Template for Submission of Scientific Information to Describe Areas Meeting Scientific Criteria for Ecologically or Biologically Significant Marine Areas

Title/Name of the area: Negombo Lagoon, Sri Lanka

Presented by

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Abstract (*in less than 150 words)*
Negombo Lagoon is one of the most productive and sensitive ecosystems in Sri Lanka. The main fresh water input comes to this lagoon from the rivers Dandugam Oya and Ja-ela. The Negombo Lagoon and its coastal environment have had a long association with the fishery industry. The salinity of Negombo Lagoon is strongly related to the monsoon rains and varies from almost zero to near oceanic salinity. Negombo Lagoon is in the mesotrophic state according to the trophic status. Altogether 89 species of benthic invertebrates, 29 mangrove species, seven sea grass species and 140 species of fish have been recorded. The lagoon and the adjacent reef areas function as the major nursery, refuge and feeding grounds for most of catadromous species. Thus, it is necessary to manage and protect this sensitive ecosystem in a sustainable manner.

Introduction

(To include: feature type(s) presented, geographic description, depth range, oceanography, general information data reported, availability of models)

Negombo Lagoon is one of the most productive estuaries in Sri Lanka. It is 12 km in length from south to north and 3.75 km at its widest point (Fig. 1). The mean depth of the lagoon is about 1.2 m. The greatest recorded water depth is 2.6 m but 10% of the lagoon has a water depth of less than 0.5 m (Fig. 2). The lagoon covers an area of approximately 32 km^2 and opens to the sea at its northern end. To the south, it is connected to the Muthurajawela marsh which covers an area of approximately 31 km^2 and together the lagoon and marsh constitute a conjoined, tidally influenced coastal wetland. The main fresh water input comes from the rivers Dandugam Oya and Ja-ela but the lagoon is characterized by a brackish water flora (seaweeds) and some mangrove forests in the northern part.

The Negombo Lagoon and its coastal environment have had a long association with the fishing industry. There are 47 jetties constructed in the channel segment of the estuary. There is a demand for the provision of a fisheries harbour in or around the vicinity of the lagoon. During the last decade, several development activities took place in the area including construction activities of the Colombo-Katunayake express highway. There are 15 aquaculture farms operating in the area, but a majority of them, either non-functioning or have been abandoned due to disease prone low yields. Local fisher community is not much enthusiastic about any type of eco-tourism as they believe that the water sports such as surfing or operating high speed boats will destroy their traditional fishing areas.

Physical environment

Topography

The lagoon is connected to the Indian Ocean through a single opening, which is an intersection of two parallel narrow channels. The channel located to the west is the main channel and is 2 km long and 150 m wide with an average depth of 2 m. The other one is relatively narrow (20 m) and shallow about 1 meter. The Canal segment consists of thirteen islands of which Munnakarai is the largest. Four islands are already inhabited and all others are covered with mangroves. Names of the islands are Munnakarai, Siriwardena Pedesa, Wedi Kanda, Maha Moliya, Kakaduwa, Katukarai, Wilisiyanduwa, Kadolgas Nella, Kuda Moliya, Kakaduwa (2), Pittipana Duwa (1), Pittipana Duwa (2) and Kuttiduwa. The lagoon is surrounded by fringe mangroves and mangrove associates. Shallow areas of the lagoon bed are covered by sea grasses and mud whereas the bottom of the lagoon mouth is full of sand.

Hydrology and Oceanography

River Input

The main fresh water source is Attanagalu Oya, which empties into the lagoon as Ja-Ela and Dandugam Oya at the southern tip of the estuary. In addition, the Kelani river water is brought into the lagoon via the Hamilton canal. The discharge from the Hamilton Canal is very small and insignificant compared to overall freshwater input. Attanagalu Oya basin, which drains an area of 727 km^2 had an average run-off of 40 m^3s^{-1} in early 1980's (Amarasinghe et al., 1999). Rydberg and Wickbom (1996) reported that the discharge varies between 20 and 100 m^3s^{-1}. Rajapaksha (1997) reported that the total discharge into the lagoon ranged from 20 to 225 m^3s^{-1}, indicating the contribution from Attanagalu Oya over 70%.

Salinity

The salinity of Negombo Lagoon is strongly related to the monsoon rains (Silva 1981; Rajapaksha, 1997) and varies from almost zero to near oceanic salinity. Comparison of measurements during the last two decades indicates that a long-term increase in the salinity (Fig. 3). The most likely explanation is a decreasing freshwater input, although there is no evidence available. The narrow entrance may also have undergone changes increasing water exchange resulting in salinity increase. This situation is restored by regular dredging of sea mouth.

Water temperature

The mean surface water temperature of the lagoon is within the range of 29.8 -30.1 ^oC, with a seasonal temperature difference of 3-6 ^oC, as reported by Silva (1981) and Rajapakshe (1997) respectively. The water temperature is at its lowest during the month of January, whereas it reaches maximum values during March – May (Fig. 4). The diel water temperature fluctuation varies from 2 to 6 ^oC and the range of temperature variation depends on the depth at the particular site. The minimum temperature occurs just before sunrise and maximum reaches around 4.00 o'clock.

Sea level and Tide

The water level in the Negombo Lagoon is strongly influenced by river inputs. Rydberg and Wickbom (1996) showed that the increase in river discharge by 100 m^3s^{-1} may elevate the mean water level in the lagoon by 10 cm. However, Wijeratne (2003) reported that the rise

could be increased up to 20 cm. Further, he reported that fortnightly tide and spring/neap difference in flow resistance forces, the lagoon mean sea level to raise during spring (Fig. 5).

The maximum tidal ranges at just outside (open sea), inside of the lagoon and at the head are 62, 21 and 24 cm respectively, while mean tidal range just outside the inlet is 30 cm. The mean tidal range remained 10 cm within the lagoon (Arulananthan, 2004). The general decrease in tidal range within the lagoon is due to tidal choking across the inlet. Sea level variations inside the lagoon also indicate that tidal choking is larger during spring tides than during neap tides (Wijeratne, 2003). Results of harmonic analysis on the sea level data indicates that the semidiurnal tides are strongly damped compared to diurnal tides in the lagoon, meanwhile fortnightly component is enhanced.

Residence time and Water exchange

In an estuary, time scales of flushing rate and residence time, which are usually used to measure the rate of water exchange between estuary and the adjacent ocean have a major impact on the ecological processes and functions including water chemistry and sedimentation and in turn biophysical environment. The water exchange and residence time in the lagoon is mainly driven by river input (Wijeratne, 2003). Negombo Lagoon features a weak tide (maximum range is about 10 cm) but a strong and variable freshwater discharge. The estimated residence time ranged from 2-4 days at high river discharge to between 11-14 days for low discharge and neap tide (Rydberg and Wickbom, 1996; Rajapaksha, 1997).

Location

Negombo Lagoon, located about 40 km north of Colombo on the west coast of Sri Lanka (7^o 10´ N and 79^o 50´ E) was a trading port during the Kotte Kingdom under the Portuguese rule (1505-1658). This elongated brackish water body falls within Ja-Ela and Negombo divisional secretariats in the Gampaha District of the Western Province of the country (Fig. 1).

(Indicate the geographic location of the area/feature. This should include a location map. It should state if the area is within or outside national jurisdiction, or straddling both.)

