified following standard manuals.

The species diversity of phytoplankton, zooplankton and holothurians were calculated according to the Shanon-Weiner formula;

$H' = \Sigma Pi \log e.pi$

Where Pi = proportion of the *i*th species in the collection and H' = diversity of a theoretically infinite population.

RESULTS

Numerical density, biomass, distribution and species diversity of holothurians in 5 islands, viz., Krusadai, Pullivasal, Poomarichan, Palliyarmunai and Anaipar Islands and Ervadi coast in the protected area of Gulf of Mannar Biosphere Reserve were studied during low tide and their results are depicted in Tables 1 and 2. The LIT study covers 500m length along the fringe of each island and the quadrant were employed at every 50m interval starting from the high tide mark of the island/shore towards the sea with a depth of 1 to 3.5 m. A total of 7 species of holothurians such as *Holothuria atra, Holothuria scabra, Bohadschia marmorata, Stichopus herrmanni, Stichopus variegatus, Stichopus* sp. and *Actinopyga miliaris* belonging to Holothuridae and Stichopodidae families were recorded from the study area. The numerical density and biomass of these species were gradually increased when the depth of the water column increased. However, the mean values for numerical density ranged from 19 ind./10m^2 at Pullivasal, Poomarichan and Anaipar Islands to 25 ind./10m^2 at Ervadi coast. The biomass in terms of fresh weight varied between 10.64 kg/10m^2 and 14.89 kg/10m^2 at Anaipar Island and Ervadi coast respectively. The results from the LIT assessment clearly indicated that *Holothuria atra* was the dominant species in the study area as it shows maximum numerical density, biomass and distribution at all the quadrants (Fig. 2). The numerical density of *Holothuria atra* is found high (20 ind./10m^2) at 1.8m depth in Krusadai Island, and minimum (2 ind./10m^2) at zero meter depth in Poomarichan Island during low tide. Similar trend of variation was observed for biomass of this species, which ranged between 0.92 kg/10^2 and 16.36kg/10m^2 at these stations respectively.

The highly valued commercial species *Holothuria scabra* was distributed least in density and biomass at all the quadrants of transect at all the islands of study. The numerical density of this species registered 1 to 4 ind./10m^2 while fresh weight varied from 0.63 kg/10^2 to 2.6 kg/10m^2. The data from the present observation inferred that the priority of dominance and abundance among the 7 species of holothurians in the presently studied stations could be patterned as *Holothuria atra* > *Bohadschia marmorata* > *Stichopus variegatus* > *Stichopus herrmanni* > *Holothuria scabra* > *Stichopus* sp. > *Actinopyga miliaris*. Species diversity of holothurians along these islands was also

Table 1: Density and biomass of Holothurians in Mandapam group of islands of Gulf of Mannar during December 2006.

Distance from island fringe (m)	Species	Krusadai Island Depth (m)	Numerical density (No./10m²)	Biomass (kg/10m²)	Pullivasal Island Depth (m)	Numerical density (No./10m²)	Biomass (kg/10m²)	Poomarichan Island Depth (m)	Numerical density (No./10m²)	Biomass (kg/10m²)
0	*Holothuria atra*	0.3	7	3.52	0.2	3	1.38	0.2	2	0.92
	Holothuria scabra		-	-		-	-		-	-
	Bohadschia marmorata		-	-		-	-		1	0.28
	Stichopus herrmanni		*2*	0.54		1	0.31		1	0.41
	Stichopus variegatus		-	-		1	0.36		-	-
	Total		9	4.06		5	2.05		3	1.61
50	*Holothuria atra*	0.5	9	4.71	0.4	6	5.21	0.5	5	3.81
	Holothuria scabra		-	-		1	0.80		-	-
	Bohadschia marmorata		*2*	1.28		2	1.21		2	1.21
	Stichopus herrmanni		*2*	0.97		1	0.37		1	0.48
	Stichopus variegatus		-	-		1	0.41		1	0.21
	Total		13	6.96		11	8.00		9	5.71
100	*Holothuria atra*	0.8	12	9.38	1.0	9	5.36	1.0	11	8.36
	Holothuria scabra		1	0.93		1	0.73		2	1.81
	Bohadschia marmorata		2	1.21		-	-		2	1.23
	Stichopus herrmanni		2	0.84		2	0.45		1	0.18
	Stichopus variegatus		2	0.73		-	-		2	0.20
	Stichopus sp.		-	-		1	0.31		-	-
	Actinopyga miliaris		-	-		-	-		-	-
	Total		19	13.09		13	6.85		18	11.78
150	*Holothuria atra*	1.0	12	8.51	1.0	12	9.15	1.0	18	13.25
	Holothuria scabra		2	2.21		2	1.20		3	2.50
	Bohadschia marmorata		2	1.73		2	1.51		1	0.78
	Stichopus herrmanni		3	0.38		1	0.18		2	0.37
	Stichopus variegatus		2	0.42		2	0.35		1	0.30
	Stichopus sp.		-	-		1	0.15		1	0.21
	Actinopyga miliaris		-	-		-	-		1	0.45
	Total		21	13.25		19	12.54		27	17.86
200	*Holothuria atra*	1.2	14	8.32	1.3	12	8.56	1.0	15	10.35
	Holothuria scabra		2	1.72		2	1.31		3	2.63
	Bohadschia marmorata		4	3.06		3	1.58		1	0.70
	Stichopus herrmanni		2	0.45		2	0.42		2	0.38
	Stichopus variegatus		2	0.63		2	0.32		1	0.45
	Stichopus sp.		1	0.18		1	0.15		1	0.13
	Actinopyga miliaris		-	-		1	0.76		1	0.50
	Total		25	14.36		23	13.10		24	15.14
250	*Holothuria atra*	1.5	17	13.10	1.5	16	11.63	1.4	14	7.67
	Holothuria scabra		3	2.10		3	1.76		3	1.28
	Bohadschia marmorata		7	3.28		3	1.38		2	1.63
	Stichopus herrmanni		3	0.92		1	0.42		1	0.40
	Stichopus variegatus		3	1.42		2	0.63		1	0.32
	Stichopus sp.		1	0.18		1	0.28		1	0.18
	Actinopyga miliaris		-	-		2	1.57		1	0.62
	Total		34	21.00		28	17.67		23	12.10
300	*Holothuria atra*	1.5	16	13.16	1.5	14	7.63	1.6	18	14.26
	Holothuria scabra		2	1.67		3	1.18		3	2.18
	Bohadschia marmorata		5	3.28		3	0.98		2	1.92
	Stichopus herrmanni		7	2.63		2	0.27		1	0.76
	Stichopus variegatus		1	0.28		1	0.18		1	0.28

Table cont....