Feature description of the proposed area

Biological Environment

Primary Productivity

The annual average of chlorophyll-a content in Negombo lagoon in 1998 and 1999 were 6.4 and 6.6 mg m^{-3} respectively (Fig. 6). Monthly variation of chlorophyll-a content of the lagoon is strongly related to prevailing monsoonal rains. Higher concentrations were observed during the southwest and northeast monsoons. In 1998, chlorophyll-a content ranged from 3.9 mg m^{-3} in January to 10.4 mg m^{-3} in May which it was ranged from 4.1 mg m^{-3} in February and 11.6 mg m^{-3} in November 1999.

Average monthly gross primary productivity of the Negombo Lagoon is within the range of 0.140 - 0. 214 gC m^{-3} h^{-1}. The lagoon is the most productive brackish water body in terms of photosynthetic primary productivity with an assimilation index[1] ranging from 18.3 - 27.8 mg C mg^{-1} Chl *a* h^{-1}. Average chlorophyll- a content of Negombo lagoon is 7.66 µg l^{-1}, thus Negombo Lagoon is in the mesotrophic state (Jayasiri, 2004) according to the trophic status classification. Chlorophyll-a concentration shall vary from 5 to 15 mg m^{-3} in a mesotrophic

[1] Assimilation index is a measure of growth rate obtained from the amount of carbon fixed per unit time and chlorophyll *a*.

water body. The average of chlorophyll-a content of the Negombo Lagoon is high in comparison with other coastal lagoons in Sri Lanka (Jayasiri, 2004). The concentration increases towards the head of the lagoon. It may be attributed to the influx of nutrient rich freshwater from Dandugam Oya, Ja-Ela and Hamilton Canal. The phytoplankton an assemblage in estuarine environment is a highly variable, reflecting the hydrodynamic variability induced by river flow, tides and winds (Jasshy et al. 1994).

Mean chlorophyll-a content indicates that the pelagic waters of Negombo lagoon does not exhibit eutrophic condition. Thus, in general oxygen depletion may not occur leading to fish kills. However, localized eutrophic conditions are reported at the head of the lagoon. Hamilton Canal has high content of chlorophyll-a in comparison with all other freshwater inlets (Table. 1), which discharge into the Negombo Lagoon. Mean chlorophyll-a concentrations of locations 5 shows a rapid increase from the location 4 (Fig. 10). However, the salinity shows an inverse relationship, which indicates that the chlorophyll-*a* is directly related to the inflow of freshwater via Ja-Ela, Dandugam Oya and Hamilton canal.

Table 1. Chlorophyll-*a* content at the inlets

Freshwater inflows	**Chl-a ($\mu g l^{-1}$)**
Dandugan Oya	5.05
Ja-Ela	3.53
Hamilton canal	18.5

Zooplankton

The abundance of zooplankton in Negombo Lagoon varied from 48-198 individuals l^{-1}. The average wet biomass of zooplankton in the lagoon was 0.5 g m^{-3}. Copepods found to be the most dominant zooplankton group which comprised of 40 % of the zooplankton community of the lagoon. Copepod larvae (nauplius) contributed for 34 % of which 87 % was calanoid copepods (Table 2).. The most dominant calanoid taxa was genus *Microcalanus* which contribute 13 % to the zooplankton community in the lagoon. Zooplankton abundance in the inlet canals to the lagoon was estimated and found the highest abundance of 145 individuals l^{-1} in the Hamilton canal and the lowest was found for the Dandugan Oya (Table. 3). The copepods are the dominant forms of the estuarine plankton that constitute to the secondary production in the M environments which is the fundamental step in the estuarine food web.

Table 2. Zooplankton in the Negombo Lagoon

Holoplankton species	Meroplankton taxa
Calanoid Copepoda	Polychaete larvae
Calanus helgolandicus	Crab Zoea
Calanus finmarchicus	Decapod larvae
Pseudocalanus elongates	Barnacle nauplius
Microcalanus sp	Bivalve larvae
Paracalanus sp.	Echnoderm larvae
Candacia sp.	Fish larvae
Labidocera sp.	
Acartia sp.	

Temora sp.
Eurytemora sp
Cyclopoida
Oithana sp.
Harpacticoida
Tigriopus sp.
Zaus sp.
Siphonostomatoida
Caligus
Copepode larvae
Cladocera
Daphnia sp.
Podon sp.
Evadne sp
Chaetognaths

Table 3. Zooplankton abundance at freshwater inlets

Freshwater outlet	**Zooplankton density (indv. l^{-1})**
Dandugan Oya	7
Ja-ela	15
Hamilton canal	111

Benthic organisms

Altogether 89 species of benthic invertebrates belonging to 58 families consisting of 36 species of polychaetes, 13 species of crustaceans, 24 species of gastropods and 16 species of bivalves have been reported from Negombo Lagoon (Dahanayaka et al. 2008). Invertebrate species recorded from the lagoon are listed in Table 4. The list is almost totally confined to annelids, arthropods and mollusks, and more specifically to polychaetes, crustaceans, gastropods and bivalves.

Polychaetes

Polychaetous annelids representing 16 families and 36 species (Erantia, 22 spp; Sedeteria, 14 spp), which constituted 40 % of the total macrofauna in Negombo Lagoon (Dahanayaka et al. 2008). Families with highest species richness are Nereididae (7 spp), Pilargidiidae (3 spp), and Spionidae (3 spp). Pilargidiids and Heterospionids are dominated in the most of the areas of the lagoon. Low diversity or absolute absence of polychaetes was recorded from the mouth region and deeper areas of middle region of the lagoon.

Their abundance and diversity were high at the marginal and inner regions. Polychaete abundance decreases with increasing depth and their diversity changes with the salinity.

Polychaetes formed the bulk of the macrobenthic fauna in the Negombo Lagoon (Dahanayaka and Wijeyaratne 2006; Dahanayaka et al. 2008).

Table 4. Benthic polychaetes recorded from Negombo lagoon (Source: Dahanayaka et al. 2008)

Family/Species	
Errantia	**Sedentariya**
Aphroditidae	Capitellidae
Harmothoe ampullifera (Grube, 1878)	*Heteromastus similis* (Southern, 1921)
Amphinomidae	*Branchiocapitella singularis* (Fauvel, 1932)
Pareurythoe pitipanaensis (De Silva, 1964)	Heterospionidae
Eunicidae	Heterospionid sp 1
Diopatra cuprea (Bosc, 1802)	Pectinariidae
Eunice sp	*Pectinaria panava* (Willey, 1905)
Goniadidae	Sabellariidae
Goniadid sp 1	Sabellariid sp 1
Lumbrineridae	Sabellidae
Lumbrinerid sp 1	*Potamilla leptochaeta* (Southern, 1921)
Nephtyidae	Sabellid sp 1
Nephtys sp	Spionidae
Nephtyidae sp 1	*Nerine cirratulus* (delle Chiaje, 1828)
Nereididae	*Scolelepis indica* (Fauvel, 1928)
Namalycastis indica (Southern, 1921)	Spionid sp 1
Tylonereis bogoyawlenskyi (Fauvel, 1911)	Syllidae
Nereis chilkaensis (Southern, 1921)	Syllid sp 1
Neanthes negomboensis (De Silva, 1964)	Sedenteria sp 1
Nereis burmensis (Monro, 1937)	Sedenteria sp 2
Nereidid sp 1	Sedenteria sp 3
Nereidid sp 2	
Pilargidiidae	
Pilargidiid sp 1	
Pilargidiid sp 2	
Pilargidiid sp 3	
Sphaerodoridae	
Sphaerodorid sp1	
Errantia sp 1	
Errantia sp 2	
Errantia sp 3	
Errantia sp 4	

Shrimp

Samarakoon and Raphael (1972) surveyed to find the seed availability in the Negombo lagoon and found that the post-larvae and juveniles of *Penaeus indicus*, *P. semisulcatus*, M*etpenaeus dobsoni* and *M. elegans* in sufficiently large numbers during the period of September to November, whilst *P. monodon* and *P. latisulcatus* were recorded in smaller numbers for a short period.