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	Stichopus sp.		1	0.16		1	0.17		1	0.16
	Actinopyga miliaris		1	0.54		1	0.63		1	0.75
	Total		33	21.72		25	11.04		27	20.31
350	*Holothuria atra*	1.8	20	16.36	1.9	18	13.15	2.0	17	12.63
	Holothuria scabra		4	2.63		3	1.92		2	1.65
	Bohadschia marmorata		3	1.29		2	1.27		2	1.02
	Stichopus herrmanni		2	0.76		2	0.67		1	0.28
	Stichopus variegatus		2	0.63		1	0.26		2	0.37
	Stichopus sp.		1	0.18		1	0.15		1	0.17
	Actinopyga miliaris		-	-		1	0.67		1	0.68
	Total		32	21.85		28	18.45		26	16.80
400	*Holothuria atra*	2.0	18	13.10	2.0	15	10.30	2.0	16	10.15
	Holothuria scabra		3	1.87		4	2.63		4	2.20
	Bohadschia marmorata		3	1.63		2	2.00		4	2.08
	Stichopus herrmanni		2	0.78		1	0.30		2	0.63
	Stichopus variegatus		1	0.26		2	0.63		1	0.15
	Stichopus sp.		1	0.17		1	0.12		1	0.11
	Actinopyga miliaris		1	0.55		-	-		-	-
	Total		29	18.36		25	15.98		28	15.32
450	*Holothuria atra*	2.3	12	6.15	2.2	13	6.72	2.0	10	4.68
	Holothuria scabra		1	0.70		2	1.56		1	0.71
	Bohadschia marmorata		3	1.52		2	0.93		2	0.98
	Stichopus herrmanni		2	0.63		1	0.28		1	0.28
	Stichopus variegatus		1	0.28		1	0.12		1	0.13
	Stichopus sp.		-	-		-	-		1	0.15
	Actinopyga miliaris		-	-		-	-		-	-
	Total		19	9.28		19	9.61		16	6.93
500	*Holothuria atra*	3.0	8	3.52	3.0	10	6.27	3.5	7	3.51
	Holothuria scabra		1	0.63		2	1.45		2	1.28
	Bohadschia marmorata		2	0.92		1	0.89		1	0.92
	Stichopus herrmanni		1	0.26		2	0.80		1	0.31
	Stichopus variegatus		-	-		1	0.38		1	0.51
	Stichopus sp.		1	0.12		-	-		-	-
	Actinopyga miliaris		1	0.62		-	-		-	-
	Total		13	6.07		15	9.81		12	6.53
	Mean Total		22	13.64		19	11.37		19	11.83
	Species Diversity		1.31			0.91			0.98	

calculated and it ranged from 0.89 ind./10m^2 at Anaipar Island to 1.47 ind./10m^2 at Ervadi coast.

The standing stock of the holothurians was assessed by Swept-area method from the bottom trawl catch data obtained from off Nagapattinam at Coromandel coast, off Adirampatnam, off Thondi at Palk Bay and off Tharuvaikulum, off Tiruchendur in Gulf of Mannar region, and the results are given in Table 3. The trawling was operated by a fishing trawler at a depth of 8-15m for the duration of 0.75 to 1.00 hrs covering a distance of 2.5-3.0 km at 3-5 knot speed. A total of 7 species such as *Holothuria atra, Holothuria scabra, Bohadschia marmorata, Stichopus variegatus, Stichopus herrmanni, Holothuria spinifera* and *Actinopyga miliaris* were recorded during the study (Fig. 3). Of these 5 species were common at all the stations. However, all the 7 species are recorded at off Tharuvaikulum followed by 6 species at off Tiruchendur during the survey. The standing stock of the holothurians comprises of all the species occurring in these areas ranged from 27.34 kg/km^2 at off Tiruchendur to 62.80 kg/km^2 at off Tharuvaikulum. The data on the percentage composition of species indicated that *Holothuria atra* is predominantly distributed at all the places of study ranging

Table 2: Density and biomass of holothurians in Kilakarai group of islands of Gulf of Mannar during December 2006.

Distance from island fringe (m)	Species	Ervadi coast Depth (m)	Numerical density (No./10m²)	Biomass (kg/10m²)	Palliyarmunai Island Depth (m)	Numerical density (No./10m²)	Biomass (kg/10m²)	Anaipar Island Depth (m)	Numerical density (No./10m²)	Biomass (kg/10m²)
0	*Holothuria atra*	0.2	12	9.51	0.3	7	2.81	0.2	4	2.15
	Holothuria scabra		-	-		-	-		-	-
	Bohadschia marmorata		4	1.28		2	1.21		2	0.92
	Stichopus herrmanni		-	-		-	-		1	0.32
	Stichopus variegatus		1	0.71		1	0.81		-	-
	Stichopus sp.		-	-		-	-		-	-
	Actinopyga miliaris		-	-		-	-		-	-
	Total		16	11.50		10	4.83		7	3.39
50	*Holothuria atra*	0.5	15	10.28	0.4	12	9.27	0.5	9	2.16
	Holothuria scabra		-	-		-	-		1	0.78
	Bohadschia marmorata		6	3.15		4	1.28		2	0.92
	Stichopus herrmanni		2	0.75		1	0.23		2	0.82
	Stichopus variegatus		1	0.38		1	0.28		1	0.53
	Stichopus sp.		-	-		1	0.13		1	0.15
	Actinopyga miliaris		-	-		-	-		1	0.63
	Total		24	14.56		16	11.19		17	8.99
100	*Holothuria atra*	0.7	18	13.28	0.8	15	10.31	0.5	12	7.63
	Holothuria scabra		1	1.21		1	0.98		1	0.82
	Bohadschia marmorata		7	3.86		6	3.51		3	1.31
	Stichopus herrmanni		2	0.75		3	0.30		3	1.08
	Stichopus variegatus		2	0.93		1	0.50		1	0.53
	Stichopus sp.		1	0.18		1	0.21		-	-
	Actinopyga miliaris		-	-		1	0.92		-	-
	Total		31	20.21		28	16.73		20	11.37
150	*Holothuria atra*	1.0	16	10.26	1.0	14	7.62	0.9	15	10.22
	Holothuria scabra		1	1.32		2	1.82		3	2.60
	Bohadschia marmorata		5	1.68		5	2.68		2	1.62
	Stichopus herrmanni		1	0.28		2	0.63		1	0.45
	Stichopus variegatus		1	0.35		-	-		1	0.29
	Stichopus sp.		-	-		1	0.18		-	-
	Actinopyga miliaris		-	-		1	0.68		1	0.71
	Total		24	14.09		25	13.61		23	15.89
200	*Holothuria atra*	1.3	16	10.50	1.5	15	9.28	1.5	17	11.31
	Holothuria scabra		1	0.86		2	1.57		3	2.20
	Bohadschia marmorata		5	2.63		7	2.93		5	2.56
	Stichopus herrmanni		1	0.26		1	0.21		1	0.28
	Stichopus variegatus		1	0.68		2	0.67		2	0.75
	Stichopus sp.		1	0.15		1	0.19		-	-
	Actinopyga miliaris		1	0.72		-	-		1	0.71
	Total		26	15.80		28	14.85		29	17.81
250	*Holothuria atra*	1.8	18	13.38	1.6	15	10.10	1.5	16	10.57
	Holothuria scabra		2	1.54		2	1.83		3	2.01
	Bohadschia marmorata		1	0.70		1	0.56		2	0.92
	Stichopus herrmanni		1	0.28		2	0.72		1	0.38
	Stichopus variegatus		1	0.27		1	0.31		-	-
	Stichopus sp.		-	-		1	0.17		-	-
	Actinopyga miliaris		1	0.70		1	0.80		1	0.70
	Total		24	16.87		23	14.49		23	14.58

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300	*Holothuria atra*	2.0	19	14.87	2.0	17	13.09	2.0	12	7.18
	Holothuria scabra		3	1.58		3	2.12		4	2.23
	Bohadschia marmorata		6	1.72		4	1.56		2	0.97
	Stichopus herrmanni		1	0.27		1	0.42		1	0.30
	Stichopus variegatus		2	0.92		1	0.29		1	0.40
	Stichopus sp.		1	0.19		-	-		1	0.20
	Actinopyga miliaris		1	0.82		-	-		1	0.85
	Total		33	20.37		26	17.48		22	12.13
350	*Holothuria atra*	2.3	11	5.28	2.0	10	4.52	2.2	11	5.08
	Holothuria scabra		-	-		1	0.76		2	1.52
	Bohadschia marmorata		5	2.52		3	1.09		2	1.08
	Stichopus herrmanni		2	0.90		2	0.43		2	0.68
	Stichopus variegatus		-	-		1	0.45		1	0.23
	Stichopus sp.		1	0.16		-	-		1	0.15
	Actinopyga miliaris		-	-		-	-		1	0.76
	Total		18	8.86		17	7.25		20	9.50
400	*Holothuria atra*	2.5	15	9.21	2.5	12	7.50	2.5	8	3.08
	Holothuria scabra		2	1.56		1	0.78		2	0.98
	Bohadschia marmorata		7	2.78		4	1.21		3	1.21
	Stichopus herrmanni		2	0.92		3	1.02		1	0.20
	Stichopus variegatus		2	0.81		1	0.28		2	0.86
	Stichopus sp.		1	0.15		-	-		1	0.15
	Actinopyga miliaris		-	-		-	-		1	0.75
	Total		29	15.43		21	10.79		18	7.23
450	*Holothuria atra*	3.0	17	10.75	2.8	16	10.00	3.0	9	3.58
	Holothuria scabra		1	0.83		3	1.80		1	1.20
	Bohadschia marmorata		7	2.86		3	1.27		2	1.52
	Stichopus herrmanni		5	1.30		2	0.63		3	1.22
	Stichopus variegatus		1	0.30		1	0.20		1	0.32
	Stichopus sp.		-	-		1	0.14		2	0.22
	Actinopyga miliaris		-	-		1	0.82		1	0.68
	Total		31	16.04		27	14.86		19	8.52
500	*Holothuria atra*	3.3	11	4.20	3.0	10	3.75	3.5	7	3.82
	Holothuria scabra		1	0.70		2	1.25		1	1.11
	Bohadschia marmorata		5	3.63		2	1.52		2	1.28
	Stichopus herrmanni		2	0.72		1	0.20		1	0.36
	Stichopus variegatus		1	0.26		2	0.80		1	0.38
	Stichopus sp.		-	-		1	0.13		-	-
	Actinopyga miliaris		1	0.60		-	-		1	0.72
	Total		21	10.11		18	7.65		13	7.67
	Mean Total		25	14.89		22	12.56		19	10.64
	Species Diversity		1.47			1.08			0.87	

from 31.25 to 41.28%. The occurrence of *Holothuria scabra* was 15.62-22.22% in these transects. Other species of holothurians have a different degree of composition on their occurrence. It is fascinating to note that the *Holothuria spinifera* was recorded only at off Tharuvaikulum and off Tiruchendur with their composition 18.75% and 16.28% respectively.

The data on the incidental catch of holothurians in the fishing gears such as trawl net, gill net, artisional mini trawl, collected from 16 stations along Palk Bay and Gulf of Mannar, are depicted in Table 4. The quantity of holothurians encountered in trawl net ranged from 15 ind./haul at Point Calimere to 55 ind./haul at Rameswaram, whereas in gill net it varied from 8 ind./netting at Muttom

Table 3: Standing stock of Holothurians in selected transects along the east coast of India during December 2006.

Transect	Depth (m)	Duration of haul (hrs)	Distance covered (km)	Species	Percentage	Standing stock in wet wt. (kg/km^2)
Off Adirampatnam	12	1.00	3.0	*Holothuria atra*	33.33	38.36
				Holothuria scabra	22.22	
				Bohadschia marmorata	11.11	
				Stichopus herrmanni	15.56	
				Stichopus variegatus	17.78	
Off Thondi	8	1.00	3.0	*Holothuria atra*	40.00	50.37
				Holothuria scabra	21.43	
				Bohadschia marmorata	7.14	
				Stichopus herrmanni	14.28	
				Stichopus variegatus	17.15	
Off Tharuvaikulum	9	0.75	3.0	*Holothuria atra*	31.25	62.80
				Holothuria scabra	15.62	
				Bohadschia marmorata	10.94	
				Stichopus herrmanni	04.69	
				Stichopus variegatus	03.13	
				Holothuria spinifera	18.75	
				Actinopyga miliaris	15.62	
Off Tiruchendur	11	0.75	2.5	*Holothuria atra*	41.86	27.34
				Holothuria scabra	18.60	
				Stichopus herrmanni	04.65	
				Stichopus variegatus	06.98	
				Holothuria spinifera	16.28	
				Actinopyga miliaris	11.63	

Table 4: Incidental catch of Holothurians along the east coast of India during December 2006 (Values are in mean number of individuals encountered).

Stn. No.	Station	Frequency of occurrence per boat		
		Trawl Net (No./haul)	Gill Net (No./netting)	Artisional mini trawl (No./haul)
1.	Point Calimere	15	9	-
2.	Adirampatnam	22	17	18
3.	Thondi	28	19	15
4.	Devipatnam	25	15	22
5.	Pampan	30	20	17
6.	Mandapam (South)	33	18	15
7.	Mandapam (North)	32	20	13
8.	Vedalai	40	21	17
9.	Rameswaram	55	25	12
10.	Ervadi	35	20	27
11.	Kilakarai	42	22	14
12.	Tharuvaikulum	38	26	11
13.	Thirespuram	47	28	19
14.	Tuticorin Harbour	52	25	20
15.	Tiruchendur	23	18	7
16.	Muttom (Kanyakumari)	17	8	-

(Note: The total number of Holothurians includes the species such as *Holothuria scabra, Holothuria spinifera, Holothuria atra, Stichopus variegatus, Stichopus herrmanni, Bohadschia marmarata, Actinopyga miliaris* and *Acadina molpadioides*)

Table 5: Phytoplankton productivity and species diversity along the east cost of India during December 2006.

Stn. No.	Station	Tide	Cell count (No. × $10^2 L^{-1}$)	Species Diversity (H')
1.	Point Calimere	LT	58.52	2.02
2.	Adirampatnam	LT	60.21	2.07
3.	Thondi	HT	102.01	2.79
4.	Devipatnam	HT	97.83	2.67
5.	Pullivasal Island	LT	143.21	3.31
6.	Krusadai Island	LT	112.40	2.72
7.	Poomarichan Island	LT	122.08	2.78
8.	Vedalai	HT	134.81	3.28
9.	Rameswaram	HT	120.75	3.07
10.	Ervadi	LT	93.18	2.90
11.	Palliyarmunai Island	LT	97.10	2.91
12.	Anaipar Island	LT	90.15	2.85
13.	Kilakarai	LT	137.83	2.91
14.	Tharuvaikulum	HT	146.21	3.52
15.	Thirespuram	HT	98.70	2.58
16.	Tuticorin Harbour	HT	121.80	2.78
17.	Tiruchendur	LT	68.21	2.15
18.	Muttom (Kanyakumari)	HT	64.86	2.11

LT - Low Tide, HT - High Tide

to 28 ind./netting at Thirespuram. Considerable number of holothurians were also encountered in artisional mini trawl ranging from 7ind./trawl at Tuticorin harbour to 27ind./trawl at Devipatnam. Commonly recorded species as incidental catch were *Holothuria atra, Holothuria scabra, Holothuria spinifera, Stichopus variegatus, Stichopus herrmanni* and *Bohadschia marmorata*.