Crabs

The grapsid and ocypodid crabs have been abundant in the mangrove areas and on mud flats of the Negombo Lagoon respectively. The most dominant species of grapsid crabs are *C. indiarum,* and C. *darwinensis*. The first record of *Metopograpsus thukuhar* and *Sesarma guttatum* in Sri Lanka were recorded in mangroves in the Negombo Lagoon (Priyadarshani et al. 2008). Xanthid crabs, especially *Baruna socialis* and *Pseidognathus dearira* have been observed to occur in association with the oysters in the Negombo Lagoon (Pinto and Wignarajah, 1980). The mud lobster, *Thalassina anomala* inhabits inside the mangrove stands. Among the other crabs that inhabit this estuarine environment are hermit crabs belong to genus *Eupagurus and* genus *Paqurus* and fiddler crabs (*Uca* sp).

Amphipod & Isopods

Among amphipods, Aorids and Gammarids are reported in most of the areas of the lagoon while Cirolanids as isopods are also reported from the Negombo Lagoon (Dahanayaka et al. 2008).

Mollusks

Bivalves: Mollusks were mainly dominated by bivalves followed by gastropods in the Negombo Lagoon. The most abundant bivalve families are Mytilidae and Veneridae. *Meretrix casta* of family Veneridae is the dominant species followed by *Modiolus undulates* and *Meretrix meretrix*. *Meretrix casta* and *Modiolus undulatus* are generally abundant in the areas near the Dandugam oya throughout the year. The adult dominates the samples during pre-monsoon, while juveniles are abundant during post-monsoon (Dahanayaka and Wijeyaratne 2006; Dahanayaka et al. 2008) indicating their breeding coincides with monsoon period.

The study on the edible oyster population, *Crassostrea cucullata* in the Negombo Lagoon (Pinto and Wignaraja, 1980) remains one of the few detailed studies of the molluscan population in any of the lagoon in Sri Lanka. Twenty four species of aquatic organisms associated with oysters, have been recorded. It has also been revealed that a vertical zonation of oysters as well as sessile fauna associated with the oysters exists on the mangrove roots.

Two peaks related to the inter-monsoonal periods and distribution of oysters in the islets in the lagoon may be attributed to the current speed which determines the accumulation of suitable substrate. Pinto and Wignaraja (1980) categorized the fauna associated with the edible oyster populations into sessile, boring and free moving (Table. 5) and distribution of some species of oyster fauna is related to the water level.

Gastropods: Families Assimineidae, Atyidae, Cerithiidae and Hydrobiidae are the most abundant families among the gastropods (Dahanayaka and Wijeyaratne 2006; Dahanayaka et al. 2008).

Table 5. Invertebrate fauna recorded from Negombo Lagoon

Group	**Species**	**Habitat**
Annelida/ Polychaeta	*Augeneria dayi*	Sandy bottom[2]

	Branchiocpitella singularis	Soft mud[2]
	Branchiomma cingulata	Tubes attached submerged stones[2]
	Diopatra cuprea	Tubes of the bottom mud[2]
	Eunice sp	Soft mud[1]
	Harmothoe ampullifera	Soft mud[2]
	Heteromastus similis	Soft mud[2]
	Hydroides inornata	On oyster shells[3]
	Marphysa mossambica	Soft mud[2]
	Namalycastis indica	Amongst debris cast on lagoon bank [2]
	Neopomatus uschakovi	Attached to shells, stones and upper surfaces of petiole bases of fallen branches[3]
	Neanthes manatensis	Associated with oyster populations[3]
	N. negomboensis	bottom mud[2]
	Nephtys polybranchia	bottom mud[1 & 2]
	Nereis burmensis	bottom mud[2]
	N. chilkaensis	Tunnels of the branches in fish traps [2]
	Nerine cirratulus	Sandy banks of the lagoon mouth[2]
	Odontosyllis gravelyi	Swimming at the lagoon surface [2]
	Pareurythoe pitipanaensis	Tunnels of the branches in fish traps [2]
	Pictinaria panava	Soft mud[2]
	Potamilla leptochaeta	Soft mud[2]
	Prionospio cirrifera	Burrowing, bottom mud[2]
	Scolelepis indica	Sandy banks of the lagoon mouth[2]
	Trypanosyllis zebra	Associated with oyster populations[3]
	Tylonereis bogoyawlenskyi	Soft mud[2]
Mollusca/ Bivalvia	*Gari variegata*	Burrowing vertically in sandy mud[1]
	Brachydontes variabilis	Associated with oyster populations[3]
	Spondylus descalis	Associated with oyster populations[3]
	Martesia striata	Associated with oyster populations[3]
	Meretrix casta	Muddy bottom[1]
	Modiolus sp.	Soft mud[2]
Mollusca/ Polyplacophora	*Squamopleura imitator*	Associated with oyster populations[3]
Mollusca/ Gastropoda	*Euchelus asper*	Associated with oyster populations[3]
	Cellana radiata	Associated with oyster populations[3]
	Nerita polita	Associated with oyster populations[3]
	Littorina scabra	Associated with oyster populations[3]
	Cliothon sp.	Soft mud[1]
	Cirithidea cingulata	Soft mud[1]
	Dentalium sp	Sandy mud[1]
	Terebralia palustris	Soft mud[1]
	Faunus ater	Soft mud[1]
Arthropoda/ Crustacea	*Scylla serrata*	Muddy bottom[1]
	Caridina sp	Muddy bottom[1]
	Eupagurus sp	Muddy bottom[1]

	Penaeus monodon	Bottom & water column[4]
	P. semisulcatus	Bottom & water column[4]
	P. indicus	Bottom & water column[4]
	Metapenaeus dobsoni	Bottom & water column[4]
	M. elegans	Bottom & water column[4]
Arthropoda/ Brachyura	*Baruna socialis*	Associated with oyster populations[3]
	Pyseidognathus deianira	Associated with oyster populations[3]
	Metapograpsus messor	Associated with oyster populations[3]
Arthropoda/ Macrura	*Alpheus edwardsii*	Associated with oyster populations[3]
Arthropoda/ Cirripedia	*Balanus amphitrite*	Associated with oyster populations[3]
Arthropoda/ Isopoda	*Ligia exotica*	Littoral[3]
	Cirolana willeyi	Associated with oyster populations[3]
Arthropoda/ Amphipoda	*Lembos sp.*	Associated with oyster populations[3]

Mangroves

The mangroves cover an area of 3.5 km^2, concentrated mainly in a narrow intertidal belt along the banks of the Negombo Lagoon (Samarakoon and van Zon, 1991). The studies conducted by Pahalawattaarachchi (1995) indicated the extent of mangrove has decreased by about 0.3 km^2 from 1985 to 1995.

Well grown and least disturbed mangroves exist at the mouth of Dandugam Oya. Most of the mangrove islands located at the sea mouth of the lagoon have been cultivated for economic purposes and environmental protection. The true mangrove stands around Negombo Lagoon, Kadolkele is the largest single stand, which covers nearly 0.14 km^2 of the intertidal land.