The total length of the holothurians observed during the present study is 18-35cm, 20-45cm, 20-45cm, 10-25cm, 22-33cm, 15-25cm, 12-22cm and 14-28cm for *Holothuria atra, Holothuria scabra, Bohadschia marmorata, Holothuria spinifera, Stichopus variegatus, Stichopus hermanni, Stochopus* sp. and *Actinopyga miliaris* respectively.

The results on the phytoplankton samples collected from seawater at all stations are presented in Tables 5 and 6. A total of 77 species of phytoplankton belonging to 55 genera were recorded from the study area. The phytoplankton total cell count ranged from 58.52×10^2 L^{-1} at Point Calimere to 146.21×10^2 L^{-1} at Tharuvaikulum. The species such as *Coscinodiscus eccentricus, Coscinodiscus oculus iridis, Coscinodiscus* sp., *Surirella flaminensis* and *Surirella maximum* were found at all the stations of study. It is fascinating to note that *Prorocentrum micans* and *Tetraedon trigonum* were recorded only at Ervadi and Thondi respectively. The total number of phytoplankton species at individual stations ranged between 22 at Muttom and 56 at Adirampatnam. The species diversity of phytoplankton was also calculated during the study period and the diversity maxima (3.52) was recorded at Thirespuram in Gulf of Mannar, and minima (2.02) at Point Calimere in Palk Bay.

The results for the qualitative and quantitative estimation of zooplankton and its distribution and density are shown in Tables 7 and 8. Altogether 61 species of zooplankton belonging to 14 groups were recorded from the present study. However, the total number of species at individual stations ranged from 22 at Devipatnam to 44 at Tuticorin harbour. The results of zooplankton study clearly indicated that the Foraminiferans were the predominant groups as they were represented by 23 spe-

Table 6: Distribution of Phytoplankton along study area during December 2006.

Sl No.	Species	Stations*																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1.	*Actinastrum hantzchii*	P	P	P		P					P	P	P				P		
2.	*Actinotychus undulates*	P	P	P		P			P		P	P	P		P		P		P
3.	*Amphora lineolata*	P	P	P	P	P		P	P				P				P		P
4.	*Amphora ostreoria*	P	P	P	P	P		P	P				P				P	P	
5.	*Asteronella japonica*			P	P			P	P		P	P	P					P	
6.	*Auladiscus orbiculatus*		P	P	P			P	P		P	P	P					P	
7.	*Auliscus sculptus*		P		P			P	P		P	P	P					P	
8.	*Bacillaria paradoxa*		P		P			P	P									P	
9.	*Bellerochea malleus*	P	P		P	P	P	P											
10.	*Biddulphia heteroceros*	P	P		P	P	P	P			P	P	P	P	P	P	P		
11.	*Campylodiscus iyengarii*	P	P	P		P	P		P		P	P	P	P	P	P	P		P
12.	*Ceratium axiale*	P	P	P		P	P		P		P	P	P	P	P	P	P		P
13.	*Ceratium azoricum*		P	P		P	P		P		P	P	P	P	P	P			P
14.	*Ceratium furca*		P	P		P	P		P		P	P	P	P	P	P			
15.	*Ceratium trichoceras*	P		P		P	P		P		P	P	P	P	P	P			
16.	*Chaetoceros coaractatus*	P		P		P	P				P	P	P	P	P	P			
17.	*Chaetoceros lorenzianus*	P		P	P	P	P	P			P	P						P	
18.	*Climacosphenia moniligera*	P	P	P		P	P	P			P	P				P			P
19.	*Closterium* sp.	P	P	P	P	P	P	P											
20.	*Coelosphaericum kuetzingianum*	P	P	P	P	P	P	P	P	P				P	P	P	P	P	P
21.	*Corethron hystrix*	P	P	P	P			P	P	P	P	P	P	P	P	P	P	P	P
22.	*Coscinodiscus eccentricus*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
23.	*Coscinodiscus jonesianus*	P	P	P	P	P			P	P	P	P	P	P	P	P	P	P	P
24.	*Coscinodisucs oculus iridis*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
25.	*Coscinodiscus* sp.	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
26.	*Cyclotella meneghiniana*		P	P	P				P	P	P					P	P	P	
27.	*Cyclotella stelligera*	P	P	P					P	P	P					P	P	P	
28.	*Cymbella marina*	P	P	P		P			P	P	P					P	P	P	
29.	*Diatoma anceps*	P							P	P	P								
30.	*Diploneis smithi*	P									P	P	P	P			P		
31.	*Diploneis weissylogii*	P	P	P															
32.	*Fragillaria crotonensis*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
33.	*Fragillaria oceanica*	P	P	P						P	P						P	P	P
34.	*Gloeotrichia echinulata*	P	P	P									P	P					
35.	*Goniaulax birostris*	P						P		P	P					P			
36.	*Gossleriella tropica*	P	P	P				P											
37.	*Gramatophora mirificum*	P	P	P				P			P								P
38.	*Gyrosigma balticum*	P	P	P									P						
39.	*Hemiculus hauckii*	P	P	P				P					P					P	
40.	*Lauderia annulata*	P	P	P	P														
41.	*Lauderia borealis*	P	P	P	P			P	P	P	P					P			P
42.	*Leptocylindrus donicus*				P	P					P	P	P	P					
43.	*Lyngbya confervoides*		P	P	P	P			P			P				P			
44.	*Melosira* sp.		P			P						P							P
45.	*Merismopedia* sp.		P		P	P			P								P		
46.	*Nitzschia seriata*		P			P									P				
47.	*Nitzschia sigma*		P			P	P	P	P	P	P	P	P	P	P	P	P	P	P
48.	*Ornithocerus steinii*		P	P	P														
49.	*Oscillatoria limosa*	P	P	P	P						P								

Table cont....

.....cont Table

50.	*Pediastrum simplex*	P	P	P	P		P							P			P	
51.	*Phyrophacus harologicum*		P	P	P				P		P		P			P		
52.	*Pleurosigma angulatum*		P				P				P			P			P	
53.	*Pleurosigma elongatum*		P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
54.	*Pleurosigma galapagense*	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
55.	*Pleurosigma normanii*	P	P			P											P		
56.	*Prorocentrum maximum*								P	P		P							
57.	*Prorocentrum micans*										P								
58.	*Protoperidinium depressum*	P	P	P	P	P	P	P	P	P	P	P	P	P					
59.	*Protoperidinium oceanicum*	P	P	P	P							P					P		
60.	*Rhaphoneis discoides*	P		P	P		P								P				
61.	*Rhizosolenia cylindricus*	P		P	P														
62.	*Rhizosolenia stolterfothii*	P		P	P			P							P				
63.	*Schroederella delicatula*	P										P						P	
64.	*Stephaenodiscus* sp.				P				P					P					
65.	*Striatella delicatula*	P										P				P			
66.	*Surirella flaminensis*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
67.	*Surirella maximum*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
68	*Synedra formosa*					P					P							P	
69.	*Tetraedron trigonum*			P															
70.	*Thalassiothrix frauenfeldii*								P								P		
71.	*Thalassiothrix longissima*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
72.	*Thalassiothrix nitzschioides*	P									P			P				P	
73.	*Trachyneis aspera*	P	P	P	P	P	P	P											
74.	*Treubaria varia*	P	P													P			
75.	*Triceratium favus*	P	P																
76.	*Umbilicosphaera mirabilis*					P			P				P		P			P	
77.	*Westella botryoides*		P								P								P
	Total No. of species	53	56	49	39	30	27	31	38	28	44	35	34	27	26	30	30	29	22

Station*: 1-Point Calimere, 2-Adirampatnam, 3-Thondi, 4-Devipatnam, 5-Pullivasal Island, 5-Krusadai Island, 7-Poomarichan Island, 8-Vedalai, 9-Rameswaram, 10-Ervadi, 11-Palliyarmunai Island, 12-Anaipar Island, 13-Kilakarai, 14-Tharuvaikulum, 15-Thirespuram, 16-Tuticorin Harbour, 17-Tiruchendur and 18-Muttom

cies followed by Copepods which comprised of 16 species. It is noteworthy to state that the distribution of Chaetognath *Sagitta enflata*, and Copepods *Acartia spinicauda, Macrosetella gracilis, Microsetella gracilis, Miracia efferata, Nanocalanus minor, Oithona brevicornis* and *Pracalanus parvus* were recorded at all stations. Other species of zooplankton had different degree of distribution. The biomass of zooplankton in terms of fresh weight, dry weight and volume were estimated. The minimum values for these variables were 1012 mg/100m^3, 287 mg/100m^3 and 2.1 mL/100m^3 at Muttom, and maximum of 4900 mg/100m^3, 1730 mg/100m^3 and 14.5 mL/100m^3 at Rameswaram respectively. The species diversity of zooplankton was calculated during the study period and it was low (0.92) at Muttom, and high (2.80) at Rameswaram.

The physico-chemical properties of seawater are the prime factors indicating the quality of the coastal waters which directly influence the primary, secondary and tertiary producers in the marine environment. The data on these parameters, obtained from surface seawater samples collected along the study area, are depicted in Table 9. The surface seawater temperature ranges from 24.1°C at Anaipar Island to 30.0°C at Tuticorin harbour. Concentration of hydrogen ion (pH) did not show any significant variation at all stations of study, however, it varied from 7.6 at Adirampatnam to 8.1 at quite a number of stations. The salinity of seawater was estimated and it registered minimum values (28.2 ppt) at Adirampatnam and maximum value (35.2 ppt) at Kilakarai. The transparency in terms

Table 7: Zooplankton productivity and diversity along the east coast of India during December 2006.

Stn. No.	Station	Tide	Numerical Density*	Fresh wt. (mg/100 m^3)	Dry wt. (mg/100 m^3)	Volume (mL/100 m^3)	Species diversity (H')
1.	Point Calimere	LT	10250	1073	312	2.4	0.97
2.	Adirampatnam	LT	9430	1128	335	2.5	0.93
3.	Thondi	HT	13280	2837	912	6.2	1.07
4.	Devipatnam	HT	13280	2915	920	6.2	1.15
5.	Pullivasal Island	LT	25210	4310	1627	12.8	2.37
6.	Krusadai Island	LT	23480	4220	1588	13.0	2.25
7.	Poomarichan Island	LT	26670	4750	1678	13.2	2.52
8.	Vedalai	HT	22610	3988	1416	12.5	2.12
9.	Rameswaram	HT	28470	4900	1730	14.5	2.80
10.	Ervadi	LT	19270	3512	1218	10.3	1.98
11.	Palliayarmunai Island	LT	17610	3458	1195	9.8	1.71
12.	Anaipar Island	LT	18320	3510	1200	7.7	1.80
13.	Kilakarai	LT	22340	4227	1518	13.0	2.30
14.	Tharuvaikulum	HT	22300	4210	1506	13.0	2.32
15.	Thirespuram	HT	22410	4001	1415	12.8	2.35
16.	Tuticorin Harbour	HT	23340	4128	1426	12.9	2.35
17.	Tiruchendur	LT	11250	1915	703	5.3	1.25
18.	Muttom (Kanyakumari)	HT	9280	1012	287	2.1	0.92

LT – Low Tide, HT – High Tide, *Numerical density (No./100 m^3).

of penetration of light in the seawater column was also measured and it shows low (2.0m) at Adirampatnam and high (5.2m) at Krusadai Island.

The nature of sea bottom along the study area was also observed and it has the characteristics of silty-sand at majority of stations in Gulf of Mannar while sandy-silt in few stations as the luxuriant growth of coral reef in this area. However, in Adirampatnam and Muttom the sea bottom is muddy and rocky respectively.

DISCUSSION

The Gulf of Mannar and Palk Bay are well known for the richness of marine biodiversity including holothurians. These areas harbour 30 species of holothurians belonging to 4 Orders, 6 Families and 12 Genera (Naganathan 2005). However, the present study recorded only 8 species viz., *Holothuria atra, Holothuria scabra, Bohadschia marmorata, Stichopus herrmanni, Stichopus variegates, Stichopus* sp., *Actinopyga miliaris* and *Holothuria spinifera* belonging to Holothuriidae and Stichopodidae families. This might be attributed to the distributional changes in the species composition as reported by James (1986a). During his study on the distribution of Indian echinoderms, it is noted that some species, which were absent at a particular place, were found to be common after a few years and vice-versa. Notably James (1986a) could not find a single specimen of *Holothuria* (*Salenkothuria*) *erinaceus* and *Phyrella fragilis* in south point of Port Blair during 1965, however, these species were found to be common in the same locality during 1975. Similarly, Gravely (1927) has reported *Stichopus chloronotus* to be common around Rameswaram but during years 1963 to 1968 when intensive collections were made, not a single specimen of the above species was seen around Rameswaram. Likewise, *Ophiocoma erinaceus* recorded by Thurston (1894) and Bell (1888), *Ophiocoma scolopandrina, Holothuria* (*Thymiosycia*) *hilla* and *Psolus complanatus* recorded by

Table 8: Distribution of zooplankton along study area during December 2006.

Sl No.	Species	Station*																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Annelid																		
1.	Setiger larva	P	P				P		P		P		P		P			P	P
2.	Spirorbis larva		P	P			P					P							
	Appendicularian																		
3.	*Oikopleura dioica*	P					P					P				P	P		
	Bivalve																		
4.	*Anadara granosa*	P	P	P															P
5.	*Crassostrea cuculata*	P		P			P											P	P
6.	*Sunetta effosa*	P	P	P									P			P	P	P	P
7.	*Tellina tellina*	P	P	P									P				P	P	P
	Chaetognath																		
8.	*Sagitta enflata*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
9.	*Sagitta maxima*			P			P				P		P	P		P	P	P	P
	Cladoceran																		
10.	Evadne tergestina	P				P	P	P		P	P		P		P	P	P	P	P
	Copepod																		
11.	*Acartia spinicauda*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
12.	*Corycaeus danae*	P			P			P	P	P	P					P	P	P	
13.	*Euterpina acutifrons*			P			P								P		P	P	
14.	*Labidocera pavo*				P			P			P			P	P	P	P		
15.	*Longipedia coronata*	P	P			P	P		P	P	P	P	P	P		P			
16.	*Lucicutia flavicornis*	P	P	P	P			P	P	P	P	P		P	P	P		P	P
17.	*Macrosetella gracilis*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
18.	*Metis jousseamei*	P	P	P							P	P	P	P	P	P	P	P	
19.	*Microsetella gracilis*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
20.	*Miracea efferata*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
21.	*Nannocalanus minor*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
22.	*Oithona brevicornis*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
23.	*Paracalanus parvus*	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
24.	*Pontella danae*		P		P			P			P			P	P	P	P		
25.	*Pontellina pulmata*		P		P		P			P				P		P	P	P	
26.	*Rhincalanus cornutus*	P	P	P				P	P	P	P		P	P		P	P	P	P
27.	*Temora discaudata*	P	P			P	P	P	P	P	P			P	P	P	P		
	Cruastacean																		
28.	Megalopa larva	P	P					P	P	P						P	P	P	
29.	Nauplii				P	P	P	P	P	P	P	P	P	P					
30.	Zoea			P	P	P	P	P	P	P	P	P	P			P	P	P	P
	Euphausid																		
31.	*Euphausia diomediae*	P	P			P	P			P	P	P				P	P	P	P
	Foraminiferan																		
32.	*Amhistegina lessonii*	P		P				P			P		P	P				P	P
33.	*Bolivinita quadrilatera*	P		P				P			P		P	P				P	P
34.	*Bolivinita rhomboidatis*		P	P	P									P	P	P		P	P
35.	*Calcarina calcar*	-	P	-	-	P	-	-	P	P	-	-	P	P	-	-	P	P	-
36.	*Ctyclogyra involvens*	-	P	P	-	-	-	-	-	-	P	-	-	-	P	-	-	-	-
37.	*Elphidium jensoni*					P								P					
38.	*Elphidium rapandus*			P															
39.	*Globigerinoides rubber*	P	P	P				P	P	P	P						P	P	
40.	*Globigerinoides sacculifer*							P	P	P	P						P	P	
41.	*Loxostomum limbatum*					P		P		P						P	P	P	