In total, 29 mangrove species have been recorded from the Negombo Lagoon of which 18 species are true mangroves (Tables 6 and 7). Thirty three other types of vegetation mainly consisted of shrubs. Family Rhizopharaceae is the most dominant mangroves with other families such asAvicennianceae and Combretaceae which showed a typical zonal distribution towards the inland. *Lumnitzera racemosa* and *Avicennia marina* are the dominate species of family Combretaceae and Avicenniaceae, respectively. *Rhizophora apiculata* and *R. mucronata* are the most abundant members of the family Rhizophoraceae while other members include *Bruguiera gymnorhiza*, *B. sexangula* and *Ceriops tagal*. Mangrove associates are found towards landside with high abundance of *Premna integrifolia*, *Derris scandens* and *Acanthus ilicifolius* (Dahanayaka, and Sumanadasa , 2007).

Table 6. List of true mangroves recorded from Kadolkele mangrove vegetation as reported by Tomlinson (1986). The abundance scale includes all three transects

Mangrove Species	Sinhala Name	Status
Family: Avicenniaceae		

Avicennia alba Blume		very rare
Avicennia marina (Forsk.) Vierh.	Manda	very common
Avicennia officinalis L.	Manda	rare
Family: Combretaceae		
Lumnitzera littorea (Jack) Voigt	Rath beriya	very rare
Lumnitzera racemosa Willd.	Sudu beriya	very common
Family: Euphorbiaceae		
Excoecaria agallocha L.	Thelakeeriya	common
Family: Meliaceae		
Xylocarpus granatum König	Mutti kadol	very rare
Family: Myrsinaceae		
Aegiceras corniculatum (L.) Blanco	Heen kadol	common
Family: Rhizophoraceae		
Rhizophora apiculata BL.	Rana kadol	very common
Rhizophora mucronata Lamk.	Murunga kadol	very common
Bruguiera sexangula (Lour.) Poir.	Ela kadol	common
Ceriops tagal (Perr.) C.B. Robinson	Punkanda	rare
Family: Rubiaceae		
Scyphiphora hydrophyllacea Gaertn.f.	Kalu kadol	very rare
Family: Sterculiaceae		
Heritiera littoralis Dryand.	Etuna	rare
Family: Sonneratiaceae		
Sonneratia alba J. Smith	Sudu mal kirala	rare
Sonneratia caseolaris (L.) Engler	Rath mal kirala	very rare

Table 7. List of mangrove associates recorded from Kadolkele as reported by Tomlinson (1986) except the genus *Acrostichum*.

Mangrove Species	**Family**	**Sinhala Name**	**Status**
Acanthus ilicifolius L.	Acanthaceae	Katu Ikiri	common
Acrostichum aureum L.	Adiantaceae	Karan koku	common
Annona glabra L.	Annonaceae	Wal anoda	common
Cerbera manghas L.	Apocynaceae	Gon kaduru	common
Phoenix zeylanica Trim.	Arecaceae	Indi	common

Dolichandrone spathacea (L.f.) K. Schumann	Bignoniaceae	Diya danga	rare
Calophyllum inophyllum L.	Clusiaceae	Domba	rare
Derris scandens Benth	Fabaceae	Kala wel	very common
Hibiscus tiliaceus L.	Malvaceae	Belipatta	very rare
Thespesia populnea (L.) Soland. ex.Corr.	Malvaceae	Suriya	very rare
Premna integrifolia Lam. (= *P. foetida* Reinw.)	Verbenaceae	Wal midi	very common

Seagrasses

Sea grass beds cover 22 % of the lagoon area and are highly productive, providing habitats for a variety of brackish water organisms including many commercially important shrimps, crabs etc. Seven sea grass species belonging to four genera have been recorded from the Negombo lagoon (i.e., *Halodule, Holophila, Potamogeton* and *Ruppia*). The sea grass beds in the Negombo lagoon constitute the single most important habitat type supporting the exceptionally high fish production of 150 kg ha^{-1} yr^{-1} (Jayakody, 1994). Sea grasses are highly abundant in the northern part of the lagoon, where a thick mangroves cover is present compared to the other areas of the lagoon. The highest biomass of sea grasses is estimated for *Halodule pinifolia*, which produces approximately 142 g m^{-2} (Pahalawattaarachchi et al. 2005).

Decline of standing crop of seagrass ecosystem in northern, eastern and western parts of the lagoon is estimated as 96 % during the period from 1997 to 2004. In Bassiyawatta located in western side indicates 50 % of total biomass reduction, while 62 % and 47 % increase in total biomass have been reported in Kurana/Katunayake, and Liyanagemulla located in eastern boarder respectively (Pahalawattaarachchi et al. 2005). *Chaetomorpha* is the most dominant filamentous macro algae, which cause light deprivation affecting the seagrass beds. The species is tolerant to salinity variations and reported to be produced negative impact on seagrass productivity..

Fisheries

Species diversity

Negombo Lagoon is rich in finfish and shellfish (prawns, crabs and molluscs) representing M, estuarine and freshwater species (Table. 8). The lagoon and the adjacent reef areas function as the major nursery, refuge and feeding grounds for most of catadromous species. It has been recorded about 140 species of fish in the Muthurajawela Marsh – Negombo lagoon coastal wetland of which a majority is catadromous (Samarakoon and van Zon, 1991b).

Many fish species found in the lagoon are commercially important and exist in substantial populations that support a fishery. Table 8 represents the species identified in the catches and their habitats which need to complete the entire life cycle. A wide range of species are caught

for consumption, for export as ornamental fish and as aquaculture seed. Four penaeid shrimp species (i.e. *Penaeus indicus, P. monodon, P. semisculcatus* and *Metapenaeus dobsoni*), and two crab species; mud crab (*Scylla serrata*) and sea crab (*Portunus pelagiucs*) are of high economic value. Some important edible fish species such as sea bass (*Lates calcarifer*), rabbit fishes (*Siganus* spp.), milk fishes (*Chanos chanos*), grey mullet (*Mugil* spp) and estuarine catfishes (*Tachysurus* spp.) are also harvested in large numbers from Negombo lagoon.

Many Penaeid shrimps show migratory behaviour between the lagoon and the sea. Species like *P. indicus*, *P. semisulcatus* and *M. dobsoni* breed in the sea and their post larvae migrate to the lagoon and stay in the lagoon till maturation, and then return to the sea for subsequent breeding and spawning (Sanders et al. 2000). The abundance and seasonal variations of the juvenile shrimps in the lagoon will have a great influence on the fishery for shrimps since the magnitude of the fishery for adults is primarily determined by the success of the larval recruitment in the previous seasons (Jayawardane and Gunawardane, 2003). Besides shrimps, some coastal finfish and shellfish species which are also found in the lagoon as listed in the Table. 8 spend at least one phase of their life cycle in the lagoon.