Table cont....

...cont. Table

42.	*Nonion depressulum*	P	P	P			P	P	P		P	P			P	P	P		P
43.	*Peneroplis pertusus*					P		P		P							P	P	
44.	*Quinqueloculina crassa subcuneata*	P	P			P	P	P			P		P	P			P		
45.	*Quinqueloculina curta*					P					P	P					P		
46.	*Quinqueloculina laevigata*				P						P			P			P		
47.	*Quinqueloculina polygona*					P				P				P			P		P
48.	*Quinqueloculina rhodiensis*	P		P				P		P		P							
49.	*Quinqueloculina seminulum*			P					P	P	P	P	P	P					
50.	*Rosalina bradyi*	P		P			P				P			P		P			
51.	*Rosalina globularis*		P			P				P				P		P			
52.	*Spirillina limbata* var. decorata		P	P		P			P		P		P		P		P		
53.	*Spiroloculina antillarum*		P		P		P				P		P		P		P		
54.	*Triculina irregularis*	P			P			P		P			P		P		P		
	Gastropod																		
55.	*Janthina janthina*	P	P												P	P			
56.	*Umbonium vestarium*	P	P	P			P		P		P			P		P	P	P	P
57.	*Veliger larvae*			P		P	P	P	P	P		P	P	P	P	P	P	P	
	Ostrocod																		
58.	*Conchoecia indica*	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P
	Pisces																		
59.	Fish eggs	P	P	P	P				P	P	P					P	P	P	P
	Salpid																		
60.	*Salpa maxima*	P	P	P					P	P	P						P		
	Tintinnid																		
61.	*Tintinnopsis cylindra*	P		P	P	P	P	P	P	P	P				P	P	P		
62.	*Tintinnopsis tubulosa*			P	P	P	P	P	P	P	P	P				P	P	P	
	Total No. of species	37	36	37	22	27	30	32	30	35	41	23	28	32	26	36	44	36	27

Station*: 1-Point Calimere, 2-Adirampatnam, 3-Thondi, 4-Devipatnam, 5-Pullivasal Island, 5-Krusadai Island, 7-Poomarichan Island, 8-Vedalai, 9-Rameswaram, 10-Ervadi, 11-Palliyarmunai Island, 12-Anaipar Island, 13-Kilakarai, 14-Tharuvaikulam, 15-Thirespuram, 16-Tuticorin Harbour, 17-Tiruchendur and 18-Muttom

Gravely (1927) could not be collected again. All this shows that some changes in the species composition have taken place time to time and it is very difficult to predict the factors contributed to the changes.

The distribution and density of holothurians, studied through LIT method, revealed that the numerical density ranged from 19-25 ind./10m^2 which comprises of 7 species in Gulf of Mannar. Among them *Holothuria atra* was found to be high and distributed throughout the study area, has a maximum density of 20 ind./10m^2 in Krusadai Island. The density of commercially important species *Holothuria scabra* was reduced to 1-4 ind./10m^2. Similarly, Venkataraman et al. (2003) observed only 45 holothurians from 21,250 m^2 area in Palk Bay region comprising of *Holothuria atra* (31 Nos.), *Holothuria scabra* (10 Nos.) and *Holothuria spinifera* (4 Nos.). It is evinced that the density of holothurians has been enhanced moderately in Gulf of Mannar after the inclusion of these animals under Schedule-I category resulting in the ban on fishing of these organisms. However, comparatively the density on individual species of holothurians was high in Andaman waters. It is reported that the numerical abundance of holothurians ranged from 10-15 ind./25m^2 for *Holothuria atra* and 10 ind./25m^2 for *Holothuria scabra* in Sesostris Bay, 10-15 ind./25m^2 for *Actinopyga miliaris* at Wandoor, 10-15 ind./25m^2 for *Bohadschia vitiensis* in Blair Reef, 5-10 ind./25m^2 for *Labidodemas*

Under quadrant in Gulf of Mannar

Different size group

Fig. 2: Holothuria atra

(a) *Bohadschia marmorata*

(b) *Holothuria scabra*

(c) *Stichopus herrmanni*

(d) *Stichopus* sp.

Fig. 3: Different species of *Holothurians.*

Fig. 4: Processed *Beche-de-mer* of *Holothuria spinifera*.

Table 9: Physico-chemical parameters of seawater along the east coast of India during December 2006.

Stn. No.	Station	Temperature(ºC)		Salinity (ppt)	pH	Trans-parency (m)	Type of coast/sea floor
		Atmosphere	Seawater				
1.	Point Calimere	27.1	25.3	30.0	7.9	2.5	Sandy mud
2.	Adirampatnam	28.0	25.0	28.2	7.6	2.0	Muddy
3.	Thondi	29.8	27.0	34.7	8.0	3.5	Sandy silt
4.	Devipatnam	30.1	28.0	35.0	8.1	4.1	Sandy silt
5.	Pullivasal Island	26.2	25.3	34.8	8.0	5.0	Silty sand
6.	Krusadai Island	27.1	25.7	34.8	8.0	5.2	Silty sand
7.	Poomarichan Island	28.2	26.0	34.9	8.1	5.5	Silty sand
8.	Vedalai	33.2	27.0	35.0	8.0	5.0	Silty sand
9.	Rameswaram	30.0	29.0	35.2	8.1	4.0	Silty sand
10.	Ervadi	27.1	25.2	34.7	7.9	4.5	Silty sand
11.	Palliyarmunai Island	27.0	25.0	34.5	7.8	4.9	Silty sand
12.	Anaipar Island	26.0	24.1	34.6	7.8	5.0	Silty sand
13.	Kilakarai	27.2	25.2	35.2	7.7	5.2	Silty sand
14.	Tharuvaikulum	30.2	28.0	33.2	7.8	2.8	Sandy silt
15.	Thirespuram	35.1	29.2	34.2	8.0	2.7	Sandy silt
16.	Tuticorin Harbour	33.2	30.0	35.1	8.1	2.5	Sandy silt
17.	Tiruchendur	31.2	29.0	35.0	8.0	2.7	Sandy
18.	Muttom (Kanyakumari)	25.0	25.0	35.0	8.1	2.8	Rocky

rugosum in Andaman Islands and 25-125 ind./25m^2 for *Holothuria leucospilota* in Hut Bay (Lalmohan et al. 1986). James (1982) reported that the density of *Holothuria scabra* was 10 ind./25m^2 in muddy flats of Indian seas. However, low density of *Holothuria scabra* during the present study mainly attributed to the overexploitation coupled with indiscriminate fishing in Gulf of Mannar and Palk Bay as this species has got great demand and market potential for high quality *beche-de-mer* (Fig. 4). The distribution of other species was also scarce while comparing with earlier records of Lalmohan et al. (1986).

The species observed through LIT method in Gulf of Mannar were also found in the standing stock assessment by Swept Area method studied in 5 stations along Palk Bay and Gulf of Mannar except *Holothuria spinfiera* which was encountered only at off Tharuvaikulum and off Tiruchendur. The data obtained from the Swept Area method clearly indicated that the density and distribution of holothurians were high in near-shore or island fringe where the depth is less than 10m, whereas in open waters, where the depth is above 10 m, its density was very low as recorded 27.34-62.80 kg/km^2 during the study. It also showed that *Holothuria atra* was a dominant species both in near-shore and offshore waters as this species got an adaptability to dwell in coral reef flats, sandy and muddy patches and also in the seaweed meadow. The data on the standing stock of holothurians calculated during the present investigation is widely varied from their density observed by James & Baskar (1944) along Palk Bay and Gulf of Mannar. The studies made by these authors reported that trawl catch of *Holothuria scabra* alone was 16.25kg at Mandapam, 120kg at Tuticorin, 27.3kg at Rameswaram, 30kg at Mullipunai, 225kg contributing 750 specimens at Sethubavachatram, 100 specimens at Kattumavadi, 150 specimens at Kottaipatnam and 50 specimens at Adirampatnam in a single haul along these coasts. The present data clearly indicated the drastic reduction in the population of *Holothuria scabra* over the period of 12 years.

Albeit a ban on holothurians fishing, it was noted that considerable quantity of these animals caught as an incidental catch by different kinds of gears, which are being operated at depth of 10-30m. Incidental catch of this organism is one of the potential factors for the reduction of wild stock as it landed regularly at a rate of 7 to 55 ind./gear/haul or netting observed through this study. Epitome of the study confirms the distribution of these faunal groups along entire stretch of Palk Bay and Gulf of Mannar. However, the frequency of occurrence was more in trawl net followed by either gill net or artisional mini trawl net in Gulf of Mannar than Palk Bay. This study also proves the predominance of *Holothuria atra* at all stations.

It is found that the holothurians were always associated with seagrass and seaweed meadow along the study area. They are commonly found along with seagrass *Cymodocea serrulata, Thallassia hemperichii* and *Halodule uninervis* and the seaweeds *Halimeda* sp., *Sargassum* sp., *Gracillaria edulis, Hypnea valentia, Padina* sp., *Gelidiella acerosa, Ulva lactuca* and *Ulva fasciata*. Similar observations were also made by Venkataraman et al. (2003) in Palk Bay where the holothurians were found dominant in seagrasses *Enhalus acroides* and *Halodule ovalis*. It is also observed from the present study that *Holothuria scabra* prefers sandy substratum and it agreed with the Mercier et al. (2000) in Salomon Islands. Considerable number of young animals of *Holothuria atra* and *Holothuria scabra,* noticed during the course of present investigation, confirms the reproductive periodicity and peak spawning of these organisms during July to October as reported by Krishnaswamy & Krishnan (1967).

The physio-chemical parameters of seawater shows no drastic changes in its quality, whereas the fluctuation in the values of salinity might be due to inflow of freshwater by riverine run-off and torrential rain along the coast during the study period. The quintessence of results acquired for seawater transparency indicated that the stations between Devipatnam and Kilakarai were high light penetration than the other stations studied. The less water transparency might be due to the higher concentration of total suspended solids mainly attributed to the river-borne sediment transported to Bay of Bengal.

The phytoplankton are the primary producers of the marine trophic level and play a vital role while assessing the health of marine environment. The higher values of phytoplankton cell count obtained in Gulf of Mannar during the present study is well agreed with the results of NEERI (2004) as it recorded 3400 to 8600 cells/L in this region. The secondary producers or primary consumers are zooplankton, highly responsible for the fishery potential including holothurians. The density, biomass and distribution of zooplankton obtained from the present study are significantly correlated with the phytoplankton productivity in quite a number of stations and indicated the balanced state of primary production and primary consumption during the period of observation. However, the low values of zooplankton productivity observed in some of the stations might be attributed to the poor phytoplankton productivity in that particular region because of very low light penetration due to high turbidity and diel vertical migration of zooplankton.

In conclusion it is observed that the population and distribution of most economically important species like *Holothuria scabra* and *Holothuria spinifera* were drastically reduced due to intensive poaching in Palk Bay and Gulf of Mannar despite the awareness about a ban on its fishing. It is also observed that 300-700 specimens of *Holothuria scabra* and 200-400 specimens of *Holothuria spinifera* at Mandapam, 150-200 specimens of *Holothuria spinifera* at Rameswaram, 600-1000 specimens comprising of *Holothuria spinifera, Bohadschia marmorata* and *Actinopyga echinites* at Kilakarai, 300-600 specimens of *Holothuria scabra* at Thondi, and 400-900 specimens of *Holothuria spinifera*

and *Actinopyga miliaris* at Tuticorin were illegally landed everyday during the course of this study. Effective implementation of the ban may be reinforced rigorously in the intensive poaching/illegal fishing areas in order to resume the optimal population density of holothurians in Gulf of Mannar. Detailed investigations on reproductive cycle, spawning beahaviour, longevity, fecundity and zoogeography of holothurians will be helpful to draw management strategies for conserving these declining resources.

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REFERENCES

Bell, F.J. 1887. Report on a collection of Echinodermata from the Andaman Island. Proc. Zool. Soc. Lond., 1887: 139-145.

Bell, F.J. 1889. Additions to the Echinoderm fauna of Bay of Bengal. Proc. Zool. Soc. Lond., 1889: 6-7.

Bell, F.J. 1888. Report on a collection of Echinoderms made at Tuticorin, Madras. By Mr. E. Thurston, Proc. Zool. Soc. Lond., 1888: 383-389.

Clark, A.M. and Row, F.W.E. 1971. Monograph of shallow-water Indo-West Pacific Echinoderms. Trustees of the British Museum (Natural History), London, 238 pp.

Coiller, C. 1830. On the Trepang or *Bachio-do-Mar* or sea slug of India: The *Holothuria tubulosa* of naturalists, Edinburgh. *New Phil. J.*, 8: 46-52.

English, S., Wilkinson, C. and Baker, V. (Eds.) 1994. Survey Manual for Tropical Marine Resources. ASEAN-Australian Marine Science Project: Living Coastal Resources. Australian Institute of Marine Science, Townsville, 368p.

Gideon, P.W., Menon, P.K.B.., Rao, S.R.V. and Jose, K.V. 1957. On the marine fauna of Gulf of Katuch: A preliminary account. J. Bombay Nat. Hist. Soc., 54: 690-706.

Gopalakrishnan, P. 1969. On the Holothuroidea (Echinodermata) of the Gulf of Kutch. J. Bombay Nat. Hist. Soc., 66(2): 399-400.

Gravely, F.H. 1927. Littoral fauna of Krusadai Island in the Gulf of Mannar. Echinodermata. Bull. Madras. Govt. Mus., 1: 163-173.