Table 8. List of fish species recorded from Negombo Lagoon (F, Fresh; B, Brackish; M, M; E, Estuarine; C, Coastal)

Family	Scientific name	English name	Environment
Ambassidae	*Ambassis gymnocephalus*	Bald glassy	F/B/M
Anguillidae	*Anguilla bicolor bicolor*	Short fin eel	F/B/M
Ariidae	*Arius spp.*		E/C
Belonidae	*Stongylura spp.*		M/E
Carangidae	*Carangoides armatus*	Long fin travelly	B/ M
	Atule mate	Yellow tail scad	B/ M
Chanidae	*Chanos chanos*	Milk fish	F/B/M
Drepanidae	*Drepane punctata*	Spotted sickle fish	B/M
Cichlidae	*Etroplus suratensis*	Banded etroplus	B
	Etroplus maculates	Spotted etroplus	F/B
	Oreochromis mossambicus	Thilapia	F/ B
Serranidae	*Epinephelus longispinis*	Longspine grouper	M
	Epinephelus tauvina	Greasy grouper	M
Cynoglossidae	*Cynoglossus spp.*		C/E
Gerreidae	*Gerres filamentosus*	Whipfin silverbiddy	F/B/M
Clupeidae	*Hilsa kelee*	Kelle shad	F/B/M
	Sardinella gibbosa	Goldstripe sardinella	M
	Sardinella longiceps	Indian oil sardine	M
	Sardinella albella	White sardinella	M
	Nematalosa nasus	Bloch's gizzard shad	F/B/M
Engraulididae	*Stolephorus commersonii*	Commersonii's anchovy	B/M
	Stolephorus indicus	Indian anchovy	B/M
	Thryssa dussumieri	Dussumier's thryssa	B/M
	Thryssa mystax	Moustached anchovy	B/M
	Thryssa setirostris	Langjaw thryssa	B/M
Hemiramphidae	*Hyporhamphus limbatus*	Congaturi halfbeak	F/B/M
	Hyporhamphus dussumieri	Dussumier's halfbeak	M
Sphyraenidae	*Sphyraena jello*	Pickhandle barracuda	B/M
Scombridae	*Rastrelliger kanagurata*	Indian mackerel	M
Lethrinidae	*Lethrinus lentjan*	Pink ear emperor	B/M
	Lethrinus nebulosus	Spangled emperor	B/M
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove red snapper	F/B/M
	Lutjanus fulviflamma	Blackspot snapper	B/M
Centropomidae	*Lates calcarifer*	Giant sea perch	F/B/M
Leiognathidae	*Leiognathus brevirostris*	Short nose ponyfish	B/M
	Leiognathus dussumieri	Dussumier's pony fish	B/M
	Leiognathus splendens	Splendid pony	B/M
	Secutor insidiator	Pugnose pony fish	B/M
	Secutor ruconius	Deep pugnose pony fish	F/B/M
Monodactylidae	*Monodactylus argenteus*	Silver moony	F/B/M

	Monodactylus falciformis	Full moony	F/B/M
Mugilidae	*Mugil cephalus*	Flat head mullet	F/B/M
Mullidae	*Upeneus bensasi*	Bensasi goatfish	M
	Upeneus taeniopterus	Finstripe goatfish	M
Sillaginidae	*Sillago sihama*	Silver sillago	B/M
Siganidae	*Siganus canaliculatus*	Whitespotted spinefoot	B/M
	Siganus jarvus	Streaked spinefoot	B/M
	Siganus vermiculatus	Vermiculated spine foot	B/M
Terapontidae	*Terapon jarbua*	Jurbua terapon	F/B/M
	Terapon puta	Smallscaled terapon	F/B/M
Pristigasteridae	*Ophisthopterus tardoore*	Tardoore	B/M
Scatophagidae	*Scatophagus argus*	Spotted scat	F/B/M
Dasyatidae	*Dasyatis kuhlii*	Blue spotted sting ray	M
Palaemonidae	*Macrobrachium rosenbergii*	Giant river prawn	F/B/ M
	Exopalaemon stylifera	Rushna shrimp	B/M
Penaeidae	*Penaeus indicus*	Indian white shrimp	M/ E
	Penaeus merguiensis	Banana prawn	M/ E
	Penaeus semisulcatus	Green tiger prawn	M/ High salinity lagoons(Post larvae and juveniles)
	Penaeus monodon	Giant tiger prawn	M(adults)/ Estuaries(Post larvae and juveniles)
	Penaeus canaliculatus	Witch prawn	Estuaries and lagoons (juveniles) /quite rare in the sea (adults)
	Penaeus latisulcatus	Western kingprawn	lagoons (juveniles)
	Metapenaeus dobsoni	Kadal shrimp	Estuaries & lagoons (juveniles & post larvae)/M(adults)
	Metapenaeus elegans	Fine shrimp	Apparently purely estuarine
	Metapenaeus moyebi	Moyebi shrimp	High saline lagoons & estuaries (juveniles & adults)
	Metapenaeus monoceros	Speckled shrimp	Estuaries (post larvae& juveniles)/M (adults)
	Metapenaeus affinis	Jinga shrimp	M (adults)/ high salinity lagoons (post larvae)
	Parapenaeopsis cornuta	Coral shrimp	Mouth of estuaries
			M/estuaries and lagoons
Portunidae	*Portunus pelagicus*	Blue swimming crab	M/ lagoons (juveniles)
	Portunus sanguinolentus	Blood spotted crab	M/ Estuaries
	Scylla serrata	Indo-pacific swamp crab	

F-Fresh, B-Brackish M-Marine

Fish catch and production

Fishing inside the lagoon is mostly conducted targeting shrimps. Around 80 % of the total catch of stake-seine net which targets pre-adults of seaward migrating shrimps comprises of penaied prawns(Jayawardane, 2001). Total annual production from five main fishing methods is 1025 Mt, where as the slightly more than one third comprises shrimps (Table 9).

Table 9. Fishing gear and respective production

Fishing gear	Total production (Mt)		
	Shrimps	**Others**	**Total**
Dragnet	45.40	75.80	121.20
Brush pile	13.66	190.30	204.00
Cast net	18.03	0	18.00
Trammel net	111.29	354.70	466.00
Stake seine net	173.95	41.12	215.10

Total	362.33	662.00	1024.30

Source: Jayawardane, 2001

Shrimps contribute to 35 % of the total production. Stake seine net and Trammel net contribute to two-third of the total catch, whereas almost 75-85 % of the catch by stake seine net is shrimp, Nevertheless absent 80 % of trammel net catch is fish. Table 10 shows the mean catches of each gear per operations, annual catch, fishing effort and percentage weights of shrimp in the total annual catch. Fishing efforts is highest for trammel net whereas it is low cost for stake-seine net which catches the highest percentage of shrimp.

Table 10. Gear specific mean catch (kg per operation) and annual catch (Mt), fishing effort and percentage shrimp production in Negombo lagoon.

Fishing gear	Mean catch	Annual catch	Fishing Effort	% shrimp
Trammel net	5.18	466	89,934	15
Cast net	0.70	18	18,107	-
Brush pile	7.09	204	29,407	5
Dragnet	15.68	121	7,803	33
Stake-seine net	26.19	215	7,559	80

Source: Jayawardane (2001).

The total annual catch by the widely used five fishing gear amounts to 1024 Mt (Table 10), whereas the shrimp contributes to almost one-third of the total production.

(This should include information about the characteristics of the feature to be proposed, e.g. in terms of physical description (water column feature, benthic feature, or both), biological communities, role in ecosystem function, and then refer to the data/information that is available to support the proposal and whether models are available in the absence of data. This needs to be supported where possible with maps, models, reference to analysis, or the level of research in the area)

Feature condition and future outlook of the proposed area

Negombo Lagoon is one of the most studied estuarine ecosystems in Sri Lanka. Almost all the aspects including its resources and uses, dynamics and ecology have been studied during the last century or so. These studies, conducted by research institutes, universities, INGOs and NGOs focused physico-chemical parameters, water quality, pollution, hydro-dynamic modeling, primary productivity, biodiversity, distribution of benthic fauna and flora, distribution and abundance of sensitive habitats such as mangroves, sea grass beds, fishery biology and ecology of both lagoon and adjacent coastal waters. Special emphases were given to the studies of recruitment patterns of prawns as both lagoon and sea components are vital in the life cycle of Paenaid prawns. Socio-economic studies have focused on both resources and user-conflicts.