Gravely, F.H. 1941. Shells and other animal remains found on the Madras beach. Bull. Madras Govt. Mus., 5: 86-90.

Hornell, J. 1917. The Indian *beche-de-mer* industry: Its history and recent revival. Madras Fish. Bull., 11(4): 119-150.

Husted, F. 1930. Bacillariophyta, Diatomaceae, In: Pasher's Diesur Wasser Flora Mitle Europas.

James, D.B. 1967. *Phyllophorus (Phyllophorella) parvipedes* Clark (Holothuroidea), a new record to the Indian Seas. J. Mar. Biol. Ass. India, 7(2): 325-327.

James, D.B. 1968. Studies on Indian Echinoderms-2. The holothurian *Stolus buccalis* (Stimpson) with notes on its systematic position. Mar. Biol. Ass. India, 8(2): 285-289.

James, D.B. 1973. *Beche-de-mer* resources of India. Proceedings of the Symposium on Living Resources, pp. 706-711. Organized by CMFRI, Cochin.

James, D.B. 1982. Ecology of intertidal echinoderms of the Indian Seas. J. Mar. Biol. Ass. India, 24(1&2): 124-129.

James, D.B. 1983. Sea Cucumber and Sea Urchin resources. Bull. Cent. Mar. Fish. Res. Inst., 34: 85-93.

James, D.B. 1986a. Zoogeography of shallow-water Echinoderms of Indian Seas. In: Recent Advances in Marine Biology, P.S.B.R. James (Ed.). Today and Tomorrow's Publishers, New Delhi. pp. 569-591.

James, D.B. 1986b. The holothurian resources for Marine Fisheries Resources and Management. R & D. Series No. 10, CMFRI, Cochin.

James, D.B. 1986c. Quality improvement in Beche-de-mer. Seafood Exp. J., 18(3): 5-10.

James, D.B. 1987. Prospects of problems of *Beche-de-mer* industry in Andaman and Nicobar Islands. Proc. Sym. Management of Coastal Ecosystems and Oceanic Resources of Andaman, Andaman Science Association, Port Blair, pp. 110-113.

James, D.B. 1988. Echinoderm fauna of the proposed National Marine Park in the Gulf of Mannar. Proc. Symp. Endangered Marine Animals and Marine Parks, pp. 403-406.

James, D.B. 1989. *Beche-de-mer* its resources, fishery and industry. Mar. Fish. Infor. Serv., T&E Ser. No. 92: 1-35.

James, D.B. 1991. Research, conservation and management of edible holothurians and their impact on *Beche-de-mer* industry. Bull. Cent. Mar. Fish. Res. Inst., 44(3): 648-661.

James, D.B. 2001. Twenty sea cucumbers from seas around India. Naga, 24(1&2): 4-8.
James, D.B. 1998. Ecological significance of echinoderms of the Gulf of Mannar. Workshop on Coastal Biodiversity of Gulf of Mannar. Organised by M.S. Swaminathan Research Foundation, Chennai, February 10-11, 1998. pp. 118-128.
James, D.B. and Baskar, B.K. 1994. Present status of the *Beche-de-mer* industry in the Palk Bay and the Gulf of Mannar. Bull. Cent. Mar. Fish. Res. Inst., 46: 85-90.
James, D.B. and James, P.S.B.R. 1993. A Handbook on Indian Sea Cucumber. Bull. Cent. Mar. Fish. Res. Inst., 59: 1-49.
James, P.S.B.R. and James, D.B. 1994. Management of Beche-de-mer industry in India. In: K. Rengarajan and D.B. James (Eds.). Proceedings of the National Workshop on Beche-de-mer. Bull. Cent. Mar. Fish. Res. Inst., 46: 17-22.
James, D.B., Gandhi, A.D. and Palaniswamy, N. 1993. Sea ranching of sea cucumbers. Marine Fisheries Information Service, T&E Ser. No. 124: 15-17.
Krishnaswamy, S. and Krishnan, S. 1967. A report on the reproductive cycle of the holothurian, *Holothuria scabra* Jaeger, Curr. Sci., 36(6): 155-156.
Lalmohan, R.S., James, D.B. and Kalimuthu, S. 1986. Mariculture Potentials. Bull. Cent. Mar. Fish. Res. Inst., 44: 85-93.
Mary Bai, M. and Ramanathan, M.B. 1977. Occurrence of the Aspidochirote holothurian, *Holothuria (Semperothuria) cinerascens* Brandt (1835) along the coast of Kanyakumari (South India). J. Bombay Nat. Hist. Soc., 74(2): 380-389.
Mercier, A., Battaglene, S.C. and Hamel, J.F. 2000. Periodic movement recruitment and size-related distribution of sea cucumber *Holothuria scabra* in Salomon Islands. Hydrobiologia, 440: 81-100.
Mukhopadhyay, S.K. and Samanta, T.K. 1983. On a collection of shallow-water holothurians from Lakshadweep. Rec. Zool. Surv. India, 81: 299-314.
Naganathan, V. 2005. Sea cucumber of Gulf of Mannar. In: Sea Cucumbers and Sea Snakes of Gulf of Mannar. p. 1-50.
NEERI 2004. Environmental Impact Assessment for Proposed Sethusamudram Ship Canal Project. National Environmental Engineering Research Institute, Nagpur.
Nithyanandan, M. 2003. Sea cucumber resources in peril. Samudra, November issue, 24-26 pp.
Parulaker, A.H. 1981. Marine fauna of Malvan, Central West Coast of India. Mahasagar, 14: 33-44.
Pauly, D. 1984. Fish Population Dynamics in Tropical Waters: A Manual for Use With Programmable Calculators. Published by International Centre for Living Aquatic Resources Management, Manila, Philippines, ICLARM Studies and Reviews, No. 8, 325 pp.
Pergallo, M. 1965. Diatomees marines, De France, District Marchitimes Voisins, Asher & Co., Amsterdam.
Rao, G. C. 1968. On *Psamothuria ganapatii* n. gen., n. sp. An interstitial holothurian from the beach sands of Waltair coast and its autoecology. Proc. Indian Acad. Sci., 67(B) (5): 201-206.
Rao, G.C. 1973. Occurrence of some juvenile stages referable to apodous holothurian *Patinapta ooplax* (Marenzeller) in the intertidal sands of Andman Islands. Proc. Indian Acad. Sci., 77(B) (6): 225-233.
Rao, G.C. 1975. On a new intersitial species of *Troochodota* (Apodida, Holothuroidea) from Andamans, India. Curr. Sci., 44(14): 508-509.
Sane, S.R. and Chhapgar B.F. 1968. Intertidal Echinodermata of Bombay. J. Bombay Nat. Hist. Soc., 59(2): 672-675.
Soota, T.D., Mukhopadyay, S.K. and Samanta, T.K. 1983. On some holothurians from the Andaman and Nicobar Islands. Rec. Zool. Surv., India, 80: 507-524.
Thurston, E. 1887. Preliminary report on the marine fauna of Rameswaram and neighbouring island. Bull. Madras Govt. Mus., 1: 1-44.
Thurston, E. 1894. Rameswaram island and fauna of the Gulf of Mannar, Madras. Madras Govt. Mus. Sci. Ser., 1: 78-138.
Venkataraman, K., Nithyanandan, M. and Raghuram, K.P. 2003. Report on the status survey of sea cucumber at selected sites in Palk Bay (Thonithurai to Thondi), Tamil Nadu. Survey Report, Marine Biological Station, Zoological Survey of India, Chennai. 9pp.