However, most of these studies are discrete, isolated, fragmented and more often limited to a single component of the ecosystem. Further, the institutes involved in these studies acted as, more or less independent actors with little interaction and under separate programmes. Thus, the studies in general had the following two deficiencies;

- Lack of multi disciplinary, integrated and holistic approach - at different point in time, the studies focused on one or the other component of the ecosystem, thus does not provide an insight into the inter-relation between the different components of the ecosystem

- Lack of holistic ecosystem based approach – the studies focused on a part of the ecosystem only, more often limited to either lagoon or coastal waters. Thus, not sufficient enough to assess and evaluate the influence of other interlinked ecosystem on the lagoon.

However, there are few studies, which are holistic to a certain extent. The following studies at least considered Negombo Lagoon and Muthurajawela as a single ecosystem but still neglected the associated coastal ecosystem.

- Environmental Profile of Muthurajawela and Negombo Lagoon and Master Plan of Muthurajawela and Negombo Lagoon by Greater Colombo Economic Commission (1991)

- Conservation Management Plan, Muthurajawela Marsh and Negombo Lagoon by Central Environmental Authourity under wetland conservation project (1994)

- Special Area Management Plan for Negombo Lagoon by Coast Conservation Department (2005).

However, this monograph makes a valiant attempt to synchronize the studies conducted at different times to address single issue or discipline to evolve an understanding on the interactions of the ecosystem components. Still it fails to include the other vital components of the ecosystem, such as catchment, Muthurajawela wetlands, coastal waters, etc. into its scope.

Apparently that the following aspects are either not studied or the studies are limited. Thus, it is recommended that the future research studies shall focus on the following aspects;

- Rapid ecological assessment to upgrade the existing knowledge on fisheries, resources, environment and socioeconomics

- Conduct a comparative study of fishing methods to adapt environmentally friendly fishing methods.

- Study the phytoplankton, zooplanktons, and benthic fauna and update the check lists of fauna and flora of the lagoon and prepare online, identification guides, keys, etc.

- Map and value mangrove ecosystems for conservation and sustainable development such eco-tourism, research and education

- Assess the pollution levels of the lagoon system and set up the standards and also identify pollutant indicators for monitoring purposes

- Geomorphological changes of the lagoon ecosystem due to siltation or the other causes
- Coastal sediment dynamics and its impact on the ecosystem
- Impact of near shore developments such as offshore sand extractions to the lagoon ecosystem
- Impact of sea level changes and climate changes on the estuarine system
- Evaluate the causes for the limited success of the Negombo Lagoon Management Authority. Study to identify the main causes for the deterioration of water quality and change in water exchange or carrying capacity

(Description of the current condition of the area – is this static, declining, improving, what are the particular vulnerabilities? Any planned research/programmes/investigations?)

Assessment of the area against CBD EBSA Criteria
(Discuss the area in relation to each of the CBD criteria and relate the best available science. Note that a proposed area for EBSA description may qualify on the basis of one or more of the criteria, and that the polygons of the EBSA need not be defined with exact precision. And modeling may be used to estimate the presence of EBSA attributes. Please note where there are significant information gaps)

CBD EBSA Criteria (Annex I to decision IX/20)	**Description** (Annex I to decision IX/20)	**Ranking of criterion relevance** (please mark one column with an X)			
		No information	**Low**	**Medium**	**High**
Uniqueness or rarity	Area contains either (i) unique ("the only one of its kind"), rare (occurs only in few locations) or endemic species, populations or communities, and/or (ii) unique, rare or distinct, habitats or ecosystems; and/or (iii) unique or unusual geomorphological or oceanographic features.			X	
Explanation for ranking					
Special importance for life-history stages of species	Areas that are required for a population to survive and thrive.				X
Explanation for ranking					
Importance for threatened, endangered or declining species and/or habitats	Area containing habitat for the survival and recovery of endangered, threatened, declining species or area with significant assemblages of such species.			X	
Explanation for ranking					
Vulnerability, fragility, sensitivity, or slow recovery	Areas that contain a relatively high proportion of sensitive habitats, biotopes or species that are functionally fragile (highly susceptible to degradation or depletion by human activity or by natural events) or with slow recovery.				X

Explanation for ranking					
Biological productivity	Area containing species, populations or communities with comparatively higher natural biological productivity.				X
Explanation for ranking					
Biological diversity	Area contains comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity.				X
Explanation for ranking					
Naturalness	Area with a comparatively higher degree of naturalness as a result of the lack of or low level of human-induced disturbance or degradation.		X		
Explanation for ranking					

Sharing experiences and information applying other criteria (Optional)

Other Criteria	**Description**	**Ranking of criterion relevance** (please mark one column with an X)			
		Don't Know	**Low**	**Medium**	**High**
Add relevant criteria					
Explanation for ranking					

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(e.g. relevant documents and publications, including URL where available; relevant data sets, including where these are located; information pertaining to relevant audio/visual material, video, models, etc.)

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Maps and Figures

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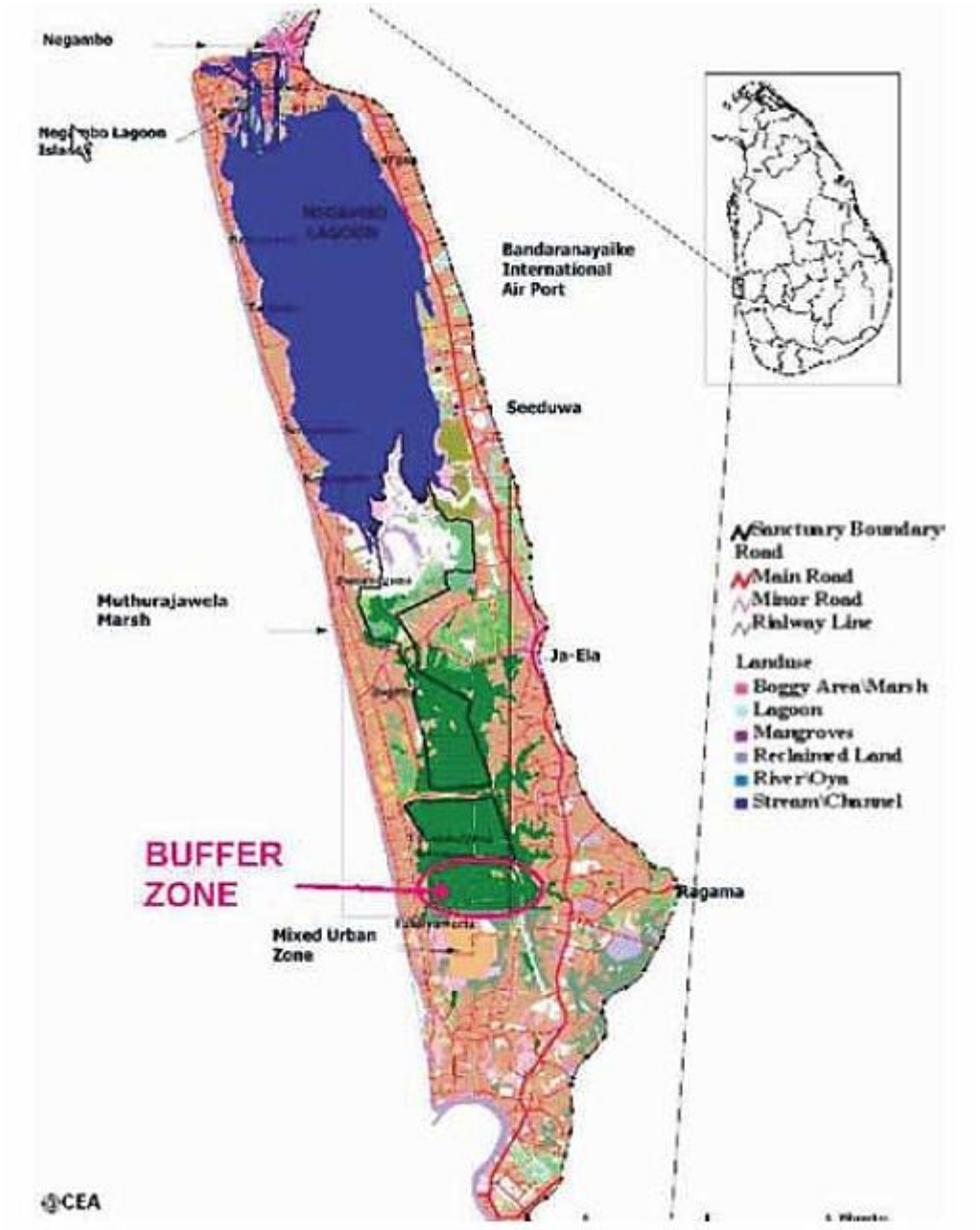

Fig. 1. Map of the Negombo Lagoon

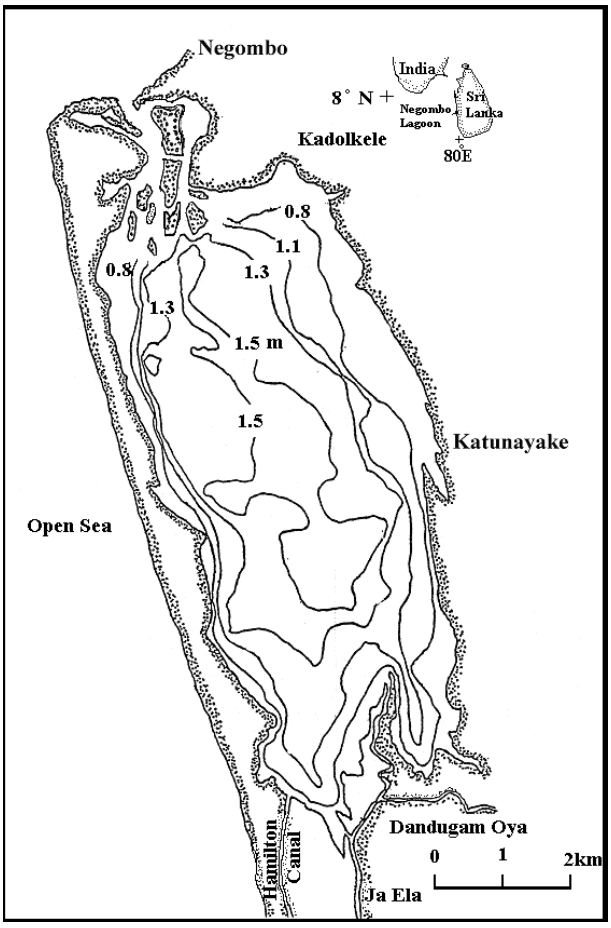

Fig. 2. Bathymetric map of Negombo Lagoon

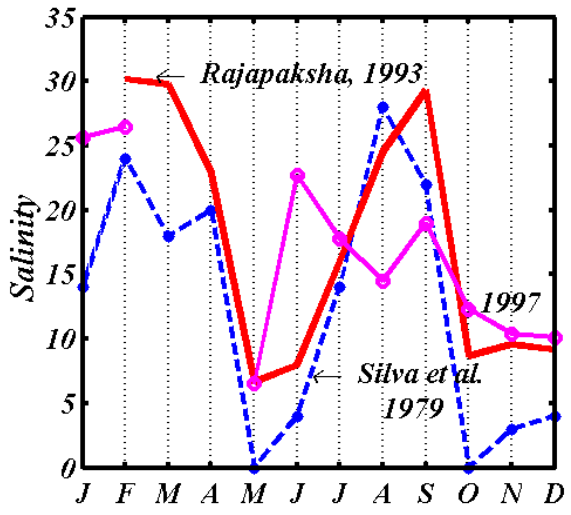

Fig. 3. Monthly salinity fluctuation

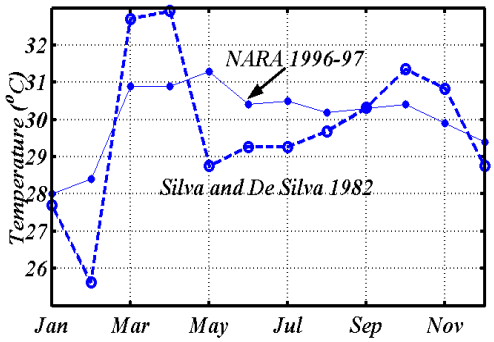

Fig. 4. Monthly temperature fluctuation

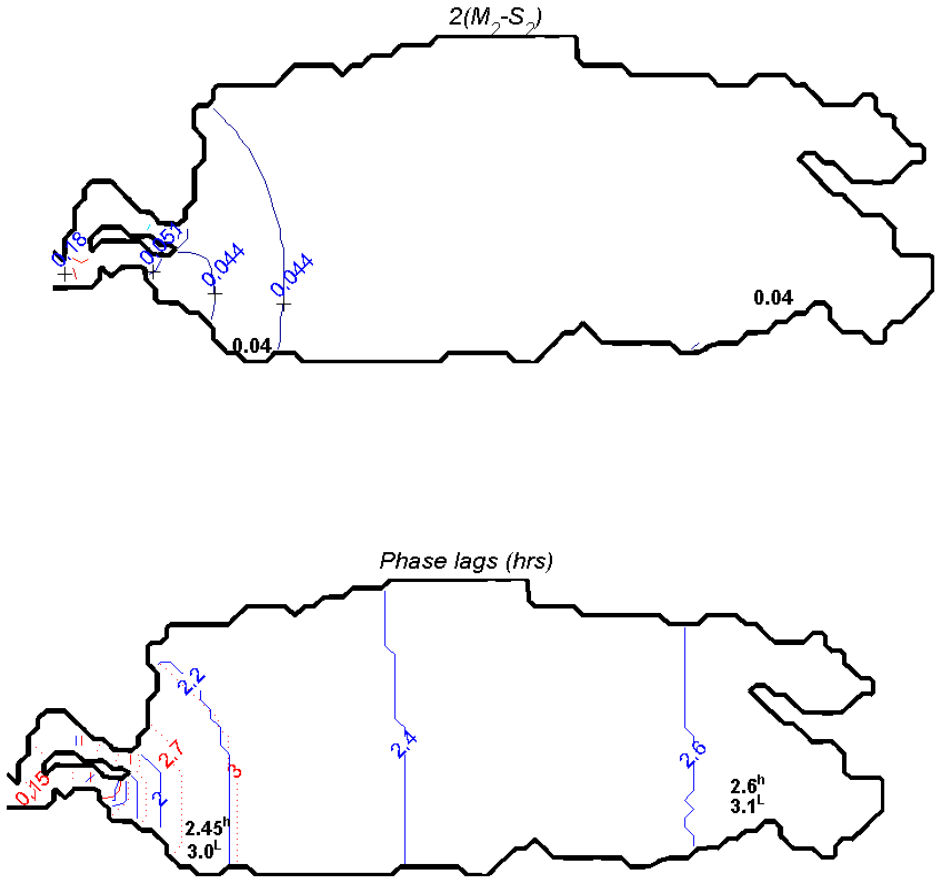

Figure 5. Spring tidal range and phase lags in Negombo Lagoon predicted by 2-D model. Numbers in "bold" are from measurements

Figure 5. Neap tidal range in Negombo Lagoon predicted by 2-D model. Numbers in “bold” are from measurements

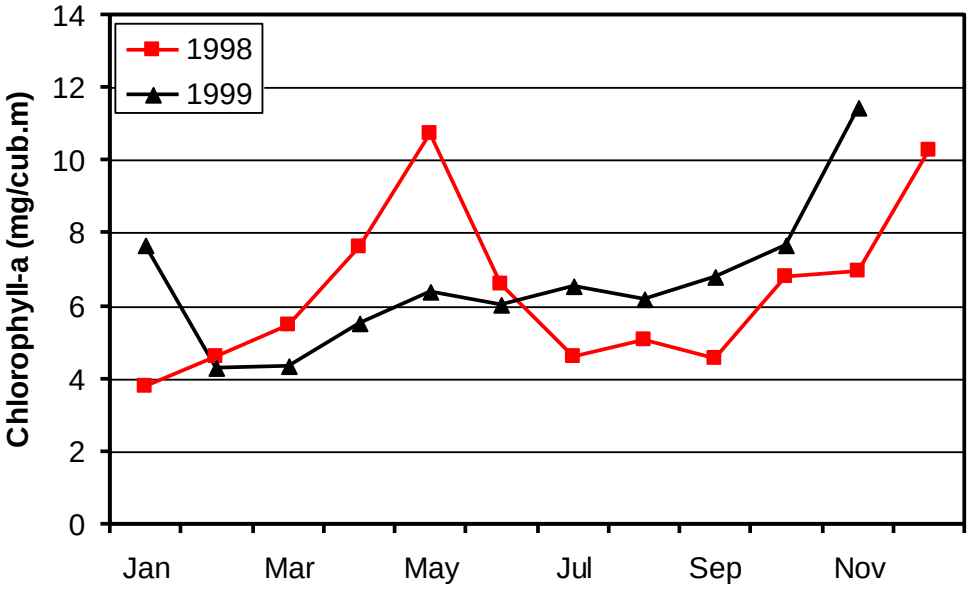

Fig. 6. Monthly variation of chlorophyll-a in the Negombo Lagoon

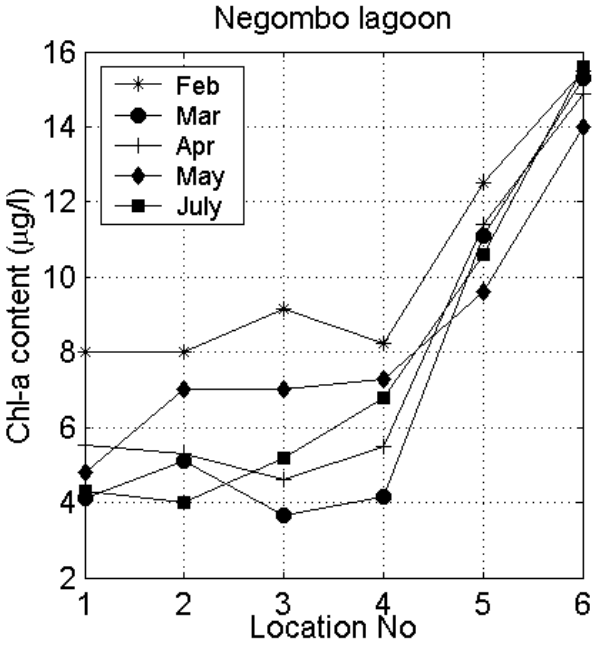

Fig. 7. Temporal and spatial variation of chl-a. Location 1 is at the mouth and 6 is at the head of the lagoon.

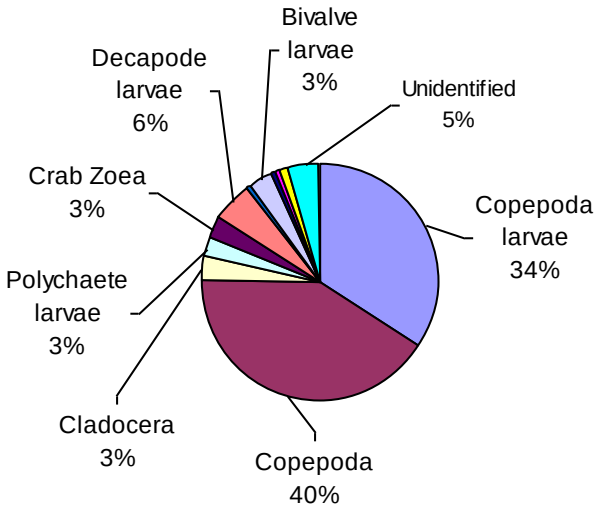

Fig. 8. Composition of dominant zooplankton groups in Negombo Lagoon

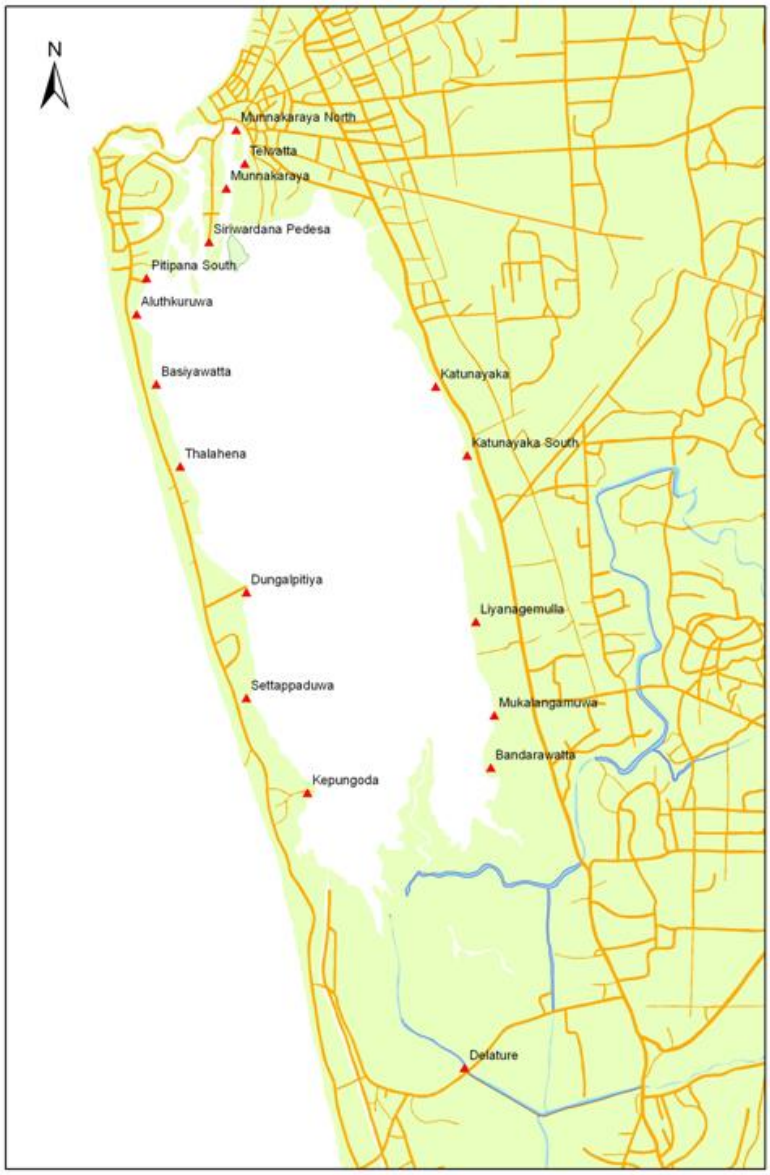

Fig. 9. A map of the important fish landing centres in the Negombo lagoon